Public Comments Received by NIST on DRAFT Reports:

NIST NCSTAR 1 through NCSTAR 1-8: Federal Building and Fire Safety Investigation of the World Trade Center Disaster: Final Reports of the National Construction Safety Team on the Collapses of the World Trade Center Towers

DRAFTS FOR PUBLIC COMMENTS
June 2005

http://www.nist.gov/el/disasterstudies/wtc/wtc_draftreports.cfm

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Submission Process for Public Comments

- NIST released the draft WTC Towers report and 42 supporting draft reports on June 23, 2005 for a six week public comment. All comments were due to NIST August 4, 2005.
- Comments were encouraged on the WTC Towers Report but welcomed on all reports. NIST requested that comments be specific in nature with recommendations for change. Comments were accepted via Web site, e-mail, fax, and regular mail.

Summary of Comments Received Summary of Comments Received

- Total number of submissions: 469
- Nearly all major building and fire safety organizations submitted comments: (e.g., ICC, NFPA, ASCE/SEI, SFPE, NCSEA, PCA, AIA, BOMA, ACI, NASFM, AFSC, NCSBCS, AMCBO, CRSI, UL, ASTM, SPI, NFSA, NRMCA)

Comments were submitted by:

- David W. Darwin & Daniel W. Falconer, American Concrete Institute
- James A. Thomas, ASTM International
- Sara C. Yerkes, International Code Council
- Robert C. Wilbe, National Conference of States on Building Codes & Standards
- Gary Keith, National Fire Protection Association
- Mary Ellen Saville, Structural Engineering Institute of ASCE
- Dave Johnston, BOMA International
- Claude Cooper, Association of Major City/County Building Officials (AMCBO)
- David P. Gustafson, Concrete Reinforcing Steel Institute
- Ed Huston, The National Council of Structural Engineering Associations
- Ray Sweeney, National Association of State Fire Marshals
- Ganesh Rao, Underwriters Laboratories
- Stephen E. Szoke , Portland Cement Association
- Allen Weidman, The Society of the Plastics Industry, Inc.
- Andrew Goldberg, The American Institute of Architects
- Mike Heimowitz, American Fire Safety Council
- Russell E. Fleming, National Fire Sprinkler Association, Inc.
- Lionel Lemay, National Ready Mixed Concrete Association
- Francis J. Lombardi, The Port Authority of New York and New Jersey
- Saroj Bhol, The Port Authority of New York and New Jersey
- Samuel S. Dannaway, Society of Fire Protection Engineers
- Gary P. Schaffer, The City of New York Law Department

- Jon Magnusson, Magnusson Klemencic Associates
- Edward A. Donoghue, National Elevator Industry, Inc.
- Thomas Young, Northwest Concrete Masonry Association
- Andrew Allsop, Arup London
- Conrad Izatt, Arup ATG
- Barbara Lane, Arup Fire
- John Lyle, Arup ATG
- Jim Quiter, Arup ATG
- Jeff Tubbs, Arup ATG
- Faith Wainwright, Arup ATG
- Shawn Bliss
- Tim Matthews, AK Productions, LLC
- Amitabha Basak, The Kuljian Corporation
- Jake Pauls, Jake Pauls Consulting Services
- Robert A. Neale, United States Fire Administration
- David May
- David J. Thomas, MSCE, P.E., Fairfax County Fire Prevention Division
- Dr. Jonathan Shimshoni, Escape Rescue Systems Ltd.
- Edwina Juillet
- Robert Elliott, Fidelity Investements Life Insurance Co.
- Genady P. Cherepanov
- Harold Sprague, Black & Veatch Special Projects Corporation
- Prof. M.Y.H Bangash
- James Quintiere, University of Maryland
- Roger Peters, Baton Rouge, LA
- Arthur Scheuerman, Ret. B.C. FDNY
- Charles Jennings, John Jay College
- Roger G. Morse AIA, Morse Zehnter Associates
- Jeri L.S. Morey, Architect
- Kim Clawson, Architect
- Paul Conant
- John G. Degenkolb, Fire Protection Engineer-Code Consultant
- John Dowling, Construction Development Manager
- Wayne Holmes, P.E., FSFPE
- Paramasivam Jayachandran
- Peter Josyph
- Wally Parker
- Randolph W. Tucker, P.E., The RJA Group
- James P. Hurst, P.E., Carl F. Baldassara, P.E., Daniel J. O'Connor, P.E.
- Tim Vellrath, P.E.
- Reijo Yli-Karjanmaa
- Alan Reiss, former dir of WTC Port Authority of NY & NJ
- Peter Szerlag
- Richard C. Schulte
- D. Alexander Floum
- Dr. F.R. Greening
- Eric Douglas
- All The Truth's Newsletter
- Nico Haupt
- Rand Fanshier
- Robert R. Grew (Retired Partner)
- Larry Dorshkind
- Sander Hicks
- Sami Yli-Karjanmaa

To: wtc@nist.gov
Cc: jim@cagley.com, daved@KU.EDU ...snip... lgriffis@walterpmoore.com
Subject: ACI Response to NIST WTC Recommendations
From: Daniel.Falconer@concrete.org

Sir/Madam,

In response to The Federal Building and Fire Safety Investigation of the World Trade Center Disaster, *Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Tower,* ACI submits the following responses for Sessions 5 (Structural Fire Response and Collapse Analysis) and 6 (Analysis of Active Fire Protection Systems, and Building & Fire Codes and Practices).

Submitted by:
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The American Concrete Institute (ACI) is a non-profit technical and educational society, dedicated to producing reliable consensus information on concrete materials and the design, behavior, construction, and repair of concrete structures. ACI commends NIST for developing this report and recommendations, and is pleased to work with NIST and others in addressing those recommendations.

General Comment: The NIST recommendations related to building design, construction practices, standards, and codes are broad in nature and will, therefore, need to be addressed by many organizations. Meeting the challenges that NIST has identified will require coordination and harmonization among various professional and technical organizations, such as ACI, ASCE, AISC, ASTM, and TMS, as well as support from practitioners and researchers in design and construction. This will likely require the formation of a coordinating body.

The following are specific responses to NIST Recommendations:

Recommendation 1: that (1) progressive collapse should be prevented in buildings through the development and nationwide adoption of consensus standards and code provisions, along with the tools and guidelines needed for their use in practice; and (2) a standard methodology should be developed—supported by analytical design tools and practical design guidance—to reliably predict the potential for complex failures in structural systems subjected to multiple hazards.

Response: Prior to the Murrah Building terrorist attack, the general issue of prevention of reinforced concrete building progressive collapse was addressed in ACI 318. Following that attack, these requirements were strengthened. When specific design criteria for prevention of progressive collapse are developed, ACI Committee 318 will develop appropriate requirements for reinforced concrete buildings.

Recommendation 3: that an appropriate criterion should be developed and implemented to enhance the performance of tall buildings by limiting how much they sway under lateral load design conditions (e.g., winds and earthquakes).

Response: ACI will ask the members of Committee 375, "Performance-Based Design of Concrete

Buildings for Wind Loads," to review and address this issue.

Recommendation 5: that the technical basis for the century-old standard for fire resistance testing of components, assemblies, and systems should be improved through a national effort. Necessary guidance also should be developed for extrapolating the results of tested assemblies to prototypical building systems.

Response: ACI's fire design recommendations and requirements rely on the results from many hundreds of fire tests, all based on the ASTM E 119 test. Substantial changes to this ASTM standard may result in the need for a fire testing program of substantial proportions. Because of a lack of existing, large scale fire testing facilities, a fire test program may require a major industry-government initiative to design and construct such facilities.

Recommendation 7: the nationwide adoption and use of the "structural frame" approach to fire resistance ratings.

Response: ACI will ask Committee 216 "Fire Resistance and Fire Protection of Structures" and Committee 318 "Structural Concrete Building Code" to review and address this issue.

Recommendation 8: that the fire resistance of structures should be enhanced by requiring a performance objective that uncontrolled building fires result in burnout without local or global collapse.

Response: ACI agrees with this goal, but research to develop reliable mathematical models is needed before implementation. Satisfying NIST Recommendation 9 is a prerequisite to satisfying this recommendation.

Recommendation 9: the development of: (1) performance-based standards and code provisions, as an alternative to current prescriptive design methods, to enable the design and retrofit of structures to resist real building fire conditions, including their ability to achieve the performance objective of burnout without structural or local floor collapse: and (2) the tools, guidelines, and test methods necessary to evaluate the fire performance of the structure as a whole system.

Response: ACI agrees with this goal. However, the ability to characterize actual building fires and their thermal impact on the elastic and inelastic behavior of concrete structures is not currently available. Development of reliable models is needed before this approach can be incorporated in building codes.

Recommendation 11: that the performance and suitability of advanced structural steel, reinforced and prestressed concrete, and other high-performance material systems should be evaluated for use under conditions expected in building fires.

Response: ACI agrees with this goal.

Recommendation 29: that continuing education curricula should be developed and programs should be implemented for training fire protection engineers and architects in structural engineering principles and design, and training structural engineers, architects, and fire protection engineers in modern fire protection principles and technologies, including fire-resistance design of structures.

Response: ACI agrees that the development of the proposed curricula would be of benefit to the industry. It is not clear, however, that we have an adequate understanding of the response of building structures under fire load.

Recommendation 30: that academic, professional short-course, and web based training materials in the use of computational fire dynamics and thermo-structural analysis tools should be developed and delivered to strengthen the base of available technical capabilities and human resources.

Response: ACI agrees with these educational goals.

Final Comment: ACI's Executive Committee affirms that NIST's recommendations in this area are valuable and worthwhile, and has created a Task Group to assure high-level cooperation. Recommendations 3 and 7 can be reviewed and addressed in the short-term, but addressing recommendations 1, 5, 8, 9, 11, 29, and 30 will depend on an increase in the current state of knowledge. The successful implementation of these recommendations will require research along with a funding source and oversight mechanism.

Subject: Comments on World Trade Center Report
To: wtc@nist.gov
From: Mike.Heimowitz@porternovelli.com

Please find attached the American Fire Safety Council's comments on the NIST report. Please contact me if you have a problem opening the attachment.

Mike Heimowitz
American Fire Safety Council
(202) 419-3251

(See attached file: NIST Comments 8-3-05.pdf)
NIST Comments 8-3-05.pdf

American Fire Safety Council
1909 K Street, N.W. • Suite 400 • Washington, D.C. 20006
Phone: 202-419-3269 • Fax: 202-955-6215

August 4, 2005

WTC Technical Information Repository
Attention: Mr. Stephen Cauffman
National Institute of Standards and Technology
Stop 8610
Gaithersburg, MD 20899-8610

Dear Mr. Cauffman:

The American Fire Safety Council (AFSC) is a non-profit organization dedicated to improving fire safety through enhancement of fire codes and standards and promoting responsible use of flame retardants and flame retardant products. AFSC's mission is to save lives and reduce injuries and property damage from fires in the United States; encourage and promote development and adoption of fire safety standards globally; and to serve as a facilitator of collaborative efforts by government, industry, fire safety groups and others to enhance and promote fire safety.

Considering our mission, AFSC welcomes the National Institute of Standards and Technology (NIST) "Final Report of the National Construction Safety Team on the Collapse of the World Trade Center Towers (Draft)." We congratulate NIST for developing this comprehensive, well-researched report and recommendations.

AFSC has reviewed the draft summary report and submits the following comments, specific to the recommendations concerning "Enhanced Fire Resistance of Structures" (Section 9.2.2), "New Methods for Fire Resistance Design of Structures," (Section 9.2.3) and "Improved Active Fire Protection" (Section 9.2.4).

AFSC is very supportive of the need for improved passive fire protection. This includes improved fire protection both for better fire resistance of building construction elements and for better reaction-to-fire performance of furnishings and contents. We firmly believe that active fire protection measures should not be used in isolation of passive fire protection, and that redundancy is always preferable to safety trade-offs.

Passive fire protection and redundancy are particularly important when dealing with occupancies where large numbers of people are potentially being exposed. Thus, high-rise buildings need to be well protected. Passive fire protection is a particularly cost-effective way of dealing with potential fire hazards. Such passive fire protection can be obtained with materials with intrinsically improved fire performance or with materials enhanced by additive or other processes to ensure compliance with the technical requirements.

AFSC believes that the present American process of consensus codes and standards development is conducive to generating good codes and good fire protection. Any failures associated with lack of code compliance should be dealt with by our legal system.

In addition, regulations, codes and standards should be designed to protect the public and the emergency responders from foreseeable problems. However, fire risk assessments should be conducted to ensure that protection measures not be required to handle unusually severe exposures, such as the September 11, 2001 terrorist attacks.

Concerning spray-applied fire resistive materials (SFRM), AFSC believes that technology exists that can be applied in such a way that the protection remains in place for the expected normal use of the construction element to which they are to be applied. This includes the use (and, if necessary, development and marketing) of sprayed fire protection systems that have the adequate adhesion capability to be effective for very long periods. Research by the materials industry should, and will, be able to present solutions to virtually any technical problem that needs to be resolved to address adequate passive fire protection.

In conclusion, AFSC applauds NIST for producing this extensive and important report and pledges to support NIST and other government agencies in finding ways to improve fire safety for the American public.

Respectfully submitted,

Mike Heimowitz

Mike Heimowitz
Program Manager
American Fire Safety Council

Subject: AIA Comments on NIST NCSTAR 1 (World Trade Center)
From: "Goldberg, Andrew" <AGoldberg@aia.org>
To: <wtc@nist.gov>
Cc: "Faucheux, Ron" <RFaucheux@aia.org ...snip... TWolfe@aia.org>, <pregrp@aol.com>

Dear Sir or Madam:

Attached are The American Institute of Architects' comments on the draft Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Towers (NIST NCSTAR 1).

If you have any questions, please do not hesitate to contact me at the phone number or email address below.

Sincerely,

Andrew Goldberg, Assoc. AIA
Manager, Federal Regulatory Activities
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AIAResponse.Final.dot

The American Institute of Architects

The World Trade Center Investigation

The AIA's Response to NIST's Draft Report and Recommendations

August 4, 2005

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Contents

Introduction

The American Institute of Architects represents more than 75,000 licensed architects, emerging professionals, and allied partners who are fully committed to the highest professional standards in the design of the nation's built environment. As the AIA's public policies state, "Architecture profoundly affects people. The work of architects is essential to human well being, and architects must embrace their ethical obligation to uphold this public trust."

The AIA and its members welcome the opportunity to provide public comments on the *Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Towers* (NIST NCSTAR 1). In June, the AIA invited its members to provide input to the Institute about the draft report and recommendations. These comments reflect the views expressed by the AIA's members.

The AIA intends to continue this dialogue with the architecture community and allied professions over the coming weeks and months, and will provide additional commentary to NIST about its report and recommendations.

The AIA cannot overstate the accomplishments of the NIST investigating team and the substantial body of information they gathered and organized in response to one of the worst catastrophes in American history. The results are a definitive historical record of the largest and most devastating building disaster ever. The AIA was honored to participate in this process by having one of its members serve on the National Construction Safety Team Advisory Committee.

Recognizing the superior design and performance of the twin towers during an unprecedented terrorist attack, the data that the investigating team compiled should not only help identify deficiencies but also serve as a testament to the buildings' ability to stand long enough after the attack to allow thousands of occupants to evacuate.

We owe it to the victims of the September 11 attacks, and to the millions of Americans who use buildings every day, to ensure that our built environment is safe, and that any changes to how we design and construct buildings come about as the result of an open, deliberative and rational building code and regulation development process.

General Issues

The Investigation: Demonstrating the Robustness of the Towers

On September 11, 2001, the World Trade Center towers were subjected to an almost unimaginable attack from hijacked, fuel-laden 767s flying at such high speeds that one of the jets nearly broke apart in midair. Following its Congressional authorization to investigate the circumstances that contributed to the towers' collapse, NIST lauds the success of the design, construction and materials for their exceptional performance. The report finds that the buildings would have survived the catastrophic event were it not for the fact that the aircraft caused extensive damage to the buildings and their fire protective systems (both passive and active), and ignited extensive fires that were limited only by the amount of combustible material they could reach.

The report presents, in its Executive Summary, the following findings regarding the design, construction and materials of the towers:

1. *...the towers withstood the impacts and would have remained standing were it not for the dislodged insulation (fireproofing) and the subsequent multifloor fires. The robustness of the perimeter frame-tube system and the large size of the buildings helped the towers withstand the impact. The structural system redistributed loads without collapsing in places of aircraft impact, avoiding larger scale damage upon impact.*

2. *The WTC towers likely would not have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact.*

3. *Since the flow of people from the building had slowed considerably 20 min* [sic] *before the tower* [WTC 1] *collapsed, the stairwell capacity was adequate to evacuate the occupants on that morning.*

4. *As in WTC 1, shortly before collapse, the flow of people from the building* [WTC 2] *had slowed considerably, indicating that the stairwell capacity was adequate that morning.*

5. *The fire safety systems (sprinklers, smoke purge, and fire alarms,) were*

designed to meet or exceed current practice.

6. *For the approximately 1,000 emergency responders on the scene, this was the largest disaster they had even seen. Despite attempts by the responding agencies to work together and perform their own tasks, the extent of the incident was well beyond their capabilities.*

7. *... the actual design and approval process produced two buildings that generally were consistent with nearly all of the provisions of the New York City Building Code and other building codes of the time. The loads for which the buildings were designed exceeded the code requirements. The quality of the structural steels was consistent with the building specifications. The departures from the building codes and standards did not have a significant effect on the outcome of September 11.*

8. *On September 11, 2001, the minimum specified thickness of the insulation was adequate to delay heating of the trusses; the amount of insulation dislodged by the aircraft impact, however, was sufficient to cause the structural steel to be heated to critical levels*

9. *.... in all cases* [during NIST's testing of fire rated assemblies], *the floors continued to support the full design load without collapse for over 2 hours.*

10. *The wind loads used for the WTC towers, which governed the structural design of the external columns and provided the baseline capacity of the structures to withstand abnormal events such as major fires or impact damage, significantly exceeded the requirements of the New York City Building Code and selected other building codes of the day.*

The North Tower. The first account of the performance of World Trade Center 1(the north tower) is found in Chapter 2 of NIST's final report. Following a detailed description of the extent of damage, the report states, "Even with all this damage, the building still stood." Ignition of the building contents by the explosion of 10,000 gallons of jet fuel is addressed in the account of WTC 1, which finds that the ignition of the contents of the building and airplane caused a fuel-controlled fire, creating an exposure that is not typical of any condition that is considered when designing buildings.

The report finds that the aircraft impact virtually destroyed the fire protection systems. The report states that the system was designed to supply water to about eight sprinkler heads at one time, enough to control the flames from as much as 1,500 square feet of burning material. The water supply was likely sufficient to control fires up to triple that size. However, the fires caused by the aircraft impact were far larger than those envisioned by any imaginable fire protection system.

The South Tower. World Trade Center 2 (the south tower) was subjected to a similar event, but faced a number of factors that were distinct from WTC 1. Those factors resulted in a larger overall fraction of the occupants surviving, despite the fact that WTC 2 collapsed in a shorter period of time. According to the report, within five minutes of the impact on WTC 1, half of the occupants of WTC 2 had left their floors, and the number of evacuees subsequently increased rapidly. Based on their perception of events occurring in WTC 1, approximately 3,000 people in WTC 2 escaped in the 16 minutes between the aircraft impact on WTC 1 and the impact on WTC 2.

The report goes on to state that WTC 2 "swayed more than one foot back and forth in each direction on the impact floors, about one-third the sway under the high winds for which the building was designed." Nonetheless, just like WTC 1, WTC 2 absorbed the aircraft strike and remained standing for nearly an hour. Similar to the circumstances of WTC 1, jet fuel played a critical role in providing an extraordinary ignition source to the fuel load in WTC 2, contributing to the ultimate failure of the structural system.

The World Trade Center collapse provided the design and construction industry with an opportunity to evaluate and reexamine its processes and practices. Based upon the outstanding success of these buildings under extraordinary circumstances, it is clear that the design community can be trusted to create redundancies for typical building emergency situations, that codes are developed in a manner that provides sufficient input from all quarters to ensure adequate life safety for typical emergency situations, and that no upgrading of code requirements is warranted given the performance of these buildings.

The Recommendations: Missed Opportunities

Although the report provides significant information regarding the performance of the buildings, their occupants and the extraordinary efforts of the responding emergency personnel, the AIA believes that a number of the recommendations in the report are not supported by the findings of the investigation. Other recommendations suggest reforms that have already been addressed by the design and construction industry or the model code organizations.

At the same time, the AIA believes that the report misses opportunities to make recommendations that would improve the understanding of how buildings perform in extreme events. Developing that understanding in order to protect building occupants must be a fundamental mission of all organizations that work to create a better built environment.

One such area is fire testing. NIST developed advanced fire modeling techniques to evaluate the complex circumstances at the World Trade Center, examining the spread of fire and its impact on structural members. This may become an important tool for designing safer buildings, although their ability to integrate known conditions into the modeling currently used in the marketplace was a major problem even for NIST when it evaluated the 2003 fire at the Station nightclub in Rhode Island.

The AIA believes that improved fire testing is a vital need, and opportunity, that must not be ignored. The Institute is therefore troubled by the fact that there are no test facilities in the United States that can accommodate the larger lengths or sizes of elements such as those found in the twin towers. If the federal government is truly committed to understanding the effects of such fire hazards on the built environment, it is critical that it provide for adequate testing facilities at home.

<u>The AIA strongly encourages NIST to recommend that funding be authorized and appropriated to construct new testing facilities or retrofit existing facilities that can address the full range of building conditions present in the United States.</u>

In addition, NIST should be encouraged to take advantage of its position as the preeminent research facility in the United States to examine innovative materials and processes and assure that they meet the most rigorous of standards appropriate for their use. Performance codes, which the AIA believes are the future direction for building codes and regulations, are sorely in need of supporting information on the actual performance of buildings and building systems. Without this data, designers are left to make assumptions based on limited resources.

Furthermore, the AIA believes that NIST should facilitate opportunities to develop "smart" building systems that would better advise first responders of actual building conditions and situations. The current efforts to improve the use of elevators in an emergency are an example of the dramatic changes that will take place to the guidance provided to building occupants.

Building Codes: An Accountable and Comprehensive System

The major finding of the NIST report is that the design and construction materials of the World Trade Center did not contribute to the disaster; they performed exceptionally well. Despite this fact, the report offers several recommendations that are not supported by the investigation, nor are they backed by substantive research. In fact, the premises of some of the statements appear to be in error.

For example, in section 9.1 ("Building Standards and Codes: Who is in Charge?"), the report states, "Very few members of the general public and building occupants participate in [the code development] process." Although this is true of most standards development groups, including NFPA and IAPMO, it is not true for the International Code Council's family of codes. State and local code enforcement officials (building, fire, plumbing, electrical, etc.) are a driving force behind code changes and have the controlling votes on all changes to ICC's codes. These officials are public officials who represent their states, counties and cities, and do not fall within any of the categories that NIST lists as "influencing the practices used in the design, construction, operation, and maintenance of buildings in the United States."

The code enforcement community has been extraordinarily aggressive in pursuing education and certification for their members. Many states and local jurisdictions have worked diligently to assure the credibility of their enforcement programs by requiring certification of training obtained by their code enforcement officials.

The question of "who is in charge" regarding the development and application of codes and standards is well established and recognized by 45 states as the code official using the *International Building Code,* and in 36 states as the code official using the *International Fire Code.*

<u>The AIA believes that state and local governments must retain the authority to determine appropriate building regulations.</u> The AIA does not agree that the federal government is in a position to supplant the voice or the rights of local and state jurisdictions by presuming to speak for the public that is given the constitutional authority through police powers to determine what is appropriate for building regulation in their communities.

The fundamental challenge regarding codes and life safety today is the lack of an understanding or an appreciation by users of the safety features designed and built into modern buildings. This includes building owners, managers, tenants and service providers who often unintentionally subvert life safety features out of ignorance about how they work. This was most evident in the Rhode Island nightclub tragedy, where modifications that were made to the interior of the building and the use of pyrophoric materials in the facility were both major violations of the applicable codes. Had the owner or the user of the space been more knowledgeable about the potential hazards associated with such actions, that disaster would likely have been averted.

Recommendations and Responses

The report states that NIST's recommendations (Section 9.2) are based on:

1. Findings related to building performance, evacuation and emergency response, and to procedures and practices used in the design, construction, operation, and maintenance of the buildings;

2. Whether these findings relate to the unique circumstances surrounding the terrorist attacks of September 11, 2001, or to normal building and fire safety considerations (including evacuation and emergency response);

3. Technical solutions that are needed to address potential risks to buildings, occupants, and emergency responders, considering both identifiable hazards and the consequences of those hazards; and

4. Whether the risks apply to all buildings or are limited to certain building types (e.g., buildings that exceed a certain height and floor area or that employ a specific type of structural system), buildings that contain specific design features, iconic/signature buildings, or buildings that house critical functions.

NIST's recommendations are broken down into eight groups. The AIA's comments follow each recommendation.

Group 1: Increased Structural Integrity

Group 1 (Increased Structural Integrity) calls for improved standards to enhance structural integrity for estimating load effects of progressive collapse and wind.

Recommendation 1. *NIST recommends that: (1) progressive collapse should be prevented in buildings through the development and nationwide adoption of consensus standards and code provisions, along with the tools and guidelines needed for their use in practice; and (2) a standard methodology should be developed—supported by analytical design tools and practical design guidance—to reliably predict the potential for complex failures in structural systems subjected to multiple hazards.*

Recommendation 2. *NIST recommends that nationally accepted performance standards be developed for: (1) conducting wind tunnel testing* *of prototype structures based on sound technical methods that result in repeatable and reproducible results among testing laboratories; and (2) estimating wind loads and their effects on tall buildings for use in design, based on wind tunnel testing data and directional wind speed data.*

Recommendation 3. *NIST recommends that an appropriate criterion should be developed and implemented to enhance the performance of tall buildings by limiting how much they sway under lateral load design conditions (e.g., winds and earthquakes).*

AIA Response

It should be noted that nothing in the NIST report criticizes nor questions the structural integrity of the World Trade Center towers and their design. In fact, the report finds that the buildings were more robust than would have been required by any code in force at the time they were designed and constructed. NIST's report focuses on the varying results they received when different consultants examined the buildings' wind design. It is the lack of a consensus method for evaluating buildings that NIST's recommendations address, not providing additional requirements for the design of structures.

A recent article by Jesse Beitel and Nestor Iwankiw, Ph.D., P.E., from Hughes Associates, Inc., in SFPE's *Fire Protection Engineering* (Summer 2005) documents a "Historical Survey of Multistory Building Collapses Due to Fire." The data in the article was taken from a NIST survey performed in 2002 that focused on buildings four or more stories tall. The survey covered the time period between 1970 and 2002 and discovered a total of 22 buildings that had either full or partial collapse. The article states, "While the number of fire events may appear low (average of one per year), these fire events are high-consequence occurrences with respect to loss of life, injuries, and economic costs." When examining those statistics, five of the fire events were the result of the September 11 attacks, and 13 of the buildings were four to eight stories tall. There were only three "high-rise" buildings that involved any collapse scenario.

The Beitel/Iwankiw article states:

> Almost 60 percent (13/22) of the cases are in the 4-8 stories range, with the remainder affecting much taller buildings. Six collapses occurred in buildings over 20 stories, and three of these were the WTC steel-framed buildings (1, 2, and 7). At least four of these fire collapses had occurred during construction or renovations of some kind, when the usual expected architectural, structural and fire protection functions were still incomplete or temporarily disrupted.

It is common knowledge that a construction site is an unsafe and dangerous environment. Additionally, the research for this study does not include any information determining whether the buildings conformed to any code or standard. Based on NIST's own study, it appears that the recommendation to increase structural integrity is due to fire events in a total of four collapsed structures four stories or taller over a 32-year period. Assuming that one of the collapses is the Murrah Federal Building in Oklahoma City, Oklahoma, in which the collapse was the result of a vehicle-borne explosive, this leaves a total of three such fire events worldwide that resulted in collapse or partial collapse of a high-rise building.

Group 2: Enhanced Fire Resistance of Structures

Group 2 (Enhanced Fire Resistance of Structures) recommends that the procedures and practices used to ensure that the basis for classification of fire resistance in buildings should be enhanced.

Recommendation 4. *NIST recommends evaluating, and where needed improving, the technical basis for determining appropriate construction classification and fire rating requirements (especially for tall buildings greater than 20 stories in height)—and making related code changes now as much as possible—by explicitly considering factors including:*

- *timely access by emergency responders and full evacuation of occupants, or the time required for burnout without local collapse;*
- *the extent to which redundancy in active fire protection (sprinkler and standpipe, fire alarm, and smoke management) systems should be credited for occupant life safety;*
- *the need for redundancy in fire protection systems that are critical to structural integrity;*
- *the ability of the structure and local floor systems to withstand a maximum credible fire scenario without collapse, recognizing that sprinklers could be compromised, not operational, or non-existent;*
- *compartmentation requirements (e.g., 12,000 ft^2) to protect the structure, including fire rated doors and automatic enclosures, and limiting air supply (e.g., thermally resistant window assemblies) to retard fire spread in buildings with large, open floor plans;*
- *the impact of spaces containing unusually large fuel concentrations for the expected occupancy of the building; and*
- *the extent to which fire control systems, including suppression by automatic or manual means, should be credited as part of the prevention of fire spread.*

Recommendation 5. *NIST recommends that the technical basis for the century-old standard for fire resistance testing of components, assemblies, and systems should be improved through a national effort. Necessary guidance also should be developed for extrapolating the results of tested assemblies to prototypical building systems.*

Recommendation 6. *NIST recommends the development of criteria, test methods, and standards: (1) for the in-service performance of spray-applied fire resistive materials (SFRM, also commonly referred to as fireproofing or insulation) used to protect structural components; and (2) to ensure that these materials, as-installed, conform to conditions in tests used to establish the fire resistance rating of components, assemblies, and systems.*

Recommendation 7. *NIST recommends the nationwide adoption and use of the "structural frame" approach to fire resistance ratings.*

AIA Response

Enhanced fire resistance was not an issue in the World Trade Center collapse, as the buildings would have survived even the massive fires caused by the aircraft had the planes not dislodged fire proofing materials.

Recommendation 4 implies that structures should be designed for an aircraft impact, which does not comport with NIST's findings. In fact, the lead investigator for NIST has stated that it is far easier to ensure that airplanes are not used as weapons against buildings than to design for such an event. As noted earlier, the instances of structural failure due to fire are extremely rare and, in a fully sprinklered building, even rarer. These facts do not indicate a need for enhanced levels of fire resistance in building design.

One of the concerns expressed with regard to construction methods involves the application of spray-on fireproofing. This debate is not new and has been well documented. It is of concern that, with such a large focus in the report on the fire resistance of materials used in the buildings, there is no mention of the appropriateness of test standards such as **ASTM E605-00** (*Test Method for Thickness and Density of Sprayed Fire-resistive Material (SFRM) Applied to Structural Members) and* **ASTM E736** (*Cohesion/Adhesion of Sprayed Fire-Resistive Materials Applied to Structural Members)*, both of which are referenced in the *International Building Code*, and thus presumably "required by code" and enforced.

Similarly lacking is reference to, or a measure of the appropriateness of, **ASTM E759** (*Effect of Deflection on Sprayed Fire-Resistive Materials Applied to Structural Members)*, **ASTM E760** (*Effect of Impact on Bonding of Sprayed Fire-Resistive Materials Applied to Structural Members)*, **ASTM E761** (*Compressive Strength of Sprayed Fire-Resistive Materials Applied to Structural Members)*, **ASTM E859** (*Air Erosion of Sprayed Fire-Resistive Materials Applied to Structural Members)*, or **ASTM E937** (*Corrosion of Steel by Sprayed Fire-Resistive Materials Applied to Structural Members)*.

In recommendation 5, NIST suggests reevaluation of the ASTM E119 procedure. The AIA believes that a better approach would be to take the research performed by NIST using recognized testing procedures to explore how the large-scale testing compares with results obtained using small-scale tests. The fact that the unrestrained assembly outperformed the restrained assembly is still unexplained. It appears that design is still taking place under the assumption that a restrained assembly will outperform an unrestrained assembly.

NIST specifically refers to the AIA in recommendation 6, suggesting that it is important "to develop criteria, test methods and standards for the 'in-service' performance of spray-applied fire resistive materials." NIST suggests that MasterSpec is the appropriate forum for such activity. Architects in general, and MasterSpec in particular, do not have that sole responsibility establishing such standards. Other agencies or organizations develop standards, which are then included in MasterSpec where appropriate as requirements for the construction of buildings. Architects and specifiers often participate in the development of standards, which is appropriate to assure the applicability of the resulting standards. But it is the collaborative development of standards that should be encouraged. With the lack of specific direction on the use of the standards that even now are found in building codes, it is unclear what NIST is recommending be done.

Lastly, recommendation 6 suggests adoption of a structural frame approach to design throughout the United States. However, the requirement for design of a structural frame has already been accomplished by the adoption of the *International Building Code* in 45 states.

Group 3: New Methods for Fire Resistance Design of Structures

Group 3 (New Methods for Fire Resistance Design of Structures) recommends that procedures used to design the fire resistance should be enhanced by considering uncontrolled fires to burnout. This recommendation suggests that new coatings and technology for evaluating them be developed to enhance conventional and high-performance structural materials.

Recommendation 8. *NIST recommends that the fire resistance of structures should be enhanced by requiring a performance objective that uncontrolled building fires result in burnout without local or global collapse.*

Recommendation 9. *NIST recommends the development of: (1) performance-based standards and code provisions, as an alternative to current prescriptive design methods, to enable the design and retrofit of structures to resist real building fire conditions, including their ability to achieve the performance objective of burnout without structural or local floor collapse: and (2) the tools, guidelines, and test methods necessary to evaluate the fire performance of the structure as a whole system.*

Recommendation 10. *NIST recommends the development and evaluation of new fire resistive coating materials, systems, and technologies with significantly enhanced performance and durability to provide protection* *following major events.*

Recommendation 11. *NIST recommends that the performance and suitability of advanced structural steel, reinforced and pre-stressed concrete, and other high-performance material systems should be evaluated for use under conditions expected in building fires.*

AIA Response

Recommendation 8 suggests consideration of designing to allow "uncontrolled fires to burnout." Such circumstances may be a consideration, but are not appropriate in most circumstances. Even where there have been uncontrolled fires that caused a "burnout," there is no evidence that current procedures are inadequate. In the article by Beitel and Iwankiw, which uses NIST data, the rationale is not present to warrant such a major change in building code requirements.

Recommendation 9 reflects actions taken by both the ICC and the NFPA in the development of performance code criteria. What is currently lacking are the tools and background information on responses of buildings and the performance of the elements within them for any given event. The AIA believes that NIST could provide a significant resource to the industry by examining actual fire scenarios more closely and developing guidelines for understanding such events. With that kind of data available, designers would be able to utilize a performance approach to building safety that is informed by real world evidence.

The AIA questions the logic behind recommendations 10 and 11. The report frequently expresses doubt about "innovative" design materials and methods in its evaluation of the floor truss systems in the World Trade Center. Yet those innovative floor framing systems performed as anticipated and were proven to be adequate based on the tests that NIST performed. Industry will continuously develop innovative materials and systems, and the AIA believes that NIST can and should play a vital role in encouraging them by facilitating more realistic testing that would replicate actual construction.

Group 4 (Improved Active Fire Protection) calls for enhancements to sprinklers, standpipes, hoses, fire alarms and smoke management systems, including redundancy.

Group 4: Improved Active Fire Protection

Recommendation 12. *NIST recommends that the performance and redundancy of active fire protection systems (sprinklers, standpipes/hoses, fire alarms, and smoke management systems) in buildings should be enhanced to accommodate the greater risks associated with increasing building height and population, increased use of open spaces, available compartmentation, high-risk building activities, fire department response limits, transient fuel loads, and higher threat profile.*

***Recommendation 13.** NIST recommends that fire alarm and communications systems in buildings should be developed to provide continuous, reliable, and accurate information on the status of life safety conditions at a level of detail sufficient to manage the evacuation process in building fire emergencies, and that standards for their performance be developed.*

***Recommendation 14.** NIST recommends that control panels at fire/emergency command stations in buildings should be adapted to accept and interpret a larger quantity of more reliable information from the active fire protection systems that provide tactical decision aids to fireground commanders, including water flow rates from pressure and flow measurement devices, and that standards for their performance be developed.*

***Recommendation 15.** NIST recommends that systems should be developed and implemented for: (1) real-time off-site secure transmission of valuable information from fire alarm and other monitored building systems for use by emergency responders, at any location, to enhance situational awareness and response decisions and maintain safe and efficient operations; and (2) preservation of that information either off-site or in a black box that will survive a fire or other building failure for purposes of subsequent investigations and analysis. Standards for the performance of such systems should be developed, and their use should be required.*

AIA Response

NIST's concerns about the redundancy of active and passive fire protective systems are valid in circumstances where *all* such systems may be rendered ineffective or inoperative. However, such circumstances are extremely rare, as was the case in the unprecedented aircraft attack on the World Trade Center. The *ICC Performance Code for Buildings and Facilities*, NFPA's 101 *Life Safety Code* and 5000 *Building Code* already include this approach to fire protection design in their performance guidelines. Although the World Trade Center was not designed for such complex circumstances, it nevertheless performed remarkably well.

Recommendations 13, 14, and 15 include opportunities for significant improvement in the performance of fire protection systems by installing smart building devices. Where there is a reasonable risk of natural or manmade hazards to a particular structure, every effort should be taken to ensure the security of the facilities and protection of the occupants.

Group 5 (Improved Building Evacuation) addresses communications systems and the design of means of egress.

***Recommendation 16.** NIST recommends that public agencies, non-profit organizations concerned with building and fire safety, and building owners*

Group 5: Improved Building Evacuation

and managers should develop and carry out public education campaigns, jointly and on a nationwide scale, to improve building occupants' preparedness for evacuation in case of building emergencies.

Recommendation 17. *NIST recommends that tall buildings should be designed to accommodate timely full building evacuation of occupants due to building-specific or large-scale emergencies such as widespread power outages, major earthquakes, tornadoes, hurricanes without sufficient advanced warning, fires, accidental explosions, and terrorist attack. Building size, population, function, and iconic status should be taken into account in designing the egress system. Stairwell and exit capacity should be adequate to accommodate counterflow due to emergency access by responders.*

Recommendation 18. *NIST recommends that egress systems should be designed: (1) to maximize remoteness of egress components (i.e., stairs, elevators, exits) without negatively impacting the average travel distance; (2) to maintain their functional integrity and survivability under foreseeable building-specific or large-scale emergencies; and (3) with consistent layouts, standard signage, and guidance so that systems become intuitive and obvious to building occupants during evacuations.*

Recommendation 19. *NIST recommends that building owners, managers, and emergency responders develop a joint plan and take steps to ensure that accurate emergency information is communicated in a timely manner to enhance the situational awareness of building occupants and emergency responders affected by an event. This should be accomplished through better coordination of information among different emergency responder groups, efficient sharing of that information among building occupants and emergency responders, more robust design of emergency public address systems, improved emergency responder communication systems, and use of the Emergency Broadcast System (now known as the Integrated Public Alert and Warning System) and Community Emergency Alert Networks.*

Recommendation 20. *NIST recommends that the full range of current and next generation evacuation technologies should be evaluated for future use, including protected/hardened elevators, exterior escape devices, and stairwell navigation devices, which may allow all occupants an equal opportunity for evacuation and facilitate emergency response access.*

AIA Response

Recommendation 16, though well intentioned, misses a key element of building safety. While ensuring proper egress during an emergency is important, too many building owners, managers and occupiers fail to prepare for emergencies before the fact. Examples of malfunctioning or failed systems (such as burned out exit sign lights or fire doors that are blocked by furniture or boxes) are routine, leaving occupants in jeopardy. It is therefore just as important to educate users about maintaining the many life safety elements in a building so that they are functioning as designed when an emergency happens.

Recommendation 17 suggests wider stairwells and greater exit capacity to accommodate regarding counter-flow from first responders. This raises a concern about orderly and controlled egress. No research is cited regarding the effect wider stairs may have, or the possibility that evacuating occupants will simply fill the larger stairwell. Faster-moving individuals will tend to pass slower people descending the stairs, potentially leading to conflict and disruption of an orderly egress process.

Regarding the distribution of exits, the current model codes address the minimum remoteness issue. Had the stairs been more remote from each other at the World Trade Center there is no guarantee that even hardened stair enclosures would not have been totally incapacitated had the aircraft impacted the buildings at or near the more remote stair. Placing stairs further outside the core of buildings reduces their level of hardening and leaves them more vulnerable to abuse by the occupants of the building.

Recommendation 20 calls for hardening of elevators and stairway enclosures as well as additional devices that aid egress. Unfortunately, the hardening issue can be a catch-22. Although hardening may help in maintaining an element's viability in certain emergency situations, the hardened features may be difficult for occupants to manage if they are damaged. Reports have emerged about individuals caught inside elevators at the twin towers who used various devices to escape by cutting their way through the drywall shaft. Would that have been possible in a hardened shaft? Furthermore, the occupants who discovered the single stair that remained partially open to the upper floors in WTC 2 would not have been able to remove "hardened" debris and egress those stairs.

Technology for aids to egress are encouraged. However the most promising development to assist egress in a tall building is a functioning elevator system, as proven in WTC 2.

Group 6: Improved Emergency

Group 6 (Improved Emergency Response) recommends technical and procedural changes to gain access to buildings and maintain effective communications and command and control in large-scale emergencies

Recommendation 21. *NIST recommends the installation of fire-protected and structurally hardened elevators to improve emergency response activities in tall buildings by providing timely emergency access to responders and allowing evacuation of mobility-impaired building occupants. Such elevators should be installed for exclusive use by emergency responders during emergencies. In tall buildings, consideration also should be given to*

Response

installing such elevators for use by all occupants.

Recommendation 22. *NIST recommends the installation, inspection, and testing of emergency communications systems, radio communications, and associated operating protocols to ensure that the systems and protocols: (1) are effective for large-scale emergencies in buildings with challenging radio frequency propagation environments; and (2) can be used to identify, locate, and track emergency responders within indoor building environments and in the field.*

Recommendation 23. *NIST recommends the establishment and implementation of detailed procedures and methods for gathering, processing, and delivering critical information through integration of relevant voice, video, graphical, and written data to enhance the situational awareness of all emergency responders. An information intelligence sector should be established to coordinate the effort for each incident.*

Recommendation 24. *NIST recommends the establishment and implementation of codes and protocols for ensuring effective and uninterrupted operation of the command and control system for large-scale building emergencies.*

Recommendation 21 largely duplicates recommendation 20. Existing elevator technology recalls all elevators for emergency use. Whether hardening is appropriate is a serious question; it has not been proven to be appropriate or even desirable in those locations where it has been attempted.

AIA Response

Group 7 (Improved Procedures and Practices) addresses code compliance by nongovernmental agencies, adoption of egress and sprinkler requirements in codes for existing buildings and maintenance of building documents over the life of the structure.

Group 7: Improved Procedures and Practices

Recommendation 25. *Nongovernmental and quasi-governmental entities that own or lease buildings and are not subject to building and fire safety code requirements of any governmental jurisdiction are nevertheless concerned about the safety of the building occupants and the responding emergency personnel. NIST recommends that such entities should be encouraged to provide a level of safety that equals or exceeds the level of safety that would be provided by strict compliance with the code requirements of an appropriate governmental jurisdiction. To gain broad public confidence in the safety of such buildings, NIST further recommends that it is important that as-designed and as-built safety be certified by a qualified third party, independent of the building owner(s). The process should not use self-approval for code enforcement in areas including interpretation of code provisions, design approval, product acceptance,* *certification of the final construction, and post-occupancy inspections over the life of the buildings.*

Recommendation 26. *NIST recommends that state and local jurisdictions should adopt and aggressively enforce available provisions in building codes to ensure that egress and sprinkler requirements are met by existing buildings. Further, occupancy requirements should be modified where needed (such as when there are assembly use spaces within an office building) to meet the requirements in model building codes.*

Recommendation 27. *NIST recommends that building codes should incorporate a provision that requires building owners to retain documents, including supporting calculations and test data, related to building design, construction, maintenance and modifications over the entire life of the building. Means should be developed for offsite storage and maintenance of the documents. In addition, NIST recommends that relevant building information should be made available in suitably designed hard copy or electronic format for use by emergency responders. Such information should be easily accessible by responders during emergencies.*

Recommendation 28. *NIST recommend that the role of the "Design Professional in Responsible Charge" should be clarified to ensure that: (1) all appropriate design professionals (including, e.g., the fire protection engineer) are part of the design team providing the standard of care when designing buildings employing innovative or unusual fire safety systems, and (2) all appropriate design professionals (including, e.g., the structural engineer and the fire protection engineer) are part of the design team providing the standard of care when designing the structure to resist fires, in buildings that employ innovative or unusual structural and fire safety systems.*

AIA Response

Recommendations 25 and 26 call for the adoption and use of codes. The AIA has long advocated that every jurisdiction in the nation, at all levels of government, to use a modern building code that is comprehensive, coordinated and contemporary. The AIA believes that the ICC family of codes, in conjunction with the NFPA electrical code, provide the "bookshelf" of codes that should be endorsed by all legislative and quasi-legislative agencies for application on all projects. Adoption of a single "bookshelf" of codes utilized by all designers, builders and operators of buildings across the nation has been a long sought goal of the AIA to avoid confusion in the creation of the built environment.

Recommendation 28 calls for the "design professional in responsible charge" to assure that the appropriate professionals are included on each design team. This is, and has been for a long time, standard practice in this country and is demanded by the licensing criteria in all states. There appears to be a presumption that fire protection engineers and structural engineers are somehow excluded from "innovative or unusual fire safety systems." It is most likely that these designers are the ones who are proposing innovative solutions to innovative designs. It would be unethical and unprofessional to fail to include a fire protection engineer or structural engineer in such projects.

Group 8: Education and Training

Group 8 (Education and Training) calls for the skills of building and fire professionals to be upgraded through education and training of fire protection engineers, structural engineers, and architects

Recommendation 29. *NIST recommends that continuing education curricula should be developed and programs should be implemented for training fire protection engineers and architects in structural engineering principles and design, and training structural engineers, architects, and fire protection engineers in modern fire protection principles and technologies, including fire-resistance design of structures.*

Recommendation 30. *NIST recommends that academic, professional short-course, and web-based training materials in the use of computational fire dynamics and thermostructural analysis tools should be developed and delivered to strengthen the base of available technical capabilities and human resources.*

AIA Response

Recommendations 29 and 30 call for education of members of the design and construction industry. As the only professional organization in the industry that holds its members to a standard of education (accredited degrees) and continuing education (18 hours of continuing education per year, of which at least eight must be related to health, safety and welfare), the AIA applauds NIST's call to others in the field to gain additional education.

However, education is only valuable if the information is readily understood and can be incorporated into every-day practice. While computational fire dynamics and thermostructural analysis tools may be helpful in certain circumstances, they must be of use to those that will make the decisions associated with fire resistance and fire protection and design.

Conclusion

NIST has undertaken an extraordinary effort to investigate and understand the consequences of the most devastating terrorist attack in our nation's history. It should be reassuring to the public that the report concludes that World Trade Center towers were well within the contemporary norms of design and construction, and that the buildings were able to stand long enough to allow thousands of people to escape.

But the terrible loss of life that day demands that we study the results of this investigation closely to learn what the design and construction professions have done right, and where improvements can be made to better protect people in buildings.

The recommendations in the NIST report are useful guidelines towards that end. However, the AIA believes that at times the recommendations overlook measures and technologies that are already in practice, or go in directions that are not supported by either the investigation or scientific research.

The need to protect the health, safety and welfare of people who use buildings is not a subject of debate. This is why the AIA requires its members to adhere to the highest professional standards and take at least eight hours of health, safety and welfare continuing education classes each and every year throughout their careers in order to remain members in good standing.

The NIST report and recommendations raise powerful issues about how best to achieve building safety and security. The AIA encourages NIST to further investigate areas such as actual building occupant loads and develop data on actual building performance through additional testing of full-sized components. NIST provides an ideal platform to investigate and report fairly these issues. However, it will be necessary to gather much more data to verify any change in the direction of model building codes. The AIA continues to believe that the best way to ensure that building codes protect the public is to ensure that model codes are developed through an open, consensus based process.

The AIA commends NIST for making education a focus of its efforts. The AIA encourages the design and construction industry, and everyone who uses buildings, to take advantage of opportunities to gain a greater understanding of how buildings affect our lives and our communities.

From: "Tim Matthews" <tim@akproductions.com>
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Subject: Comments on Report NIST NCSTAR 1, WTC Investigation

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Report Number: NIST NCSTAR 1, WTC Investigation

General Comments - The primary focus of the findings and recommendations of the NIST with regards to the WTC investigation revolves around building design, construction, and operation. While these are critical areas of focus, for this report to truly be effective in saving lives, these findings must also include in depth and comprehensive recommendations regarding **tenant** life safety training.

Many of the study's findings can effect improvements on future construction. However, the one recommendation that would have the greatest impact on the thousands of existing buildings across the nation would be establishing a national standard for tenant training in high rise office buildings. Currently, the FDNY is preparing a final draft of 'Rule 3 RCNY 6-02' that will require all office buildings in NY to develop non-fire Emergency Action Plans. This rule requires building owners to educate building occupants on the emergency procedures contained in the plan. The NIST study is an excellent forum for determining a national standard on tenant training, but the education of building occupants continues to be overlooked throughout the industry, and is primarily overlooked in this report, as the training recommendations section 9.2.8 focuses on building and fire safety professionals only.

While it seems very reasonable that tenant education must be a key focus of any national standard attempting to improve the level of safety in tall office buildings, this study has not made this critical area of life safety training and risk management a top priority.

Please consider the following facts from **Section 8.4.2, pg. 238**:

• Two-thirds of WTC 1 and WTC 2 occupants participated in at least one fire drill in the twelve months prior to September 11, 2001. Nearly all (93 percent) of these occupants were **instructed** about the location of the nearest stairwell.

• Occupants were often unprepared to encounter transfer hallways during the stairwell descent. Groups of evacuees occasionally hesitated or debated a course of action upon encountering a transfer hallway.

Tenant education, including the distribution of building information, emergency procedures for a variety of scenarios, and education on the location of multiple exit stairwells are a few of the critical elements that must be included in a comprehensive tenant education program. Emergency procedures brochures, building diagrams, online training programs, and drills are a few of the tools that can be used to educate building occupants.

Report Number: NIST NCSTAR 1
Page Number: Section 9.2.8 - Education and Training - pg 272
Paragraph/Sentence: Sentence one, opening paragraph
Comment: The education and training recommendations need to include a section addressing tenants and building occupants AND focus on more than just building evacuation. For many emergencies, evacuation is not the proper action. However, evacuation is the only training activity mentioned in this report.
Reason For Comment: This section recommends a national training effort for building and fire safety professionals, but ignores the necessity for a national training and education initiative designed for the thousands of building occupants in office buildings.
Suggestion For Revision: Addition of a second sentence to the opening paragraph. **"Furthermore, a national training and education effort shall be initiated to better train the occupants of tall office buildings on the correct response in emergency situations."**

Report Number: NIST NCSTAR 1
Page Number: Section 9.2.8 - Education and Training - pg 272

Paragraph/Sentence: Addition of Recommendation 31
Comment: Tenant training and education is currently not included in the **Education and Training** recommendation section.
Reason For Comment: The fastest way to help save lives in the thousands of existing high rise office buildings is to implement a tenant training and education program.
Suggestion For Revision: Recommendation 31. NIST recommends that a national education and training initiative be created to teach the tenants of office buildings the correct response to a variety of emergency scenarios including building evacuation and shelter in place. Building owners and managers shall educate tenants on the life safety systems present in their building, provide training materials explaining egress routes and stairwell information, and develop educational programs explaining the correct response in emergency situations. It is further recommended that the owners and managers of high rise office buildings implement the necessary systems for collecting and storing the training history of each building occupant.

Thank you for your consideration,

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**About AK: Founded in 1981, AK Productions LLC has grown into the country's leading provider of customized, cost-effective life safety and security training programs and materials for commercial office buildings. Visit us on the Web at www.akproductions.com

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Subject: NIST's 2005 WTC Enquiry : LACK OF ANSWERS' MYSTERY DEEPENS !

NIST's 2005 WTC Enquiry : LACK OF ANSWERS' MYSTERY DEEPENS !

"AllTheTruth"'s reply to NIST's call for Public's input on WTC Inquiry :

- NIST Enquiry confirms AllTheTruth's Questions,

but deepens 9/11 Mystery by an astonishing lack of Answers !

=> Criminal Responsibilities for WTC Collapse, destruction of Evidence, and trapped Victims ?

"All The Truth"'s NewsLetter

By : Blas Mirco and Maltes' Friends

4 to 5 August 2005/-

Email at : all_the_truth@ftml.net.
www.freewebs.com/allthetruth +
(Currently under Attack by strange Hackers, who destroyed 5 Years of publications : 2001 - 2005, precisely this week of NIST's WTC Enquiry's Time Deadline !
See infra.)

A) ON THE SUBSTANCE OF NIST's DRAFT REPORT

B) On TIME DEADLINES and BRUTAL HARASSMENTS/OBSTRUCTIONS

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- (A) ON THE SUBSTANCE OF NIST's DRAFT REPORT

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* NIST can -and must - do like NASA : Rectify Errors before landing !

>>> NASA proves, these Hours, that ERRORS CAN and must BE RECTIFIED, Damages Repaired, gaps can be filed, even during a Space-Flight of only a few Days !

=> Why Not NIST, during a WTC Enquiry of many Years ?

==

The Draft Reports of NIST's Enquiry on WTC confirm the crucial importance of certain critical Questions raised by "AllTheTruth".

But NIST's findings, and their limits, deepen, also, the Mystery of lack of Answers ! Which becomes astonishing, even after Years of technical Enquiry, and millions of Federal Funds...

Various Converging Indications raise the question even of Criminal Responsibilities eventually involved.

All this highlights the regrettably Narrow limits inside which NIST's Technical Enquiry is closed, to the detriment of the vital need to find all the Truth on 9/11 Barbarities. (See :"AllTheTruth" :" NIST on WTC : 9/11 "Out of Scope" ? ", in : http://www.freewebs.com/allthetruth/nist911outofscope.htm).

To put it in a nutshell :

- NIST's detailed tests and arguments confirmed that neither Airplanes' Impact, NOT EVEN FIRES, aren't the cause of WTC's collapse : Buildings were able to withstand such strains.

But dislodging of Fireproof protection and/or other factors led to the drama.

- However, NIST appears unable to give a full and convincing explanation about what really caused that.

It leaves, also, without any convincing explanation, the crucial question why WTC's top, after leaning, at first, and "tilting" aside,

suddenly changed direction and, instead of toppling over, leaving the rest of the building intact,

on the contrary "changed" its movement "downwards", to a "vertical, total collapse", too similar to "controlled demolitions", (as AllTheTruth observed from the start).

+ Moreover, NIST indicates that Fireproof dislodging might, eventually, have "Malicious" causes.

It's also obvious that the scandalous "disappearance" and loss of WTC's Steel (vainly denounced since 2001 by Sally Regenhard and "AllTheTruth"), leaving less than 1%, stands behind many "lacks of Information" denounced by NIST, (including on Fireproofing, WTC Columns, Fire Alarms, etc.).

This is added to the confirmation that most People killed were trapped inside WTC by the absence of Helicopter Rescue and blocked doors towards Towers' Roof, as it had been decided by NYPD, which was, then, directed by ex-Mayor Giuliani's pal, Mr. Kerik.

His department was also involved in the strange, but critical dysfunction of Radio-transmitters, which hindered Rescuers a.o. from knowing on Time what was going on.

And in the Violent "clashes", imprisonment and threats against heroic NY Fire-Fighters and Victims' Families' access to WTC's Ground Zero : Suddenly blocked on October 2001, after "AllTheTruth" launched a call to search for clues on WTC's strange, vertical collapse, too similar to "controlled demolitions", by examining the debris.

Today, after Mr. Kerik's personal links even to Steel recycling' "Mafia" at New Jersey were revealed in 2004, the Question becomes inevitable :

- Both in his and others' cases : Are there any Criminal Responsibilities involved in WTC's strange, vertical and excessively deadly collapse ?

In Particular :

- The most solid, well-documented NIST's finding is that Fires were not the real cause of WTC's collapse, nor Airplanes' impact :

- "Fires did not cause Collapse" : WTC "Towers did not collapse under Aircraft Impact and Fires" alone, repeatedly stresses NIST.

This conclusion seems proved by a long series of Tests, Documentary evidence, Calculations, Logic Arguments, etc.

It confirms "AllTheTruth"'s criticism of ASCE's preliminary draft, back in 2002, which had pushed mainstream Media, like New York Times, AP, etc. to erroneously claim that it was simply the strength of the Fires which bended WTC's steel structure, causing its total destruction.

- According to NIST, it should be a "widely dislodged Fireproofing", and/or other "Structural damage", which caused WTC's collapse.

But NIST is unable to find enough proof on the real situation of

WTC's Fireproofing, or even of its Columns...

- Curiously, NIST claims that, despite the huge and controversial disappearance of WTC's Steel, nevertheless, the remaining pieces would provide "sufficient" evidence.

However, this is blatantly contradicted by the Fact that, as it acknowledges, only .. less than 1% of WTC's steel remains : Only 0,25 % !

Moreover, NIST denounces, elsewhere, that there is few or "No Information" available on WTC's exterior and mainly "core Columns", Floors' Trusses, etc., mainly on the crucial question of the level of Fireproofing and thermal Insulation damage, among many other Evidence which lacks : Left without Material proof, it is obliged to "guess" and make "assumptions" on WTC's Steel structure, only by ... "Photos and Videos" !

NIST also observes that WTC's "Fire Alarms", which, normally, could "collect Valuable Information" for "Fires in a Building", were "not used" during 9/11, and, even today, have "No Information" to provide.

Despite the importance of Water Sprinklers and other Fire protection systems which appeared damaged, NIST doesn't even raise any question on what might have happened, a few days before 9/11, during intrusions in WTC's Fire protection mechanisms by shady individuals reportedly involved in an ID-card Fraud and a Murder of witness in Memphis.

NIST notes, nevertheless, that a crucial dislodging of Fireproofing might have been done "Maliciously".

But, once again, it doesn't even ask to extend Enquiries to eventual Criminal interferences in WTC.

+ On the main point : WTC's Collapse, NIST observes that, at first, the Towers' "Upper Section" had started to "Tilt" "towards the Side", and "Rotate" at its Top Part, ready to fall aside and leave the greater part of the building standing.

But, afterwards, suddenly, something happened, and it "changed direction", after strange (and unexplained) "Dust puffs" and a "Dust Cloud" covered the scene : Instead, WTC's upper section, subsequently, "fell Downwards", "Vertically", followed by a "Total, Global Collapse" of all WTC in its entirety, from Top to the Basis.

=> Precisely, this is the most Important Fact on which "AllTheTruth"s critical questions on WTC have focused since 2001

:

It seems natural that the smaller, Top part, hit by Airplanes, would have fallen aside, leaving the longer part of WTC intact, to remain standing, and save many Human Lives.

But, on the contrary, here, an exceptional, never seen before, Vertical and Total Collapse occurred, for unknown reasons, concentrating all WTC's debris at its feet, almost as it occurs in the images of "Controlled Demolitions" (See "AllTheTruth"'s abundant publications and Documentation on that point).

Astonishingly, NIST has NOTHING serious to say in order to explain this paradox :

In 10.000 pages, it adds only one (1 !) short sentence, claiming (WITHOUT ANY PROOF) that "the fall of the (smaller) upper Section above the impact", "exceeded the energy which could be withstand by WTC's Structure in its (much larger) remaining portion". Thus, it's simply .. "Gravity" which would have provoked WTC's "Global Collapse"... Without any Fact, Nor any Argument, or other Proof, at all : Only an unbelievably Short and Empty Claim !

Despite the fact that this controversial claim on WTC's collapse has been largely discussed, analyzed and refuted earlier, including by our own counter-arguments,

nevertheless, NIST behaves as if it hadn't" ever heard anything, and/or didn't have anything to reply ...

=> It says NOTHING at all on the Controversy. Not even a word !

WTC's "vertical", total collapse, too similar to "controlled demolitions", and, plus particularly, the hollow claim about .. "Gravity", has been strongly criticized and refuted, with many arguments and facts, already Years ago :

F. ex. in "AllTheTruth"'s March 2002 Publication, titled : - "NEWTON DID IT, NOT ME !", about Dr Astaneh's claim and "US Congress 1st Hearing on 9/11-WTC" (See :
http://www.freewebz.com/allthetruth/newtondiditnotmeafterusc.htm).

Even if 911 Victims' Families and Friends, Experts, Officials, NGOs, involved Citizens, etc., (even ... U.S. Congress !) have already largely heard and debated about this Controversy about WTC's "vertical, total collapse" and the pseudo - "Gravity" claim,

nevertheless, NIST, after 3 Years of "Enquiry", astonishingly, makes as if it didn't know nothing about all that...

Despite admitting "substantial Uncertainties" on WTC's "Probable" collapse "sequence", which is condemned to remain highly hypothetical, and not convincing at all...

+ Another Important point, concerns WTC's Emergency EVACUATION operations :

- NIST's Data confirm that greatest part among the People who were killed, had been "trapped" in WTC's upper floors, over Aircraft's impact.

=> Most of them died because there was no possibility for Helicopter Rescue from the Top Floor, NIST observes.

This was "one of the few Options available" to those People, NIST rightfully notes.

Moreover, "1968 NYC Code required Access to Roofs", Reports denounce.

- But, Roof Helicopter Evacuation was rejected by NYPD on 9/11, (directed then by ex-Mayor Giuliani's pal, Mr. Kerik), and People were shut off WTC's Top, since Doors had been "Blocked" by a so-called (in)"Security" service, which "trapped" them until an atrocious death...

The Deadly Scandal appears even bigger, since NIST notes that WTC inhabitants had NOT even been WARNED that Doors towards the Top had been "blocked", so that 9/11 Victims would tragically try to go upstairs, provoking even more atrocious deaths..

However, when it comes, precisely, to the Controversy about whether Helicopter Rescue from the Top, could and should, or not, have been carried out, things become surprisingly Nasty :

- NIST simply observes that NYPD (i.e. Mr. Kerik) had "refused" Helicopter Evacuation, and that NY-New Jersey Port Authority had "blocked Doors", without even warning People..

On this crucial, Life or Death, point, NIST only notes that, according to NYPD, an Helicopter had tried to land on WTC's roof at the beginning of Aircraft's Fires, but abandoned any other attempt after facing Heat and Smoke, because of a blatant Refusal and Interdiction ordered by NYPD (that is to say Mr. Kerik, then).

"Helicopter Rescue" from WTC's Top Floors "was NEVER CONSIDERED" by NYPD and NYNJPA, NIST reveals.

- WHY ? - Because someone found "too much Smoke to land", at an "early stage", at the beginning of Aircraft's initial Fire-balls, and because, "only a few" might have been rescued, in such conditions, NIST claims.

But it says Nothing about the period AFTER Aircraft's initial Fires had diminished and even ceased, which was much longer...

And, NIST never explains why "only a few" might have been rescued from the Top of the flat-roofed WTC Towers, and not many : Astonishingly, NIST limits itself only into a 1 sentence Claim, without Proofs, nor arguments, Not any Debate, nothing to convince...

Moreover, Helicopter Rescue from the Building's Top WINDOWS, technically possible, is NOT EVEN CITED, while People were notoriously abandoned and obliged to jump out of WTC's Windows to atrocious Deaths !

At least Technicians might have been able to penetrate at WTC's Roof and repair the Building's Water Supply system for Fire-Sprinklers, which had been reportedly dislodged after Aircrafts' impacts, according to NIST.

But any kind of use of WTC's Flat roofed Tops by Helicopters, had been scandalously "EXCLUDED by NYPD", (that is to say ex-NY Mayor Giuliani's partner, Mr. Kerik).

=> Given the crucial Importance of the matter (most Deaths resulting from People "trapped" by the blockade of WTC's top), NIST should, at least, Seriously Examine all the existing Possibilities, and make a full Enquiry on whether Helicopter Rescue could and should have been used to save Human Lives.

On the contrary, NIST's Drafts astonishingly are Empty on this important point, limited only into copying a NYPD's Controversial claim, and a superficial sentence, without any real proof....

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=> NIST Enquiry's Scope was already too narrow :

Nothing about Airplanes' "Hijacking" ; Nor about Political and other stakes for choosing 11 September's Date, among 365 possible per Year ; Nothing on WTC's New York context : Old WTC buildings, out-passed by New Skyscrapers prepared f.ex. at Times Square, where ex-NY Mayor Giuliani chose for his office ; NY-NJ Port Authority's wish to build a New, Bigger "Transport Hub" at WTC's area (as it was proved true these Days) ; etc.

=> It should not become even more restricted, this time by what appears to be at least, among some of NIST's technicians, an astonishing narrow-mindness (See above) ...

People should not be flooded by 10.000 pages of Technical Data, only to find out that, after Years of an Enquiry using millions of Federal Funds, many main, crucial Questions of substance have been hastily and superficially abandoned without any real, serious reply..

NIST should raise and pursue all important issues : Including Criminal and other Responsibilities of some for Hiding or Destroying Material Evidence (f.ex. WTC's Steel, Fire Alarms, etc).

And it's not possible to stress the crucial importance of "dislodged Fireproofing", while remaining, at the same time, Indifferent on Facts indicating that sly Individuals, involved in ID cards Fraud and Murder of eye-Witness, had access to WTC's core, a few days before 9/11, including on Sprinklers, etc.

=> Some well-placed and efficient Enquiries could become "Ariadne's threads" towards unmasking those who are really responsible for 9/11 deadly Barbary...

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- (B) On TIME DEADLINES and BRUTAL HARASSMENTS/OBSTRUCTIONS :

[Brutalities and Harassment delay AllTheTruth's reply => NIST's WTC Enquiry kept in the Dark ?

=> No Bureaucratic Pretexts to Obstruct Critical Observations on so Serious issues as 9/11 !

Surprisingly, AllTheTruth was brutally hindered to present its observations according to NIST's invitation, until 4 August 5.pm. Deadline, and was obliged to do so shortly afterwards.

Some of its main, leading and long-standing members suddenly faced scandalous and unprecedented Brutal or sly Obstruction and/or Harassment, delaying and canceling crucial meetings scheduled to prepare "AllTheTruth"'s reply to NIST's call during the previous week-end.

Even "All The Truth"'s long-standing Website (2001 - 2005) was suddenly aggressed, without any warning, and its Historic content (full of useful Data for NIST's WTC Enquiry was destroyed these days...

Thus, the only possibility was to present, the week-end of NIST's Deadline, at least a brief, incomplete, but substantial critical Note on AllTheTruth's main observations.

AllTheTruth's members were First to call for an Investigation on WTC strange, vertical collapse, (too similar to "controlled demolitions"), and struggled since October 2001, together with Victims' Families and Friends, (mainly Sally Regenhard, NY Firefighters, Experts, and others), to push until the need for a serious Enquiry was acknowledged by U.S. Authorities. This struggle, accompanied by WTC-focused critical observations of rare depth continued for Many Years, 2004 included.

=> Therefore, No Formal, Bureaucratic Pretexts could be convincing as a hollow attempt to Exclude and Ignore "AllTheTruth"s Critical Observations, just for a few Hours/Day, in such a crucial Enquiry spreading along Many YEARS :

Considering also the Importance of the Human, Social and Political Issues at stake, this would be tantamount to excessive formalism and Scandalous Abuse. Everybody would assume its Responsibilities in front of People and History.

A fortiori, when those who brutally and/or slyly obstructed and harassed AllTheTruth's members, in an obvious attempt to destroy Time just at the eve of NIST's deadline,

are astonishingly close (geographically and socio-politically) to certain Circles which have been, since long, suspected and denounced by "AllTheTruth" as probably involved in a trans-national sly Criminal Network which may hide behind 9/11 Barbarities.

=> Who would dare become Accomplice of Brutal and/or sly Aggressors, only in order to skip Critical Observations from People who asked and struggled among the first, since 2001, for a WTC Enquiry ?

NIST's WTC Enquiry should be kept "Clean", crystal-clear, and beyond any suspicion,
without being Stained by Negative Incidents.

As NIST's new Director, Hratch Semerjian, stressed : -"We need to hear from the public" : Until then, "Our job is not done".
"We will finalize our reports ..after receiving public comments.".

(NDLR : This has Nothing to do with U.S. President GWBush, contrary to what some Manipulative Provocations claimed elsewhere : On the contrary, some of "AllTheTruth"s long-standing members, after careful analysis, have actively supported his reElection in 2004 for a fresh, New mandate.

Moreover, AllTheTruth has published the view of most of its members that 911 and a series of other incidents may form a series of attempts to push U.S. President GWBush into a "sly trap", in order to exploit it politically afterwards, for reasons extending to issues of paramount importance for all Humankind).]

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(2) COMMENTS in NIST's Format

(Preliminary, Incomplete, hasty observations to NIST Draft, given the absence of Time.

NB => See ATTACHED LETTER
for Urgent, recent Events,
overall view and more concrete details).

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NIST NCSTAR 1 (Draft)

- Page Number:

- Paragraph /Sentence :

- Comment:

- Reason for Comment:

- Suggestion for Revision:

=================================

NIST NCSTAR 1 (Draft)

- Page Number: xxxiv

- Paragraph 2/Sentence 1 : "Public Outreach
During the course of this Investigation, NIST held public briefings and meetings ...to solicit input from the public, present preliminary findings, and obtain comments on the direction and progress of the Investigation from the public ..."

- Comment:
More Input from the Public is needed, until NIST's Enquiry fullfils its mission.

- Reason for Comment:
WTC Investigation is far from completed yet (See infra).

- Suggestion for Revision:
ADD : "... NIST held [+ AND WILL HOLD] public briefings and meetings ...to solicit input from the public, present preliminary findings, and obtain comments ..;"
=========================

NIST NCSTAR 1 (Draft)

- Page Number: xli

- Paragraph 1/Sentence 1 : "E.1 GENESIS OF THIS INVESTIGATION
On August 21, 2002, the National Institute of Standards and Technology (NIST) announced its building and fire safety investigation of the World Trade Center (WTC) disaster."

- Comment:
It ommits the True "Genesis" of WTC's Investigation : - WTC Investigation's "Genesis" stems from pressing demands of 9/11Victims' Families and Friends, as well as concerned Citizens and Experts, who strived since October 2001 up to August 2002 to ask for an Independent, Transparent, Efficient and Full Investigation on WTC collapse and those really responsible.

Sally Regenhard (since December 2001) and "All The Truth"'s members and Friends (since October 2001), as well as NY Firefighters, etc. (since November 2001), spearheaded the Popular demand for an WTC Investigation from the start.

- Reason for Comment: (See Supra).

- Suggestion for Revision:
+ ADDE : + AFTER ALLMOST A YEAR OF PRESSING DEMANDS FROM 9/11 VICTIMS' FAMILIES AND FRIENDS, ..."on Augusr 21, 2002, ..(../..)"

==================================

NIST NCSTAR 1 (Draft)

- Page Number: xlii

- Paragraph 3/Sentence 1 :
"The scarcity of physical evidence
that is typically available in place for reconstruction of a disaster
..."

- Comment:
It ommits to mention the important Fact that a strong Controversy opposed Victims' Families and Friends to ex-NYC Mayor Mr. Giuliani because of his decision to recycle almost all WTC's Steel, removing and destroying most of the available "Physical Evidence".

- Reason for Comment: (See supra).

- Suggestion for Revision:
+ ADDE : + THE CONTROVERSIAL REMOVAL OF ALMOST ALL OF WTC's STEEL, DESPITE PROTESTS FROM VICTIMS' FAMILIES AND FRIENDS, PROVOKED A .. scarcity of physical evidence ...."

==================================

NIST NCSTAR 1 (Draft)

- Page Number: xliii

- Paragraph 3/Sentence 1 :
"The output ... was subject to uncertainties in the as-built condition of the towers, the interior layout and furnishings, the aircraft impact, the internal damage to the towers (especially the thermal insulation for fire protection of the structural steel, which is colloquially referred to as fireproofing), the redistribution of the combustibles, and the response of the building structural components to the heat from the fires. ..."

- Comment:
Ommits to mention the main Cause of those "Uncertainties".

- Reason for Comment:
It is important not to hide the Truth that the controversial Destruction of most Material Evidence (WTC Steel and debris : See supra) is one of the most grave obstacles to NIST's Investigation, causing many "Uncertainties".

- Suggestion for Revision:
+ ADDE : + BECAUSE OF THE EARLY DESTRUCTION OF MATERIAL EVIDENCE (MAINLY WTC's STEEL), "the output .. was subject to Uncertainties ..."

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NIST NCSTAR 1 (Draft)

- Page Number: xliii

- Paragraph 6/Sentence 1 :
"The two aircraft hit the towers at high speed and did considerable damage to principal structural components: core columns, floors, and perimeter columns."

- Comment:
Inaccurate.

- Reason for Comment:
NIST admits, elsewhere, that for the situation of most Columns which were not directly hit by Debris (90 % of WTC's structure !) there is "No

Information"..

- Suggestion for Revision:
+ INSERT : + "The two aircraft hit the towers at high speed and did considerable damage to principal structural components: THOSE core columns, floors, and perimeter columns WHICH WERE DIRECTLY AFFECTED BY DEBRIS".

==================================

NIST NCSTAR 1 (Draft)

- Page Number:
xliii

- Paragraph 7/Sentences 1 + 2:
"In WTC 1, the fires weakened the core columns and caused the floors on the south side of the building to sag. ....

.. The top section of the building tilted to the south and began its descent."

- Comment:
Grossly Inaccurate (See also infra).

- Reason for Comment:
(a) Proof for "weakening" by the "fires" was found by NIST only on Columns hit by Debris, while it had "No Information" on any other Columns (90% of WTC's building remaining standing, beneath).

(b) The "Top .. tilted" aside, at first.
But something happened, afterwards, and it "changed" its direction and appearance, replacing it wifh a "Vertical, Total Collapse" of all WTC, (instead of toppling over and falling to one side.(See + infra)

There are 2 different, and opposite movements, and not only one.

=> Simply claim that it was .."Gravity", which destroyed 90% of WTC "robust" buildings, which remained intact, is obviously not enough, nor convincing - particularly after a long Controversy in many and various Published texts and Debates 2001 - 2004. (See attached Letter for more concrete Details).

- Suggestion for Revision:
+ INSERT : - "The top section of the building INITIALLY tilted to the south.

BUT AFTERWARDS, INSTEAD OF FALLING ASIDE, AND LEAVING THE REST OF THE BUILDING INTACT,

ON THE CONTRARY, IT SUDDENLY began TO descent, AND DISINTEGRATE VERTICALLY, TOGETHER WITH ALL THE REST OF WTC BUILDING"

+ "NO CLEAR AND UNQUESTIONABLE PROOF WAS YET FOUND FOR THE REAL CAUSE OF
THAT RADICAL AND CRUCIAL "CHANGE"

=> A SERIOUS AND THOROUGH INVESTIGATION IS REQUIRED IN ORDER TO ESTABLISH THE FACTS, DISSIPATE ANY INCOMPREHENSIBLE PHENOMENON (f.ex. "Dust Clouds" cited by NIST) AND ANY CONTROVERSY ON WHAT PROVOCED WTC's VERTICAL, TOTAL COLLAPSE".

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NIST NCSTAR 1 (Draft)

- Page Number: xliv

- Paragraph 3/Sentence 1 :
"The WTC towers likely would not have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact."

- Comment:
Interesting NIST Finding, but its Cause remains largely Unknown : => A full Investigation is required. (See attached Letter).

- Reason for Comment:
For such a Crucial Fact, its Cause must be clearly established.

- Suggestion for Revision:
+ ADDE, IN FINE : "....+ AN INVESTIGATION ON WHAT CAUSED SUCH A WIDE DISLODGING OF THERMAL INSULATION MUST BE SERIOUSLY AND THOROUGHLY CONDUCTED UNTIL ALL MAIN FACTS ARE KNOWN".

=======================

NIST NCSTAR 1 (Draft)

- Page Number: xliv

- Paragraph 1 /Sentence 5 :
"• In WTC 2, ...The top section of
the building tilted to the east and to the south
and began its descent."

- Comment: (Comp. above).

- Reason for Comment: (Comp. above).

- Suggestion for Revision: (Comp. above).

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NIST NCSTAR 1 (Draft)

- Page Number: xliv

- Paragraph 2 /Sentence 2 :
"... In WTC 1, ...1,355 people were trapped in the upper floors .."

+ ADDE NEW

- Comment:
Astonishingly, nothing is said about more than a Thousand People
notoriously "trapped" at the upper floors by the Controversial Blocked
Doors and mainly the absence of Helicopter Rescue, (despite the access
requested even by NYC 1968 Code, but refused by NYPD - Mr. Kerik).

This is a very grave Ommission,
risking to compromise NIST's objectivity in the eyes of the Public.

When even the minor issue of a few "disabled" people takes a whole
paragraph, there is no excuse to totally ommit the long-standing
Controversy on Helicopter Rescue at Flat-roofed high-rise buildings,
which affected more than a Thousand People at WTC...

- Reason for Comment:
NB : See attached Letter for many concrete details.

- Suggestion for Revision:
+ ADDE : + "In WTC 1, ...1,355 people were trapped in the upper floors
.. BY DOORS WHICH HAD BEEN BLOCKED WITHOUT WARNING, AND BY A
CONTROVERSIAL ABSENCE OF ANY HELICOPTER RESCUE FROM THE TOP AND/OR
FROM
THE WINDOWS".

(+ Skip the MISLEADING sentence "where the aircraft destroyed all escape routes" : It was NYPD's chief who refused any Helicopter Rescue and had blocked the Doors towards WTC's Top.

NIST's Reports don't have any serious Evidence, nor solid, unquestionable Proof, that Helicopter Rescue would be really "impossible", as he claimed. (See attached Letter)

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NIST NCSTAR 1 (Draft)

- Page Number: xlvii

- Paragraph 9 /Sentence 1 :
"• Improved Building Evacuation: Building evacuation should be improved to include system designs that facilitate safe and rapid egress, ..."

- Comment:
Helicopter Rescue technics, from the Top Floors and Upper Windows, must be studied and developped for High-Rise buildings and Skyscrapers.

- Reason for Comment:
WTC proved that Thousands of Human Lives at High Rise Buildings often depend on the existence or absence of Helicopter Rescue technics.

- Suggestion for Revision:
+ ADDE, IN FINE : ""• Improved Building Evacuation: Building evacuation should be improved to include system designs that facilitate safe and rapid egress, ...INCLUDING POSSIBILITIES FOR ANY HELLICOPTER RESCUE FOR HIGH-RISE BUILDINGS AND SKYSCRAPERS... "

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NB :

- These observations, naturally should be repeated whenever NIST's Draft repeats similar issues (there are many such repetitions).

+ Many other observations = Ommitted, because of Time restraints.

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Email at : all_the_truth@ftml.net.
www.freewebs.com/allthetruth +
(Currently under Attack by strange Hackers, who destroyed 5 Years of publications : 2001 - 2005, precisely this week of NIST's WTC Enquiry !

Frequently updated, according to main developments and investigations' needs and results.

Investigative Website dedicated to help all those who search to find the whole truth on 9/11 Barbarities and other outstanding crises around the World.

Founded by a group of people who initiated Public Debates on 9/11 (and NY FF's) concluding (since end October 2001) into an "Urgent call for an independent, pluralist, transparent and full Enquiry
(starting by WTC's strange, deadly implosions)
before Material and Witnesses' Evidence is destroyed".

From the beginning and for Years, "AllTheTruth" has been striving (in a desinterested, benevolent, active and serious way, facing various aggressions and sacrificing even health of some of its members) to help unveil all the truth and shred full light on all 9/11Barbarities,
despite
surprising strange obstacles.

Supports from the start (mid-December 2001) Sally Regenhard's Call for an "Independent Blue Ribbon Panel Enquiry on Why (and How) WTC collapsed", as well as (27 Feb. 2002) the call of "Families of September 11" to "extend" USC-checked "independent Investigation" on the way 4 Airplanes were led and let to be hijacked and crashed.]

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http://www.fastmail.fm - Access all of your messages and folders
wherever you are

X-Sieve: CMU Sieve 2.2
From: "Blas Mirco and Maltes' Friends" <all_the_truth@ftml.net>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1
Date: Mon, 08 Aug 2005 08:34:48 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: all_the_truth@ftml.net

Information Submitted on: 8/8/2005.

Name : Blas Mirco and Maltes' Friends
Affiliation : "All The Truth" 9/11 Group (2001 - 2005)
Email Address : all_the_truth@ftml.net
Phone :
Report Number : NCSTAR 1
Page Number : (See infra)
Paragraph : (See infra)
Comment : (See infra)
Comment Reason : (See infra)

Revision Suggestion : (Preliminary, Incomplete, hasty observations to NIST Draft,
given the absence of Time.

NB => See ATTACHED LETTER
for Urgent, recent Events,
overall view and more concrete details).

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NIST NCSTAR 1 (Draft)

- Page Number:

- Paragraph /Sentence :

- Comment:

- Reason for Comment:

- Suggestion for Revision:

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NIST NCSTAR 1 (Draft)

- Page Number: xxxiv

- Paragraph 2/Sentence 1 : "Public Outreach
During the course of this Investigation, NIST held public briefings and meetings ...to solicit input from the public, present preliminary findings, and obtain comments on the direction and progress of the Investigation from the public ..."

- Comment: More Input from the Public is needed, until NIST's Enquiry fullfils its mission.

- Reason for Comment: WTC Investigation is far from completed yet (See infra).

- Suggestion for Revision: ADD : "... NIST held [+ AND WILL HOLD] public briefings and meetings ...to solicit input from the public, present preliminary findings, and obtain comments ..;"
==========================

NIST NCSTAR 1 (Draft)

- Page Number: xli

- Paragraph 1/Sentence 1 : "E.1 GENESIS OF THIS INVESTIGATION
On August 21, 2002, the National Institute of Standards and Technology (NIST) announced its building and fire safety investigation of the World Trade Center (WTC) disaster."

- Comment:
It ommits the True "Genesis" of WTC's Investigation : - WTC Investigation's "Genesis" stems from pressing demands of 9/11Victims' Families and Friends, as well as concerned Citizens and Experts, who strived since October 2001 up to August 2002 to ask for an Independent, Transparent, Efficient and Full Investigation on WTC collapse and those really responsible.

Sally Regenhard (since December 2001) and "All The Truth"'s members and Friends (since October 2001), as well as NY Firefighters, etc. (since November 2001), spearheaded the Popular demand for an WTC Investigation from the start.

- Reason for Comment: (See Supra).

- Suggestion for Revision:

+ ADDE : + AFTER ALLMOST A YEAR OF PRESSING DEMANDS FROM 9/11 VICTIMS' FAMILIES AND FRIENDS, ..."on Augusr 21, 2002, ..(../..)"

=================================

NIST NCSTAR 1 (Draft)

- Page Number: xlii

- Paragraph 3/Sentence 1 :
"The scarcity of physical evidence
that is typically available in place for reconstruction of a disaster
..."

- Comment:
It ommits to mention the important Fact that a strong Controversy opposed Victims' Families and Friends to ex-NYC Mayor Mr. Giuliani because of his decision to recycle almost all WTC's Steel, removing and destroying most of the available "Physical Evidence".

- Reason for Comment: (See supra).

- Suggestion for Revision:
+ ADDE : + THE CONTROVERSIAL REMOVAL OF ALMOST ALL OF WTC's STEEL, DESPITE PROTESTS FROM VICTIMS' FAMILIES AND FRIENDS, PROVOKED A .. scarcity of physical evidence ...."

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NIST NCSTAR 1 (Draft)

- Page Number:

- Paragraph 2/Sentence 1 :
"The output ... was subject to uncertainties in the as-built condition of the towers, the interior layout and furnishings, the aircraft impact, the internal damage to the towers (especially the thermal insulation for fire protection of the structural steel, which is colloquially referred to as fireproofing), the redistribution of the combustibles, and the response of the building structural components to the heat from the fires. ..."

- Comment:
Ommits to mention the main Cause of those "Uncertainties".

- Reason for Comment:
It is important not to hide the Truth that the controversial Destruction of most Material Evidence (WTC Steel and debris : See supra) is one of

the most grave obstacles to NIST's Investigation, causing many "Uncertainties".

- Suggestion for Revision:
+ ADDE : + BECAUSE OF THE EARLY DESTRUCTION OF MATERIAL EVIDENCE (MAINLY WYC's STEEL), "the output .. was subject to Uncertainties ..."

==================================
NIST NCSTAR 1 (Draft)

- Page Number: xliii

- Paragraph 6/Sentence 1 :
"The two aircraft hit the towers at high speed and did considerable damage to principal structural components: core columns, floors, and perimeter columns."

- Comment:
Inaccurate.

- Reason for Comment:
NIST admits, elsewhere, that for the situation of most Columns which were not directly hit by Debris (90 % of WTC's structure !) there is "No Information"..

- Suggestion for Revision: + INSERT : + "The two aircraft hit the towers at high speed and did considerable damage to principal structural components: THOSE core columns, floors, and perimeter columns WHICH WERE DIRECTLY AFFECTED BY DEBRIS".

==================================
NIST NCSTAR 1 (Draft)

- Page Number:
xliii

- Paragraph 7/Sentences 1 + 2:
"In WTC 1, the fires weakened the core columns and caused the floors on the south side of the building to sag. ....

.. The top section of the building tilted to the south and began its descent."

- Comment:
Grossly Inaccurate (See also infra).

- Reason for Comment:
(a) Proof for "weakening" by the "fires" was found by NIST only on Columns hit by Debris, while it had "No Information" on any other Columns (90% of WTC's building remaining standing, beneath).

(b) The "Top .. tilted" aside, at first.
But something happened, afterwards, and it "changed" its direction and appearance, replacing it wifh a "Vertical, Total Collapse" of all WTC, (instead of toppling over and falling to one side.(See + infra)

There are 2 different, and opposite movements,
and not only one.

=> Simply claim that it was .."Gravity", which destroyed 90% of WTC "robust" buildings, which remained intact, is obviously not enough, nor convincing - particularly after a long Controversy in many and various Published texts and Debates 2001 - 2004. (See attached Letter for more concrete Details).

- Suggestion for Revision:
+ INSERT : - "The top section of the building INITIALLY tilted to the south.

BUT AFTERWARDS, INSTEAD OF FALLING ASIDE, AND LEAVING THE REST OF THE BUILDING INTACT,

ON THE CONTRARY, IT SUDDENLY began TO descent, AND DISINTEGRATE VERTICALLY, TOGETHER WITH ALL THE REST OF WTC BUILDING"

+ "NO CLEAR AND UNQUESTIONABLE PROOF WAS YET FOUND FOR THE REAL CAUSE OF
THAT RADICAL AND CRUCIAL "CHANGE"

=> A SERIOUS AND THOROUGH INVESTIGATION IS REQUIRED IN ORDER TO ESTABLISH THE FACTS, DISSIPATE ANY INCOMPREHENSIBLE PHENOMENON (f.ex. "Dust Clouds" cited by NIST) AND ANY CONTROVERSY ON WHAT PROVOCED WTC's VERTICAL, TOTAL COLLAPSE".

==================================
NIST NCSTAR 1 (Draft)

- Page Number: xliv

- Paragraph 3/Sentence 1 :
"The WTC towers likely would not have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact."

- Comment:
Interesting NIST Finding, but its Cause remains largely Unknown : => A full Investigation is required. (See attached Letter).

- Reason for Comment:
For such a Crucial Fact, its Cause must be clearly established.

- Suggestion for Revision: + ADDE, IN FINE : "....+ AN INVESTIGATION ON WHAT CAUSED SUCH A WIDE DISLODGING OF THERMAL INSULATION MUST BE SERIOUSLY AND THOROUGHLY CONDUCTED UNTIL ALL FACTS ARE KNOWN".

=======================

NIST NCSTAR 1 (Draft)

- Page Number: xliv

- Paragraph /Sentence :
"• In WTC 2, ...The top section of the building tilted to the east and to the south and began its descent."

- Comment: (Comp. above).

- Reason for Comment: (Comp. above).

- Suggestion for Revision: (Comp. above).

=================================

NIST NCSTAR 1 (Draft)

- Page Number: xliv

- Paragraph 2 /Sentence 2 : "... In WTC 1, ...1,355 people were trapped in the upper floors .."

+ ADDE NEW

- Comment:
Astonishingly, nothing is said about more than a Thousand People

notoriously "trapped" at the upper floors by the Controversial Blocked Doors and mainly the absence of Helicopter Rescue, (despite the access requested even by NYC 1968 Code, but refused by NYPD - Mr. Kerik).

This is a very grave Ommission,
risking to compromise NIST's objectivity in the eyes of the Public.

When even the minor issue of a few "disabled" people takes a whole paragraph, there is no excuse to totally ommit the long-standing Controversy on Helicopter Rescue at Flat-roofed high-rise buildings, which affected more than a Thousand People at WTC...

- Reason for Comment: NB : See attached Letter for many concrete details.

- Suggestion for Revision: + ADDE : + "In WTC 1, ...1,355 people were trapped in the upper floors
.. BY DOORS WHICH HAD BEEN BLOCKED WITHOUT WARNING, AND BY A CONTROVERSIAL ABSENCE OF ANY HELICOPTER RESCUE FROM THE TOP AND/OR FROM
THE WINDOWS".

(+ Skip the MISLEADING sentence "where the aircraft destroyed all escape routes" : It was NYPD's chief who refused any Helicopter Rescue and had blocked the Doors towards WTC's Top.

NIST's Reports don't have any serious Evidence, nor solid, unquestionable Proof, that Helicopter Rescue would be really "impossible", as he claimed. (See attached Letter)

==================================
NIST NCSTAR 1 (Draft)

- Page Number: xlvii

- Paragraph /Sentence :
"• Improved Building Evacuation: Building evacuation should be improved to include system designs that facilitate safe and rapid egress, ..."

- Comment:
Helicopter Rescue technics, from the Top Floors and Upper Windows, must be studied and developped for High-Rise buildings and Skyscrapers.

- Reason for Comment:
WTC proved that Thousands of Human Lives at High Rise Buildings often depend on the existence or absence of Helicopter Rescue technics.

- Suggestion for Revision: + ADDE, IN FINE : ""• Improved Building Evacuation: Building evacuation should be improved to include system designs that facilitate safe and rapid egress, ...INCLUDING POSSIBILITIES FOR ANY HELLICOPTER RESCUE FOR HIGH-RISE BUILDINGS AND SKYSCRAPERS... "

====================================

NB :

- These observations, naturally should be repeated whenever NIST's Draft repeats similar issues (there are many such repetitions).

+ Many other observations = Ommitted, because of Time restraints.

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(2)

"All The Truth"s open LETTER : attached :

A) On TIME DEADLINES and BRUTAL HARASSMENTS/OBSTRUCTIONS

B) ON THE SUBSTANCE OF NIST's DRAFT REPORT

==============

- (A) On TIME DEADLINES and BRUTAL HARASSMENTS/OBSTRUCTIONS :

[Brutalities and Harassment delay AllTheTruth's reply => NIST's WTC Enquiry kept in the Dark ?

=> No Bureaucratic Pretexts to Obstruct Critical Observations on so Serious issues as 9/11 !

Surprisingly, AllTheTruth was brutally hindered to present its observations according to NIST's invitation, until 4 August 5.pm. Deadline, and was obliged to do so shortly afterwards.

Some of its main, leading and long-standing members suddenly faced scandalous and unprecedented Brutal or sly Obstruction and/or Harassment, delaying and canceling crucial meetings scheduled to prepare "AllTheTruth"'s reply to NIST's call during the previous week-end.

Even "All The Truth"'s long-standing Website (2001 - 2005) was suddenly aggressed, without any warning, and its Historic content (full of useful Data for NIST's WTC Enquiry was destroyed these days...

Thus, the only possibility was to present, the week-end of NIST's Deadline, at least a brief, incomplete, but substantial critical Note on AllTheTruth's main observations.

AllTheTruth's members were First to call for an Investigation on WTC strange, vertical collapse, (too similar to "controlled demolitions"), and struggled since October 2001, together with Victims' Families and Friends, (mainly Sally Regenhard, NY Firefighters, Experts, and others), to push until the need for a serious Enquiry was acknowledged by U.S. Authorities. This struggle, accompanied by WTC-focused critical observations of rare depth continued for Many Years, 2004 included.

=> Therefore, No Formal, Bureaucratic Pretexts could be convincing as a hollow attempt to Exclude and Ignore "AllTheTruth"s Critical Observations, just for a few Hours/Day, in such a crucial Enquiry spreading along Many YEARS :

Considering also the Importance of the Human, Social and Political Issues at stake, this would be tantamount to excessive formalism and Scandalous Abuse. Everybody would assume its Responsibilities in front of People and History.

A fortiori, when those who brutally and/or slyly obstructed and harassed AllTheTruth's members, in an obvious attempt to destroy Time just at the eve of NIST's deadline,

are astonishingly close (geographically and socio-politically) to certain Circles which have been, since long, suspected and denounced by "AllTheTruth" as probably involved in a trans-national sly Criminal Network which may hide behind 9/11 Barbarities.

=> Who would dare become Accomplice of Brutal and/or sly Aggressors, only in order to skip Critical Observations from People who asked and struggled among the first, since 2001, for a WTC Enquiry ?

NIST's WTC Enquiry should be kept "Clean", crystal-clear, and beyond any suspicion,
without being Stained by Negative Incidents.

As NIST's new Director, Hratch Semerjian, stressed : -"We need to hear from the public" : Until then, "Our job is not done".
"We will finalize our reports ..after receiving public comments.".

(NDLR : This has Nothing to do with U.S. President GWBush,
contrary to what some Manipulative Provocations claimed elsewhere :
On the contrary, some of "AllTheTruth"s long-standing members, after careful analysis, have actively supported his reElection in 2004 for a fresh, New mandate.

Moreover, AllTheTruth has published the view of most of its members that 911 and a series of other incidents may form a series of attempts to push U.S. President GWBush into a "sly trap", in order to exploit it politically afterwards, for reasons extending to issues of paramount importance for all Humankind).]

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

X-Sieve: CMU Sieve 2.2
From: "Blas Mirco and Maltes' Friends" <all_the_truth@ftml.net>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1
Date: Mon, 08 Aug 2005 08:25:40 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: all_the_truth@ftml.net

Information Submitted on: 8/8/2005.

Name : Blas Mirco and Maltes' Friends
Affiliation : "All The Truth" 9/11 Group (2001 - 2005)
Email Address : all_the_truth@ftml.net
Phone :
Report Number : NCSTAR 1
Page Number : xlvii
Paragraph : - Paragraph 9 /Sentence 1 :
"• Improved Building Evacuation: Building evacuation should be improved to include system designs that facilitate safe and rapid egress, ..."

Comment : Helicopter Rescue technics, from the Top Floors and Upper Windows, must be studied and developped for High-Rise buildings and Skyscrapers.

Comment Reason : WTC proved that Thousands of Human Lives at High Rise Buildings often depend on the existence or absence of Helicopter Rescue technics.

Revision Suggestion : + ADDE, IN FINE : ""• Improved Building Evacuation: Building evacuation should be improved to include system designs that facilitate safe and rapid egress, ...INCLUDING POSSIBILITIES FOR ANY HELLICOPTER RESCUE FOR HIGH-RISE BUILDINGS AND SKYSCRAPERS... "

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1
Date: Mon, 08 Aug 2005 08:22:46 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: all_the_truth@ftml.net

Information Submitted on: 8/8/2005.

Name : Blas Mirco and Maltes' Friends
Affiliation : "All The Truth" 9/11 Group (2001 - 2005)
Email Address : all_the_truth@ftml.net
Phone :
Report Number : NCSTAR 1
Page Number : xliv
Paragraph : - Paragraph 2 /Sentence 2 :
"... In WTC 1, ...1,355 people were trapped in the upper floors .."

Comment : Astonishingly, nothing is said about more than a Thousand People notoriously "trapped" at the upper floors by the Controversial Blocked Doors and mainly the absence of Helicopter Rescue, (despite the access requested even by NYC 1968 Code, but refused by NYPD - Mr. Kerik).

This is a very grave Ommission,
risking to compromise NIST's objectivity in the eyes of the Public.

When even the minor issue of a few "disabled" people takes a whole paragraph, there is no excuse to totally ommit the long-standing Controversy on Helicopter Rescue at Flat-roofed high-rise buildings, which affected more than a Thousand People at WTC...

Comment Reason : NB : See attached Letter for many concrete details.

Revision Suggestion : + ADDE : + "In WTC 1, ...1,355 people were trapped in the upper floors
.. BY DOORS WHICH HAD BEEN BLOCKED WITHOUT WARNING, AND BY A CONTROVERSIAL
ABSENCE OF ANY HELICOPTER RESCUE FROM THE TOP AND/OR FROM THE WINDOWS".

(+ Skip the MISLEADING sentence "where the aircraft
destroyed all escape routes" : It was NYPD's chief who refused any Helicopter Rescue and had blocked the Doors towards WTC's Top.

NIST's Reports don't have any serious Evidence, nor solid, unquestionable

Proof, that Helicopter Rescue would be really "impossible", as he claimed. (See attached Letter)

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From: "Blas Mirco and Maltes' Friends" <all_the_truth@ftml.net>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1
Date: Mon, 08 Aug 2005 08:19:53 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: all_the_truth@ftml.net

Information Submitted on: 8/8/2005.

Name : Blas Mirco and Maltes' Friends
Affiliation : "All The Truth" 9/11 Group (2001 - 2005)
Email Address : all_the_truth@ftml.net
Phone :
Report Number : NCSTAR 1
Page Number : xliv
Paragraph : - Paragraph 3/Sentence 1 :
- Paragraph 1 /Sentence 5 :
"• In WTC 2, ...The top section of
the building tilted to the east and to the south
and began its descent."

Comment : Grossly Inaccurate (See also supra).

Comment Reason : The "Top .. tilted" aside, at first.
But something happened, afterwards, and it "changed" its direction and
appearance, replacing it wifh a "Vertical, Total Collapse" of all WTC,
(instead of toppling over and falling to one side.(See + infra)

There are 2 different, and opposite movements,
and not only one.

=> Simply claim that it was .."Gravity", which destroyed 90% of WTC "robust"
buildings, which remained intact, is obviously not enough, nor convincing -
particularly after a long Controversy in many and various Published texts and
Debates 2001 - 2004. (See attached Letter for more concrete Details).

Revision Suggestion : + INSERT : - "The top section of the building INITIALLY
tilted to the
south.

BUT AFTERWARDS, INSTEAD OF FALLING ASIDE, AND LEAVING THE REST OF THE
BUILDING
INTACT,

ON THE CONTRARY, IT SUDDENLY began TO descent, AND DISINTEGRATE

VERTICALLY,
TOGETHER WITH ALL THE REST OF WTC BUILDING"

+ "NO CLEAR AND UNQUESTIONABLE PROOF WAS YET FOUND FOR THE REAL CAUSE OF THAT
RADICAL AND CRUCIAL "CHANGE"

=> A SERIOUS AND THOROUGH INVESTIGATION IS REQUIRED IN ORDER TO ESTABLISH THE
FACTS, DISSIPATE ANY INCOMPREHENSIBLE PHENOMENON (f.ex. "Dust Clouds" cited by
NIST) AND ANY CONTROVERSY ON WHAT PROVOCED WTC's VERTICAL, TOTAL COLLAPSE".

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1
Date: Mon, 08 Aug 2005 08:15:43 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: all_the_truth@ftml.net

Information Submitted on: 8/8/2005.

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Affiliation : "All The Truth" 9/11 Group (2001 - 2005)
Email Address : all_the_truth@ftml.net
Phone :
Report Number : NCSTAR 1
Page Number : xliv
Paragraph : Paragraph 3/Sentence 1 :
"The WTC towers likely would not have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact."
Comment : Interesting NIST Finding, but its Cause remains largely Unknown : =>
A full Investigation is required. (See attached Letter).

Comment Reason : For such a Crucial Fact, its Cause must be clearly established.

Revision Suggestion : + ADDE, IN FINE : "....+ AN INVESTIGATION ON WHAT CAUSED SUCH A WIDE DISLODGING OF THERMAL INSULATION MUST BE SERIOUSLY AND THOROUGHLY
CONDUCTED UNTIL ALL MAIN FACTS ARE KNOWN".

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1
Date: Mon, 08 Aug 2005 08:13:28 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: all_the_truth@ftml.net

Information Submitted on: 8/8/2005.

Name : Blas Mirco and Maltes' Friends
Affiliation : "All The Truth" 9/11 Group (2001 - 2005)
Email Address : all_the_truth@ftml.net
Phone :
Report Number : NCSTAR 1
Page Number : xliii
Paragraph : - Paragraph 7/Sentences 1 + 2:
"In WTC 1, the fires weakened the core columns and caused the floors on the south side of the building to sag. ....

.. The top section of the building tilted to the
south and began its descent."

Comment : Grossly Inaccurate (See also infra).

Comment Reason : (a) Proof for "weakening" by the "fires" was found by NIST only on Columns hit by Debris, while it had "No Information" on any other Columns (90% of WTC's building remaining standing, beneath).

(b) The "Top .. tilted" aside, at first.
But something happened, afterwards, and it "changed" its direction and appearance, replacing it wifh a "Vertical, Total Collapse" of all WTC, (instead of toppling over and falling to one side.(See + infra)

There are 2 different, and opposite movements,
and not only one.

=> Simply claim that it was .."Gravity", which destroyed 90% of WTC "robust" buildings, which remained intact, is obviously not enough, nor convincing - particularly after a long Controversy in many and various Published texts and Debates 2001 - 2004. (See attached Letter for more concrete Details).

Revision Suggestion : + INSERT : - "The top section of the building INITIALLY tilted to the
south.

BUT AFTERWARDS, INSTEAD OF FALLING ASIDE, AND LEAVING THE REST OF THE BUILDING
INTACT,

ON THE CONTRARY, IT SUDDENLY began TO descent, AND DISINTEGRATE VERTICALLY,
TOGETHER WITH ALL THE REST OF WTC BUILDING"

+ "NO CLEAR AND UNQUESTIONABLE PROOF WAS YET FOUND FOR THE REAL CAUSE OF THAT
RADICAL AND CRUCIAL "CHANGE"

=> A SERIOUS AND THOROUGH INVESTIGATION IS REQUIRED IN ORDER TO ESTABLISH THE
FACTS, DISSIPATE ANY INCOMPREHENSIBLE PHENOMENON (f.ex. "Dust Clouds" cited by
NIST) AND ANY CONTROVERSY ON WHAT PROVOCED WTC's VERTICAL, TOTAL COLLAPSE".

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

X-Sieve: CMU Sieve 2.2
From: "Blas Mirco and Maltes' Friends" <all_the_truth@ftml.net>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1
Date: Mon, 08 Aug 2005 08:11:23 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: all_the_truth@ftml.net

Information Submitted on: 8/8/2005.

Name : Blas Mirco and Maltes' Friends
Affiliation : "All The Truth" 9/11 Group (2001 - 2005)
Email Address : all_the_truth@ftml.net
Phone :
Report Number : NCSTAR 1
Page Number : xliii
Paragraph : Paragraph 6/Sentence 1 :
"The two aircraft hit the towers at high speed and did considerable damage to principal structural components: core columns, floors, and perimeter columns."

Comment : Inaccurate.

Comment Reason : NIST admits, elsewhere, that for the situation of most Columns which were not directly hit by Debris (90 % of WTC's structure !) there is "No Information"..

Revision Suggestion : + INSERT : + "The two aircraft hit the towers at high speed and did considerable damage to principal structural components: THOSE core columns, floors, and perimeter columns WHICH WERE DIRECTLY AFFECTED BY DEBRIS".

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Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
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Affiliation : "All The Truth" 9/11 Group (2001 - 2005)
Email Address : all_the_truth@ftml.net
Phone :
Report Number : NCSTAR 1
Page Number : xliii
Paragraph : Paragraph 3/Sentence 1 :
"The output ... was subject to uncertainties in the as-built condition of the towers, the interior layout and furnishings, the aircraft impact, the internal damage to the towers (especially the thermal insulation for fire protection of the structural steel, which is colloquially referred to as fireproofing), the redistribution of the combustibles, and the response of the building structural components to the heat from the fires. ..."

Comment : Ommits to mention the main Cause of those "Uncertainties".

Comment Reason : It is important not to hide the Truth that the controversial Destruction of most Material Evidence (WTC Steel and debris : See supra) is one of the most grave obstacles to NIST's Investigation, causing many "Uncertainties".

Revision Suggestion : + ADDE : + BECAUSE OF THE EARLY DESTRUCTION OF MATERIAL
EVIDENCE (MAINLY WYC's STEEL), "the output .. was subject to Uncertainties ..."

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

X-Sieve: CMU Sieve 2.2
From: "Blas Mirco and Maltes' Friends" <all_the_truth@ftml.net>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1
Date: Mon, 08 Aug 2005 08:04:47 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: all_the_truth@ftml.net.

Information Submitted on: 8/8/2005.

Name : Blas Mirco and Maltes' Friends
Affiliation : "All The Truth" 9/11 Group (2001 - 2005)
Email Address : all_the_truth@ftml.net.
Phone :
Report Number : NCSTAR 1
Page Number : xlii
Paragraph : Paragraph 3/Sentence 1 :
"The scarcity of physical evidence
that is typically available in place for reconstruction of a disaster ..."
Comment : It ommits to mention the important Fact that a strong Controversy opposed Victims' Families and Friends to ex-NYC Mayor Mr. Giuliani because of his decision to recycle almost all WTC's Steel, removing and destroying most of the available "Physical Evidence".

Comment Reason : (See supra).

Revision Suggestion : + ADDE : + THE CONTROVERSIAL REMOVAL OF ALMOST ALL OF WTC's STEEL, DESPITE PROTESTS FROM VICTIMS' FAMILIES AND FRIENDS, PROVOKED A ..
scarcity of physical evidence ...."

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

X-Sieve: CMU Sieve 2.2
From: "Blas Mirco and Maltes' Friends" <all_the_truth@ftml.net>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1
Date: Mon, 08 Aug 2005 08:03:01 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: all_the_truth@ftml.net

Information Submitted on: 8/8/2005.

Name : Blas Mirco and Maltes' Friends
Affiliation : "All The Truth" 9/11 Group (2001 - 2005)
Email Address : all_the_truth@ftml.net
Phone :
Report Number : NCSTAR 1
Page Number : xli
Paragraph : - Paragraph 1/Sentence 1 : "E.1 GENESIS OF THIS INVESTIGATION
On August 21, 2002, the National Institute of Standards and Technology (NIST) announced its building and fire safety investigation of the World Trade Center (WTC) disaster."

Comment : It ommits the True "Genesis" of WTC's Investigation : - WTC Investigation's "Genesis" stems from pressing demands of 9/11Victims' Families and Friends, as well as concerned Citizens and Experts, who strived since October 2001 up to August 2002 to ask for an Independent, Transparent, Efficient and Full Investigation on WTC collapse and those really responsible.

Sally Regenhard (since December 2001) and "All The Truth"'s members and Friends (since October 2001), as well as NY Firefighters, etc. (since November 2001), spearheaded the Popular demand for an WTC Investigation from the start.

Comment Reason : (See Supra).

Revision Suggestion : + ADDE : + AFTER ALLMOST A YEAR OF PRESSING DEMANDS FROM
9/11 VICTIMS' FAMILIES AND FRIENDS, ..."on Augusr 21, 2002, ..(../..)"

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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From: "Blas Mirco and Maltes' Friends" <all_the_truth@ftml.net>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1
Date: Mon, 08 Aug 2005 07:59:02 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: all_the_truth@ftml.net

Information Submitted on: 8/8/2005.

Name : Blas Mirco and Maltes' Friends
Affiliation : "All The Truth" (2001 - 2005)
Email Address : all_the_truth@ftml.net
Phone :
Report Number : NCSTAR 1
Page Number : xxxiv
Paragraph : - Paragraph 2/Sentence 1 : "Public Outreach
During the course of this Investigation, NIST held public briefings and meetings ...to solicit input from the public, present preliminary findings, and obtain comments on the direction and progress of the Investigation from the public ..."

Comment : More Input from the Public is needed, until NIST's Enquiry fullfils its mission.
Comment Reason : WTC Investigation is far from completed yet (See infra).

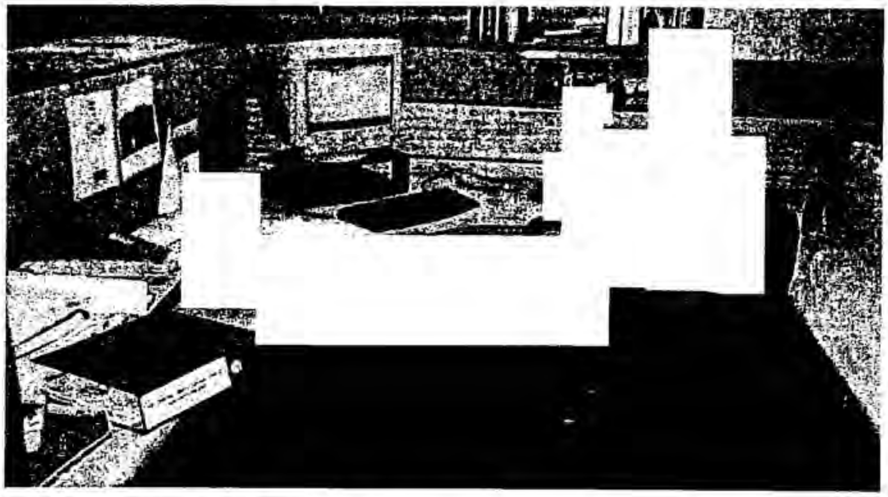
Revision Suggestion : ADD : "... NIST held [+ AND WILL HOLD] public briefings and meetings ...to solicit input from the public, present preliminary findings, and obtain comments ..;"

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

8. Knoll furniture symbols library www.knoll.com/furniture symb dnld.htm
9. Sunder, S.S. "World Trade Center Investigation Status" October 19, 2004, BFRL-NIST.
10. Sadek, F., Riley, M.A., Simiu, E., Fritz, W. and Lew, H.S."Baseline Structural Performance and Aircraft Impact Damage Analysis" June 22, 2004.
11. Hamburger, R., et al. FEMA report "Chapter 2 WTC 1 and WTC 2" fema403_ch2.pdf
12. Sadek, F., Riley, M.A., Simiu, E., Fritz, W. and Lew, H.S."Baseline Structural Performance and Aircraft Impact Damage Analysis" October 10, 2004, BFRL-NIST.
13. NIST Special publication 1000-4 "December 2003 public update on the Federal Building and Fire Safety investigation of the WTC Disaster" 12/20/2003, NIST.
14. McAllister, T., et al. FEMA WTC report "Chapter1-Introduction"

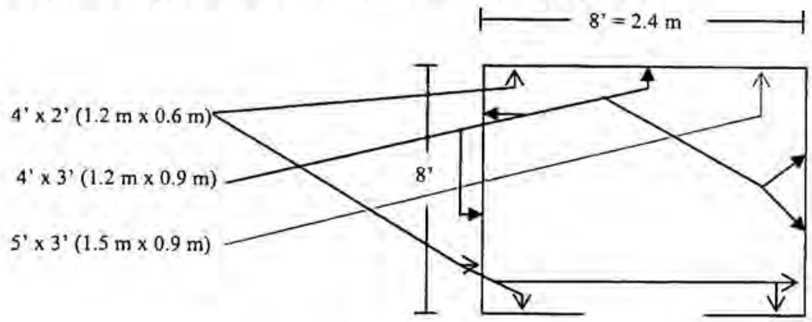
Appendices

A.1 Photo of typical workstation

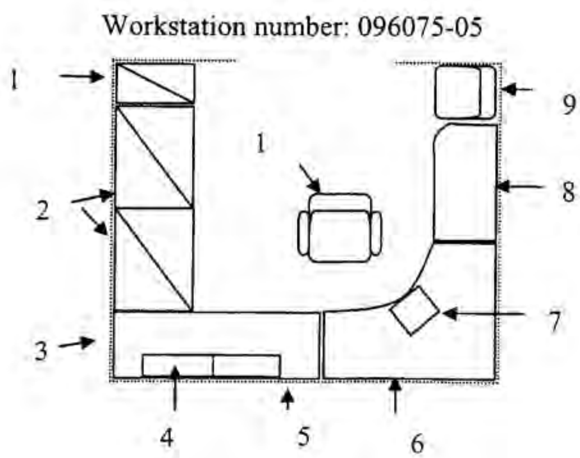


A.2 Panel layout of NIST workstation

Workstation layout using the NIST 8'x8' (2.44 m x 2.44 m) printout:



A.3 Workstation symbol example



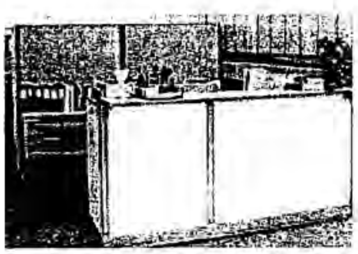
1. Credenza

2. Lateral file cabinets-two drawers

3. Supplemental work surface

4. Overhead storage

5. Privacy panel



6. Morrison desk

7. Computer

8. Rounded edge supplemental work surface

9. Visitor chair

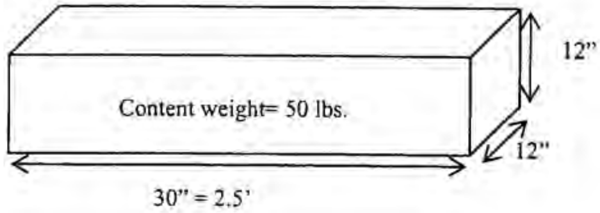
10. Staff chair

A.4 Sample calculations

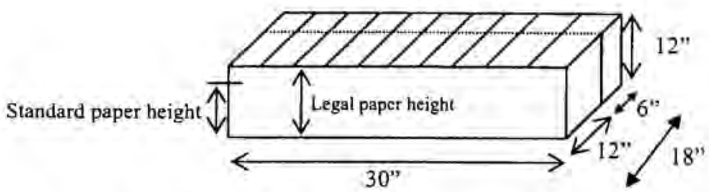
1. For load survey of panels, I determined that one sheet of paper weighs 0.01 lbs (0.0045 kg), therefore 0.25 lbs (0.11 kg) = 25 sheets of paper and 1 ream of paper = 500 sheets = 5 lbs (2.27 kg).
2. Load survey of pantry was done by estimation of the ENFP department pantry. The area of contents in the room considered were the storage racks, three file cabinet drawers, microwave, refrigerator, and few boxes of stored party supplies.
3. Load survey for the desk tops was done by weighing contents of one desk then observing other desks in the engineering building, physician offices and the desk of an MRI technician. Work desk was apportioned three pounds of combustible material in the form of paper weight. The supplemental desk was estimated to have six pounds of additional paper weight on desk surface.
4. File cabinet weight for the credenza was based on the following horizontal file weights from the ENFP department: the first file drawer contained 294 files, weighed 37 lbs (16.8 kg), and measured 18.75 inches (0.48 m) long. The second file cabinet contained 138 files and was 16 inches (0.41 m) long. Therefore, the credenza file drawer which holds horizontal files is about 23.43 lbs (10.63 kg) which was then rounded to 24 lbs (10.9 kg) of paper weight contained in the credenza to account for note pads, other files and additional combustible office supplies. My findings are consistent with the check done by Dr.Quintiere in Appendix A.5.
5. Storage file cabinet drawer in ENFP photocopy room held 10 reams of paper at about 2.5" (0.064 m) thick and five pounds per ream. One drawer held ~ 50 lbs (22.68 kg) of photocopy paper.

A.5 Dr. Quintiere check of file cabinet content and comparison

Horizontal File Cabinet:



Lateral File Cabinet:



Legal paper ~ 50(3/2)=75 lbs (34.02 kg)
Standard paper ~ 50 lbs (22.68 kg)
Drawer capacity = 150 lbs (68.04 kg)
30 inches = 0.762 m
18 inches = 0.457 m
12 inches = 0.305 m
6 inches = 0.15 m

A.7 NIST Presentation Explanatory Page for the Excel Document 'NIST prsntn'

The following information is meant to clearly explain the Excel documents used to analyze the combustible load on the 96th floor of the WTC North tower.

Table 1. For Excel sheet 'item wts."

Column designation	Description of how the value was obtained and/or what it means/relevance
A1	For ease of identification when printed I inserted column and row details.
A2	Row and column designations for ease of reference.
B2	Heading to show that the following data is calculated from information obtained by Quintiere & Stewart of UMCP.
C2	WTC1 96th floor ('item wts.') to let reader know which printed sheet they are viewing.
B4	Classification refers to the description of where the furniture item may typically found on the 96th floor.
C4	Item type refers to the physical description of an individual item found on the 96th floor as obtained from Gensler Architectural plans and Appendix J of the NIST preliminary WTC report.
D2-D4	Stock identification numbers were obtained from comparing the Gensler Architectural plans to the AutoCAD symbol library obtained from www.Knoll.com
E3-E4	Weight of furniture per item refers to the weight of one piece of furniture as it is, complete and unpacked. These weights were obtained from a Knoll Sales person.
E5	Weight of furniture in pounds (lbs)
F5	Weight of furniture in kilograms (kgs)
G3-G4	Number of items refers to the number of items found on the 96th floor of WTC 1. This information was obtained from Gensler Architectural plans.
H2-H4	The weight of combustible material for empty furniture item refers to the amount of material for a single, unused piece of furniture (obtained from Knoll sales person who was referring to either a binder or computer when we spoke but did not

To: wtc@nist.gov
From: all_the_truth@ftml.net (by way of Inquiries <inquiry@nist.gov>)
Subject: NIST's 2005 WTC Enquiry : LACK OF ANSWERS' MYSTERY DEEPENS !

NIST's 2005 WTC Enquiry : LACK OF ANSWERS' MYSTERY DEEPENS !

"AllTheTruth"'s reply to NIST's call for Public's input on WTC Inquiry :

- NIST Enquiry confirms AllTheTruth's Questions,

but deepens 9/11 Mystery by an astonishing lack of Answers !

=> Criminal Responsibilities for WTC Collapse, destruction of Evidence, and trapped Victims ?

"All The Truth"'s NewsLetter

By : Blas Mirco and Maltes' Friends

4 to 5 August 2005/-

Email at : all_the_truth@ftml.net.
www.freewebs.com/allthetruth +
(Currently under Attack by strange Hackers, who destroyed 5 Years of publications : 2001 - 2005, precisely this week of NIST's WTC Enquiry's Time Deadline !
See infra.)

A) ON THE SUBSTANCE OF NIST's DRAFT REPORT

B) On TIME DEADLINES and BRUTAL HARASSMENTS/OBSTRUCTIONS

==============

- (A) ON THE SUBSTANCE OF NIST's DRAFT REPORT

----

* NIST can -and must - do like NASA : Rectify Errors before landing !

>>> NASA proves, these Hours, that ERRORS CAN and must BE RECTIFIED, Damages Repaired, gaps can be filed, even during a Space-Flight of only a few Days !

=> Why Not NIST, during a WTC Enquiry of many Years ?

===

The Draft Reports of NIST's Enquiry on WTC confirm the crucial importance of certain critical Questions raised by "AllTheTruth".

But NIST's findings, and their limits, deepen, also, the Mystery of lack of Answers ! Which becomes astonishing, even after Years of technical Enquiry, and millions of Federal Funds...

Various Converging Indications raise the question even of Criminal Responsibilities eventually involved.

All this highlights the regrettably Narrow limits inside which NIST's Technical Enquiry is closed, to the detriment of the vital need to find all the Truth on 9/11 Barbarities. (See :"AllTheTruth" :" NIST on WTC : 9/11 "Out of Scope" ? ", in : http://www.freewebs.com/allthetruth/nist911outofscope.htm).

To put it in a nutshell :

- NIST's detailed tests and arguments confirmed that neither Airplanes' Impact, NOT EVEN FIRES, aren't the cause of WTC's collapse : Buildings were able to withstand such strains.

But dislodging of Fireproof protection and/or other factors led to the drama.

- However, NIST appears unable to give a full and convincing explanation about what really caused that.

It leaves, also, without any convincing explanation, the crucial question why WTC's top, after leaning, at first, and "tilting" aside,

suddenly changed direction and, instead of toppling over, leaving the rest of the building intact,

on the contrary "changed" its movement "downwards", to a "vertical, total collapse", too similar to "controlled demolitions", (as AllTheTruth observed from the start).

+ Moreover, NIST indicates that Fireproof dislodging might, eventually, have "Malicious" causes.

It's also obvious that the scandalous "disappearance" and loss of WTC's Steel (vainly denounced since 2001 by Sally Regenhard and "AllTheTruth"), leaving less than 1%, stands behind many "lacks of Information" denounced by NIST, (including on Fireproofing, WTC Columns, Fire Alarms, etc.).

This is added to the confirmation that most People killed were trapped inside WTC by the absence of Helicopter Rescue and blocked doors towards Towers' Roof, as it had been decided by NYPD, which was, then, directed by ex-Mayor Giuliani's pal, Mr. Kerik.

His department was also involved in the strange, but critical dysfunction of Radio-transmitters, which hindered Rescuers a.o. from knowing on Time what was going on.

And in the Violent "clashes", imprisonment and threats against heroic NY Fire-Fighters and Victims' Families' access to WTC's Ground Zero : Suddenly blocked on October 2001, after "AllTheTruth" launched a call to search for clues on WTC's strange, vertical collapse, too similar to "controlled demolitions", by examining the debris.

Today, after Mr. Kerik's personal links even to Steel recycling' "Mafia" at New Jersey were revealed in 2004, the Question becomes inevitable :

- Both in his and others' cases : Are there any Criminal Responsibilities involved in WTC's strange, vertical and excessively deadly collapse ?

In Particular :

- The most solid, well-documented NIST's finding is that Fires were not the real cause of WTC's collapse, nor Airplanes' impact :

- "Fires did not cause Collapse" : WTC "Towers did not collapse under Aircraft Impact and Fires" alone, repeatedly stresses NIST.

This conclusion seems proved by a long series of Tests, Documentary evidence, Calculations, Logic Arguments, etc.

It confirms "AllTheTruth"'s criticism of ASCE's preliminary draft, back in 2002, which had pushed mainstream Media, like New York Times, AP, etc. to erroneously claim that it was simply the strength of the Fires which bended WTC's steel structure, causing its total destruction.

- According to NIST, it should be a "widely dislodged Fireproofing", and/or other "Structural damage", which caused WTC's collapse.

But NIST is unable to find enough proof on the real situation of WTC's Fireproofing, or even of its Columns...

- Curiously, NIST claims that, despite the huge and controversial disappearance of WTC's Steel, nevertheless, the remaining pieces would provide "sufficient" evidence.

However, this is blatantly contradicted by the Fact that, as it acknowledges, only .. less than 1% of WTC's steel remains : Only 0,25 % !

Moreover, NIST denounces, elsewhere, that there is few or "No Information" available on WTC's exterior and mainly "core Columns", Floors' Trusses, etc., mainly on the crucial question of the level of Fireproofing and thermal Insulation damage, among many other Evidence which lacks : Left without Material proof, it is obliged to "guess" and make "assumptions" on WTC's Steel structure, only by ... "Photos and Videos" !

NIST also observes that WTC's "Fire Alarms", which, normally, could "collect Valuable Information" for "Fires in a Building", were "not used" during 9/11, and, even today, have "No Information" to provide.

Despite the importance of Water Sprinklers and other Fire protection systems which appeared damaged, NIST doesn't even raise any question on what might have happened, a few days before 9/11, during intrusions in WTC's Fire protection mechanisms by shady individuals reportedly involved in an ID-card Fraud and a Murder of witness in Memphis.

NIST notes, nevertheless, that a crucial dislodging of Fireproofing might have been done "Maliciously".

But, once again, it doesn't even ask to extend Enquiries to eventual Criminal interferences in WTC.

+ On the main point : WTC's Collapse, NIST observes that, at first, the Towers' "Upper Section" had started to "Tilt" "towards the Side", and "Rotate" at its Top Part, ready to fall aside and leave the greater part of the building standing.

But, afterwards, suddenly, something happened, and it "changed direction", after strange (and unexplained) "Dust puffs" and a "Dust Cloud" covered the scene : Instead, WTC's upper section, subsequently, "fell Downwards", "Vertically", followed by a "Total, Global Collapse" of all WTC in its entirety, from Top to the Basis.

=> Precisely, this is the most Important Fact on which "AllTheTruth"s critical questions on WTC have focused since 2001 :

It seems natural that the smaller, Top part, hit by Airplanes, would have fallen aside, leaving the longer part of WTC intact, to remain standing, and save many Human Lives.

But, on the contrary, here, an exceptional, never seen before, Vertical and Total Collapse occurred, for unknown reasons, concentrating all WTC's debris at its feet, almost as it occurs in the images of "Controlled Demolitions" (See "AllTheTruth"'s abundant publications and Documentation on that point).

Astonishingly, NIST has NOTHING serious to say in order to explain this paradox :

In 10.000 pages, it adds only one (1 !) short sentence, claiming (WITHOUT ANY PROOF) that "the fall of the (smaller) upper Section above the impact", "exceeded the energy which could be withstand by WTC's Structure in its (much larger) remaining portion". Thus, it's simply .. "Gravity" which would have provoked WTC's "Global Collapse"... Without any Fact, Nor any Argument, or other Proof, at all : Only an unbelievably Short and Empty Claim !

Despite the fact that this controversial claim on WTC's collapse has been largely discussed, analyzed and refuted earlier, including by our own counter-arguments,

nevertheless, NIST behaves as if it hadn't" ever heard anything, and/or didn't have anything to reply ...

=> It says NOTHING at all on the Controversy. Not even a word !

WTC's "vertical", total collapse, too similar to "controlled demolitions", and, plus particularly, the hollow claim about .. "Gravity", has been strongly criticized and refuted, with many arguments and facts, already Years ago :

F. ex. in "AllTheTruth"'s March 2002 Publication, titled : - "NEWTON DID IT, NOT ME !", about Dr Astaneh's claim and "US Congress 1st Hearing on 9/11-WTC" (See :
http://www.freewebz.com/allthetruth/newtondiditnotmeafterusc.htm).

Even if 911 Victims' Families and Friends, Experts, Officials, NGOs, involved Citizens, etc., (even ... U.S. Congress !) have already largely heard and debated about this Controversy about WTC's "vertical, total collapse" and the pseudo - "Gravity" claim,

nevertheless, NIST, after 3 Years of "Enquiry", astonishingly, makes as if it didn't know nothing about all that...

Despite admitting "substantial Uncertainties" on WTC's "Probable" collapse "sequence", which is condemned to remain highly hypothetical, and not convincing at all...

+ Another Important point, concerns WTC's Emergency EVACUATION operations :

- NIST's Data confirm that greatest part among the People who were killed, had been "trapped" in WTC's upper floors, over Aircraft's impact.

=> Most of them died because there was no possibility for Helicopter Rescue from the Top Floor, NIST observes.

This was "one of the few Options available" to those People, NIST rightfully notes.

Moreover, "1968 NYC Code required Access to Roofs", Reports denounce.

- But, Roof Helicopter Evacuation was rejected by NYPD on 9/11, (directed then by ex-Mayor Giuliani's pal, Mr. Kerik), and People were shut off WTC's Top, since Doors had been "Blocked" by a so-called (in)"Security" service, which "trapped" them until an atrocious death...

The Deadly Scandal appears even bigger, since NIST notes that WTC inhabitants had NOT even been WARNED that Doors towards the Top had been "blocked", so that 9/11 Victims would tragically try to go upstairs, provoking even more atrocious deaths..

However, when it comes, precisely, to the Controversy about whether Helicopter Rescue from the Top, could and should, or not, have been carried out, things become surprisingly Nasty :

- NIST simply observes that NYPD (i.e. Mr. Kerik) had "refused" Helicopter Evacuation, and that NY-New Jersey Port Authority had "blocked Doors", without even warning People..

On this crucial, Life or Death, point, NIST only notes that, according to NYPD, an Helicopter had tried to land on WTC's roof at the beginning of Aircraft's Fires, but abandoned any other attempt after facing Heat and Smoke, because of a blatant Refusal and Interdiction ordered by NYPD (that is to say Mr. Kerik, then).

"Helicopter Rescue" from WTC's Top Floors "was NEVER CONSIDERED" by NYPD and NYNJPA, NIST reveals.

- WHY ? - Because someone found "too much Smoke to land", at an "early stage", at the beginning of Aircraft's initial Fire-balls, and because, "only a few" might have been rescued, in such conditions, NIST claims.

But it says Nothing about the period AFTER Aircraft's initial Fires had diminished and even ceased, which was much longer...

And, NIST never explains why "only a few" might have been rescued from the Top of the flat-roofed WTC Towers, and not many : Astonishingly, NIST limits itself only into a 1 sentence Claim, without Proofs, nor arguments, Not any Debate, nothing to convince...

Moreover, Helicopter Rescue from the Building's Top WINDOWS, technically possible, is NOT EVEN CITED, while People were notoriously abandoned and obliged to jump out of WTC's Windows to atrocious Deaths !

At least Technicians might have been able to penetrate at WTC's Roof and repair the Building's Water Supply system for Fire-Sprinklers, which had been reportedly dislodged after Aircrafts' impacts, according to NIST.

But any kind of use of WTC's Flat roofed Tops by Helicopters, had been scandalously "EXCLUDED by NYPD", (that is to say ex-NY Mayor Giuliani's partner, Mr. Kerik).

=> Given the crucial Importance of the matter (most Deaths resulting from People "trapped" by the blockade of WTC's top), NIST should, at least, Seriously Examine all the existing Possibilities, and make a full Enquiry on whether Helicopter Rescue could and should have been used to save Human Lives.

On the contrary, NIST's Drafts astonishingly are Empty on this important point, limited only into copying a NYPD's Controversial claim, and a superficial sentence, without any real proof....

==============

=> NIST Enquiry's Scope was already too narrow :

Nothing about Airplanes' "Hijacking" ; Nor about Political and other stakes for choosing 11 September's Date, among 365 possible per Year ; Nothing on WTC's New York context : Old WTC buildings, out-passed by New Skyscrapers prepared f.ex. at Times Square, where ex-NY Mayor Giuliani chose for his office ; NY-NJ Port Authority's wish to build a New, Bigger "Transport Hub" at WTC's area (as it was proved true these Days) ; etc.

=> It should not become even more restricted, this time by what appears to be at least, among some of NIST's technicians, an astonishing narrow-mindness (See above) ...

People should not be flooded by 10.000 pages of Technical Data, only to find out that, after Years of an Enquiry using millions of Federal Funds, many main, crucial Questions of substance have been hastily and superficially abandoned without any real, serious reply..

NIST should raise and pursue all important issues : Including Criminal and other Responsibilities of some for Hiding or Destroying Material Evidence (f.ex. WTC's Steel, Fire Alarms, etc).

And it's not possible to stress the crucial importance of "dislodged Fireproofing", while remaining, at the same time, Indifferent on Facts indicating that sly Individuals, involved in ID cards Fraud and Murder of eye-Witness, had access to WTC's core, a few days before 9/11, including on Sprinklers, etc.

=> Some well-placed and efficient Enquiries could become "Ariadne's threads" towards unmasking those who are really responsible for 9/11 deadly Barbary...

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- (B) On TIME DEADLINES and BRUTAL HARASSMENTS/OBSTRUCTIONS :

[Brutalities and Harassment delay AllTheTruth's reply => NIST's WTC Enquiry kept in the Dark ?

=> No Bureaucratic Pretexts to Obstruct Critical Observations on so Serious issues as 9/11 !

Surprisingly, AllTheTruth was brutally hindered to present its observations according to NIST's invitation, until 4 August 5.pm. Deadline, and was obliged to do so shortly afterwards.

Some of its main, leading and long-standing members suddenly faced scandalous and unprecedented Brutal or sly Obstruction and/or Harassment, delaying and canceling crucial meetings scheduled to prepare "AllTheTruth"'s reply to NIST's call during the previous week-end.

Even "All The Truth"'s long-standing Website (2001 - 2005) was suddenly aggressed, without any warning, and its Historic content (full of useful Data for NIST's WTC Enquiry was destroyed these days...

Thus, the only possibility was to present, the week-end of NIST's Deadline, at least a brief, incomplete, but substantial critical Note on AllTheTruth's main observations.

AllTheTruth's members were First to call for an Investigation on WTC strange, vertical collapse, (too similar to "controlled demolitions"), and struggled since October 2001, together with Victims' Families and Friends, (mainly Sally Regenhard, NY Firefighters, Experts, and others), to push until the need for a serious Enquiry was acknowledged by U.S. Authorities. This struggle, accompanied by WTC-focused critical observations of rare depth continued for Many Years, 2004 included.

=> Therefore, No Formal, Bureaucratic Pretexts could be convincing as a hollow attempt to Exclude and Ignore "AllTheTruth"s Critical Observations, just for a few Hours/Day, in such a crucial Enquiry spreading along Many YEARS :

Considering also the Importance of the Human, Social and Political Issues at stake, this would be tantamount to excessive formalism and Scandalous Abuse. Everybody would assume its Responsibilities in front of People and History.

A fortiori, when those who brutally and/or slyly obstructed and harassed AllTheTruth's members, in an obvious attempt to destroy Time just at the eve of NIST's deadline,

are astonishingly close (geographically and socio-politically) to certain Circles which have been, since long, suspected and denounced by "AllTheTruth" as probably involved in a trans-national sly Criminal Network which may hide behind 9/11 Barbarities.

=> Who would dare become Accomplice of Brutal and/or sly Aggressors, only in order to skip Critical Observations from People who asked and struggled among the first, since 2001, for a WTC Enquiry ?

NIST's WTC Enquiry should be kept "Clean", crystal-clear, and beyond any suspicion,
without being Stained by Negative Incidents.

As NIST's new Director, Hratch Semerjian, stressed : -"We need to hear from the public" : Until then, "Our job is not done".
"We will finalize our reports ..after receiving public comments.".

(NDLR : This has Nothing to do with U.S. President GWBush, contrary to what some Manipulative Provocations claimed elsewhere : On the contrary, some of "AllTheTruth"s long-standing members, after careful analysis, have actively supported his reElection in 2004 for a fresh, New mandate.

Moreover, AllTheTruth has published the view of most of its members that 911 and a series of other incidents may form a series of attempts to push U.S. President GWBush into a "sly trap", in order to exploit it politically afterwards, for reasons extending to issues of paramount importance for all Humankind).]

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(2) COMMENTS in NIST's Format

(Preliminary, Incomplete, hasty observations to NIST Draft,
given the absence of Time.

NB => See ATTACHED LETTER
for Urgent, recent Events,

overall view and more concrete details).

=====================================

NIST NCSTAR 1 (Draft)

- Page Number:

- Paragraph /Sentence :

- Comment:

- Reason for Comment:

- Suggestion for Revision:

==================================

NIST NCSTAR 1 (Draft)

- Page Number: xxxiv

- Paragraph 2/Sentence 1 : "Public Outreach
During the course of this Investigation, NIST held public briefings and meetings ...to solicit input from the public, present preliminary findings, and obtain comments on the direction and progress of the Investigation from the public ..."

- Comment:
More Input from the Public is needed, until NIST's Enquiry fullfils its mission.

- Reason for Comment:
WTC Investigation is far from completed yet (See infra).

- Suggestion for Revision:
ADD : "... NIST held [+ AND WILL HOLD] public briefings and meetings ...to solicit input from the public, present preliminary findings, and obtain comments ..;"
==========================

NIST NCSTAR 1 (Draft)

- Page Number: xli

- Paragraph 1/Sentence 1 : "E.1 GENESIS OF THIS INVESTIGATION
On August 21, 2002, the National Institute of Standards and Technology (NIST) announced its building and fire safety investigation of the World Trade Center (WTC) disaster."

- Comment:
It ommits the True "Genesis" of WTC's Investigation : - WTC Investigation's "Genesis" stems from pressing demands of 9/11Victims' Families and Friends, as well as concerned Citizens and Experts, who strived since October 2001 up to August 2002 to ask for an Independent, Transparent, Efficient and Full Investigation on WTC collapse and those really responsible.

Sally Regenhard (since December 2001) and "All The Truth"'s members and Friends (since October 2001), as well as NY Firefighters, etc. (since November 2001), spearheaded the Popular demand for an WTC Investigation from the start.

- Reason for Comment: (See Supra).

- Suggestion for Revision:
+ ADDE : + AFTER ALLMOST A YEAR OF PRESSING DEMANDS FROM 9/11 VICTIMS' FAMILIES AND FRIENDS, ..."on Augusr 21, 2002, ..(../..)"

==================================

NIST NCSTAR 1 (Draft)

- Page Number: xlii

- Paragraph 3/Sentence 1 :
"The scarcity of physical evidence
that is typically available in place for reconstruction of a disaster
..."

- Comment:
It ommits to mention the important Fact that a strong Controversy opposed Victims' Families and Friends to ex-NYC Mayor Mr. Giuliani because of his decision to recycle almost all WTC's Steel, removing and destroying most of the available "Physical Evidence".

- Reason for Comment: (See supra).

- Suggestion for Revision:
+ ADDE : + THE CONTROVERSIAL REMOVAL OF ALMOST ALL OF WTC's STEEL, DESPITE PROTESTS FROM VICTIMS' FAMILIES AND FRIENDS, PROVOKED A ..

scarcity of physical evidence ...."

==================================

NIST NCSTAR 1 (Draft)

- Page Number: xliii

- Paragraph 3/Sentence 1 :
"The output ... was subject to uncertainties in the as-built condition of the towers, the interior layout and furnishings, the aircraft impact, the internal damage to the towers (especially the thermal insulation for fire protection of the structural steel, which is colloquially referred to as fireproofing), the redistribution of the combustibles, and the response of the building structural components to the heat from the fires. ..."

- Comment:
Ommits to mention the main Cause of those "Uncertainties".

- Reason for Comment:
It is important not to hide the Truth that the controversial Destruction of most Material Evidence (WTC Steel and debris : See supra) is one of the most grave obstacles to NIST's Investigation, causing many "Uncertainties".

- Suggestion for Revision:
+ ADDE : + BECAUSE OF THE EARLY DESTRUCTION OF MATERIAL EVIDENCE (MAINLY WTC's STEEL), "the output .. was subject to Uncertainties ..."

==================================

NIST NCSTAR 1 (Draft)

- Page Number: xliii

- Paragraph 6/Sentence 1 :
"The two aircraft hit the towers at high speed and did considerable damage to principal structural components: core columns, floors, and perimeter columns."

- Comment:
Inaccurate.

- Reason for Comment:
NIST admits, elsewhere, that for the situation of most Columns which were not directly hit by Debris (90 % of WTC's structure !) there is "No Information"..

- Suggestion for Revision:

+ INSERT : + "The two aircraft hit the towers at high speed and did considerable damage to principal structural components: THOSE core columns, floors, and perimeter columns WHICH WERE DIRECTLY AFFECTED BY DEBRIS".

==================================

NIST NCSTAR 1 (Draft)

- Page Number:
xliii

- Paragraph 7/Sentences 1 + 2:
"In WTC 1, the fires weakened the core columns and caused the floors on the south side of the building to sag. ....

.. The top section of the building tilted to the south and began its descent."

- Comment:
Grossly Inaccurate (See also infra).

- Reason for Comment:
(a) Proof for "weakening" by the "fires" was found by NIST only on Columns hit by Debris, while it had "No Information" on any other Columns (90% of WTC's building remaining standing, beneath).

(b) The "Top .. tilted" aside, at first.
But something happened, afterwards, and it "changed" its direction and appearance, replacing it wifh a "Vertical, Total Collapse" of all WTC, (instead of toppling over and falling to one side.(See + infra)

There are 2 different, and opposite movements, and not only one.

=> Simply claim that it was .."Gravity", which destroyed 90% of WTC "robust" buildings, which remained intact, is obviously not enough, nor convincing - particularly after a long Controversy in many and various Published texts and Debates 2001 - 2004. (See attached Letter for more concrete Details).

- Suggestion for Revision:
+ INSERT : - "The top section of the building INITIALLY tilted to the south.

BUT AFTERWARDS, INSTEAD OF FALLING ASIDE, AND LEAVING THE REST OF THE BUILDING INTACT, ON THE CONTRARY, IT SUDDENLY began TO descent, AND DISINTEGRATE VERTICALLY, TOGETHER WITH ALL THE REST OF WTC BUILDING"

+ "NO CLEAR AND UNQUESTIONABLE PROOF WAS YET FOUND FOR THE REAL CAUSE OF
THAT RADICAL AND CRUCIAL "CHANGE"

=> A SERIOUS AND THOROUGH INVESTIGATION IS REQUIRED IN ORDER TO ESTABLISH THE FACTS, DISSIPATE ANY INCOMPREHENSIBLE PHENOMENON (f.ex. "Dust Clouds" cited by NIST) AND ANY CONTROVERSY ON WHAT PROVOCED WTC's VERTICAL, TOTAL COLLAPSE".

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NIST NCSTAR 1 (Draft)

- Page Number: xliv

- Paragraph 3/Sentence 1 :
"The WTC towers likely would not have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact."

- Comment:
Interesting NIST Finding, but its Cause remains largely Unknown : => A full Investigation is required. (See attached Letter).

- Reason for Comment:
For such a Crucial Fact, its Cause must be clearly established.

- Suggestion for Revision:
+ ADDE, IN FINE : "....+ AN INVESTIGATION ON WHAT CAUSED SUCH A WIDE DISLODGING OF THERMAL INSULATION MUST BE SERIOUSLY AND THOROUGHLY CONDUCTED UNTIL ALL MAIN FACTS ARE KNOWN".

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NIST NCSTAR 1 (Draft)

- Page Number: xliv

- Paragraph 1 /Sentence 5 :
"• In WTC 2, ...The top section of
the building tilted to the east and to the south

and began its descent."

- Comment: (Comp. above).

- Reason for Comment: (Comp. above).

- Suggestion for Revision: (Comp. above).

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NIST NCSTAR 1 (Draft)

- Page Number: xliv

- Paragraph 2 /Sentence 2 :
"... In WTC 1, ...1,355 people were trapped in the upper floors .."

+ ADDE NEW

- Comment:
Astonishingly, nothing is said about more than a Thousand People notoriously "trapped" at the upper floors by the Controversial Blocked Doors and mainly the absence of Helicopter Rescue, (despite the access requested even by NYC 1968 Code, but refused by NYPD - Mr. Kerik).

This is a very grave Ommission,
risking to compromise NIST's objectivity in the eyes of the Public.

When even the minor issue of a few "disabled" people takes a whole paragraph, there is no excuse to totally ommit the long-standing Controversy on Helicopter Rescue at Flat-roofed high-rise buildings, which affected more than a Thousand People at WTC...

- Reason for Comment:
NB : See attached Letter for many concrete details.

- Suggestion for Revision:
+ ADDE : + "In WTC 1, ...1,355 people were trapped in the upper floors
.. BY DOORS WHICH HAD BEEN BLOCKED WITHOUT WARNING, AND BY A CONTROVERSIAL ABSENCE OF ANY HELICOPTER RESCUE FROM THE TOP AND/OR FROM
THE WINDOWS".

(+ Skip the MISLEADING sentence "where the aircraft destroyed all escape routes" : It was NYPD's chief who refused any Helicopter Rescue and had blocked the Doors towards WTC's Top.

NIST's Reports don't have any serious Evidence, nor solid, unquestionable Proof, that Helicopter Rescue would be really "impossible", as he claimed. (See attached Letter)

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NIST NCSTAR 1 (Draft)

- Page Number: xlvii

- Paragraph 9 /Sentence 1 :
"• Improved Building Evacuation: Building evacuation should be improved to include system designs that facilitate safe and rapid egress, ..."

- Comment:
Helicopter Rescue technics, from the Top Floors and Upper Windows, must be studied and developped for High-Rise buildings and Skyscrapers.

- Reason for Comment:
WTC proved that Thousands of Human Lives at High Rise Buildings often depend on the existence or absence of Helicopter Rescue technics.

- Suggestion for Revision:
+ ADDE, IN FINE : ""• Improved Building Evacuation: Building evacuation should be improved to include system designs that facilitate safe and rapid egress, ...INCLUDING POSSIBILITIES FOR ANY HELLICOPTER RESCUE FOR HIGH-RISE BUILDINGS AND SKYSCRAPERS... "

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NB :

- These observations, naturally should be repeated whenever NIST's Draft repeats similar issues (there are many such repetitions).

+ Many other observations = Ommitted, because of Time restraints.

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Email at : all_the_truth@ftml.net.
www.freewebs.com/allthetruth +
(Currently under Attack by strange Hackers, who destroyed 5 Years of publications : 2001 - 2005, precisely this week of NIST's WTC Enquiry !

Frequently updated, according to main developments and investigations' needs and results.

Investigative Website dedicated to help all those who search to find the whole truth on 9/11 Barbarities and other outstanding crises around the World.

Founded by a group of people who initiated Public Debates on 9/11 (and NY FF's) concluding (since end October 2001) into an "Urgent call for an independent, pluralist, transparent and full Enquiry
(starting by WTC's strange, deadly implosions)
before Material and Witnesses' Evidence is destroyed".

From the beginning and for Years, "AllTheTruth" has been striving
(in a desinterested, benevolent, active and serious way, facing various aggressions and sacrificing even health of some of its members) to help unveil all the truth and shred full light on all 9/11Barbarities,
despite
surprising strange obstacles.

Supports from the start (mid-December 2001) Sally Regenhard's Call for an "Independent Blue Ribbon Panel Enquiry on Why (and How) WTC collapsed", as well as (27 Feb. 2002) the call of "Families of September 11" to "extend" USC-checked "independent Investigation" on the way 4 Airplanes were led and let to be hijacked and crashed.]

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From: "Carolyn Fitch" <cfitch@ncsbcs.org>
To: <wtc@nist.gov>
Cc: <coopercg@ci.richmond.va.us ...snip... mail\)" <rwible@ncsbcs.org>
Subject: AMCBO Comments to WTC Final Report

The Association of Major City & County Building Officials (AMCBO) is pleased to submit the attached comments to the Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Towers.

Carolyn Fitch
AMCBO Secretariat Staff
703 437-0100 ext. 238

AMCBO Comments WTC Report 080405.doc

AMCBO

Association of Major City/County
Building Officials
505 Huntmar Park Drive, Suite 210
Herndon, VA 20170
(703) 437-0100. Fax (703) 481-3596

To: Dr. Shyam Sunder, Acting Assistant Director, Building and Fire Research Laboratory, and Lead Investigator, World Trade Center Disaster

From: Claude Cooper, AMCBO Chairman

Cc: U. S. Conference of Mayors
National Association of Counties
AMCBO Members

Date: August 3, 2005

Subject: Comments from the Association of Major City and County Building Officials on the June 23, 2005, Draft Final Report and Recommendations of the National Construction Safety Team on the World Trade Center Collapse

Thank you for inviting national comment on the June 23 draft final report of the National Construction Safety Team on the collapse of the World Trade Center and its 30 recommendations. Representing the building commissioners of the nation's largest cities and counties, AMCBO is pleased to offer for NIST's consideration the following comments.

<u>Overview of Report & Recommendations</u>

The National Institute of Standards and Technology has done an excellent job of thoroughly analyzing the effect of the tragedy on September 11, 2001, at the World Trade Center on the buildings occupants and first responders. The attack on, fires, and subsequent collapse of the World Trade Center represents a unique event that hopefully will not be repeated. Nevertheless, there certainly are lessons that can be learned from this unfortunate disaster.

There is a natural tendency among some in our community to "let the report stand on its own and let the model codes and standards communities deal with it." However, those of us who are public officials in major cities and counties realize that terrorism can strike anywhere and at any time – especially at targets that are highly visible or strategic to our economy. Typically those targets will continue to be in our major urban areas, and they will involve iconic buildings or buildings of significant economic importance. That being the case, major jurisdictions have a stake in your report and AMCBO offers the following overarching and specific comments.

Overarching Comments

Safety Record of High Rise Buildings: The attack on and collapse of the World Trade Center is a unique tragedy and one should be careful in interpreting the results of the NIST report. It could be easy for some to read the report and conclude that all high rise buildings are dangerous. That would not square with the facts that high rise buildings in this country have an enviable safety record. Fewer lives are lost annually in high rise buildings than in single family detached dwellings. We believe that NIST makes that distinction in its report. We trust that others reading the NIST report will likewise do so and the NIST findings will not be used to undermine public confidence in our existing high rise building stock.

Role that High Rise Construction Plays in Major Jurisdictions: Over the last half-century, the land use policies in this country have been questionable. Americans embraced the automobile and after World War II were off to the suburbs. The green countryside gave way to suburbia and many city dwellers took advantage of it, creating urban blight. The result has been rush-hour congestion, traffic jams, smog and environmental degradation. Cities have been denied the tax base of the suburbs while attempting to deal with a diverse population with high social needs. Cities have had to deal with the social issues of a population often with a low income, crime and urban decay. After a half-century, Americans are beginning to reverse this trend and find their way back to urban life for its cultural amenities and conveniences.

Cities have to have high rise buildings for commercial, residential, and cultural purposes. Cities will suffer if they lose the prospect of high rise buildings because they will become too expensive to construct or the public fears their safety. People could get the perception that high rise buildings are inherently dangerous and decide that "urban sprawl" is more desirable. In truth, smart growth and growth that goes up is better overall than less dense sprawl.

More enlightened land use policies allow cities to develop dense population areas by building high rise buildings. These urban areas can be served by mass transit that is more environmentally friendly and more energy efficient than the automobile. In addition, the needs of an aging population can be better served in a dense urban area than in suburbia. This report could be one factor in creating another flight from the city if it is used to create a perception that existing high rise buildings are inherently unsafe. Also, addressing a perceived "safety problem" may create regulations that make high rise buildings uneconomical to construct. This would be unfortunate for America's cities and surrounding counties and would be counter productive for a robust economy.

A common "rule of thumb" is that at least 80% of the gross floor area of a building must be leasable floor space for an economic building. High rise buildings may be priced "out of the market" if design constraints and safety requirements reduce that ratio below 80%. This issue and other cost implications need to be addressed in implementing recommendations in the NIST World Trade Center report.

Impact on Existing Building Stock and Retrofit: The NIST report studied the World Trade Center and orientated most of its recommendations toward new construction. In truth, there is a large stock of existing buildings in cities. The age of these buildings ranges from 1 to 100 years. These buildings must remain useable components of our building stock. Economic vitality and historical preservation are important reasons for cities to reuse the existing building stock. A significant percentage of development in urban areas is funded by "tax breaks" from historic preservation interests. NIST should be encouraged to study methods for economically retrofitting safety improvements in these buildings. AMCBO recognizes that retrofitting is very complex, and it will require considerable research and funding from multiple sources.

These existing buildings can be grouped into commercial and residential buildings for discussion purposes.

Commercial buildings are those buildings used for business, mercantile, assembly and other related purposes. Generally, the private sector can do a limited amount of safety related improvements if they can "pass the costs through" to the tenants with a long-term lease. This is generally ten years. However, there must be a legal basis for establishing this need. The results of NIST research can provide the scientific and technical basis for determining the legal requirement.

Residential buildings include condominiums and apartments. Typically these are occupied by older Americans and a significant percentage of the occupants are on a "fixed income". They cannot absorb the cost of making these safety-related improvements. Also, these people are politically active. It is very difficult politically for politicians to impose new building regulations on these people to make safety-related improvements in the building. NIST research can help identify less expensive alternatives and help find improvements that are more feasible.

Comments Specific to the Eight Groupings of NIST Recommendations

AMCBO has specific positions on each of the groups of recommendations as follows:

Group 1 Increased Structural Integrity
AMCBO endorses these recommendations.

Group 2 Enhanced Fire Resistance of Structures
AMCBO endorses these recommendations and suggests that NIST seek funding to conduct the research needed to secure answers to these questions. Manufacturers of products fund much of the research on fire rating of assemblies. These recommendations go further and recommend that more research be done into the underlying assumptions of building design for life safety. AMCBO feels that research is needed to secure answers to these questions and that the Government should conduct the research.

Group 3 New Methods of Fire Resistance Design of Structures
AMCBO endorses these recommendations and suggests that NIST seek funding to conduct the research needed to secure answers to these questions.

Group 4 Improved Active Fire Protection
AMCBO endorses these recommendations.

Group 5 Improved Building Evacuation
AMCBO feels that research is needed on evacuation techniques and practices and that the Government should conduct the research.

Group 6 Improved Emergency Response
AMCBO endorses these recommendations.

Group 7 Improved Procedures and Practices
AMCBO endorses these recommendations.

Group 8 Education and Training
AMCBO endorses these recommendations.

AMCBO thanks NIST for this study and urges it to work with the construction and codes and standards communities and regulatory and elected officials to take a careful approach toward implementation least it produces a product that is too expensive to construct. Also, a global vision is needed along with more research – a global vision that keeps our urban areas as desirable and viable places to work and live.

AMCBO commits itself to assisting NIST on an "as needed" basis for further research or comments on future efforts. In that regard please feel free to contact me in Richmond at 804 646-6624 or contact AMCBO Secretariat, Robert Wible, at 703 481-2035.

Sincerely,

Claude G Cooper

Claude Cooper
AMCBO Chairman

From: "Mr. Kim Clawson" <kclawson@voa.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/4/2005.

Name : Mr. Kim Clawson
Affiliation : Architect
Email Address : kclawson@voa.com
Phone : 312-453-7615
Report Number : NCSTAR 1
Page Number : 218
Paragraph : "...no later than August 4, 2005..."
Comment : The amount of review and response time for commenting on the 30 recommendations is inadequate, and should be extended, or a second review and response period should be provided.
Comment Reason : In many respects the recommendations should ultimately be the most important outcome of the WTC study. Although the findings of the investigation were released in a continuing manner as the investigation progressed over nearly a two year period, the recommendations were withheld, and a mere six weeks has been granted to review and formulate responses.

Revision Suggestion : If NIST is truly serious about obtaining meaningful dialogue regarding these recommendations, and providing recommendations that lead to responsible and effective changes, then an expanded and extended dialogue and response time should be provided.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Conrad Izatt <conrad.izatt@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : Conrad Izatt
Affiliation : Arup ATG
Email Address : conrad.izatt@arup.com
Phone : 02077552244
Report Number : NCSTAR1-2B
Page Number : Page 11
Paragraph : Section 2.2.3 Paragraph 1
Comment : The synthetic stress-strain curves were based on several data sources to account for the multiple sources of steel used in the construction of the WTC towers. It would have been more sensible and representative to base the steel material properties on the synthetic stress-strain curves rather than on a set of test results for one particular steel.
Comment Reason : Steel material properties could be more representative of the variety of steels used in the WTC towers.

Revision Suggestion : Explain why the steel material properties were based on a set of test results for one particular steel rather than the synthetic stress-strain curves developed.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Conrad Izatt <conrad.izatt@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : Conrad Izatt
Affiliation : Arup ATG
Email Address : conrad.izatt@arup.com
Phone : 02077552244
Report Number : NCSTAR1-2B
Page Number : Page 14
Paragraph : Section 2.2.4 Paragraph 1
Comment : The use of Cowper-Symonds parameters to factor the yield-strength is a relatively crude method and (for a particular strain rate) factors the whole stress-strain curve by the same amount. In reality, the strain rate enhancement at a particular strain rate differs along the whole stress-strain curve. If the tests were performed at high strain rates, then stress-strain curves should have been available at these high strain rates. The steel material properties could have been input into the material model as a table of stress-strain curves at different strain rates.
Comment Reason : Steel material strain-rate properties could be modelled more accurately.

Revision Suggestion : Explain why Cowper-Symonds parameters were used instead of using the high strain rate stress-strain curves.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Conrad Izatt <conrad.izatt@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : Conrad Izatt
Affiliation : Arup ATG
Email Address : conrad.izatt@arup.com
Phone : 02077552244
Report Number : NCSTAR1-2B
Page Number : Page 15
Paragraph : Section 2.2.4 Table 2-1
Comment : It is not clear whether the brick element failure strains quoted in Table 2-1 are applicable to the fine or medium meshes.
Comment Reason : Unclear applicability of brick element failure strain values.

Revision Suggestion : Explain what the brick element failure strains in Table 2-1 are applicable to.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Conrad Izatt <conrad.izatt@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : Conrad Izatt
Affiliation : Arup ATG
Email Address : conrad.izatt@arup.com
Phone : 02077552244
Report Number : NCSTAR1-2B
Page Number : Page 26
Paragraph : Section 2.4 Concrete Constitutive Models
Comment : There are many constitutive models available in LS-DYNA which can represent concrete behaviour. In addition to the compression behaviour, the tensile behaviour (cracking and fracture) is also likely to be important.
Other concrete material models (such as the Winfrith concrete model □ material type 84) are able to represent the cracking and fracture energy with greater realism than the pseudo-tensor material model.
Comment Reason : Other constitutive models within LS-DYNA may have provided a more realistic behaviour, particularly for tensile cracking and fracture.

Revision Suggestion : Explain with more detail why LS-DYNA material type 16 (pseudo-tensor concrete) was chosen in preference to other available material models.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Conrad Izatt <conrad.izatt@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : Conrad Izatt
Affiliation : Arup ATG
Email Address : conrad.izatt@arup.com
Phone : 02077552244
Report Number : NCSTAR1-2B
Page Number : Page 26
Paragraph : Section 2.4 Concrete Constitutive Models
Comment : This section does not give any information concerning any aspects of the tensile behaviour of the concrete.
Comment Reason : An important aspect of the concrete behaviour has not been accounted for.

Revision Suggestion : Describe the behaviour and modelling of the tensile aspects of the concrete.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Conrad Izatt <conrad.izatt@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : Conrad Izatt
Affiliation : Arup ATG
Email Address : conrad.izatt@arup.com
Phone : 02077552244
Report Number : NCSTAR1-2B
Page Number : Page 27
Paragraph : Section 2.4 Concrete Constitutive Models
Comment : The simulation of an unconfined concrete compression test is a very basic test and demonstrates only one aspect of the material behaviour. Concrete material behaviour is complicated and requires many different tests to demonstrate that the material model and parameters adequately represent realistic concrete behaviour in the likely impact conditions.
Comment Reason : The simple unconfined concrete compression test is not sufficient to demonstrate the adequacy of the material model and parameters.

Revision Suggestion : A more rigorous demonstration that the concrete modelling is adequately representative of the concrete behaviour under all of the likely loading scenarios.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Conrad Izatt <conrad.izatt@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : Conrad Izatt
Affiliation : Arup ATG
Email Address : conrad.izatt@arup.com
Phone : 02077552244
Report Number : NCSTAR1-2B
Page Number : Page 32
Paragraph : Section 2.4 Figure 2-32 Concrete Constitutive Models
Comment : The curve for the strain rate multiplier shown in Figure 2-32 shows a smooth and gradual increase from a strain rate of 0.1/s up to 1000/s. There is much published documentation (including the references quoted in the work) that indicates that the curve is not smooth and gradual, but kinked (little increase up to about 30/s and then increasing above that).
Comment Reason : The strain rate enhancement curve used differs slightly in shape from the more usual and accepted shape.

Revision Suggestion : Explain why the more usual and accepted strain rate enhancement has not been used.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Conrad Izatt <conrad.izatt@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : Conrad Izatt
Affiliation : Arup ATG
Email Address : conrad.izatt@arup.com
Phone : 02077552244
Report Number : NCSTAR1-2B
Page Number : Page 112
Paragraph : Section 5.4 Floor Assembly Component Analyses
Comment : The plow-type impactor used to test the detailed and simplified floor assembly component models appears to have a predominately cutting action. The impact from an engine is more likely to be a blunt impact.
Comment Reason : The impactor uses a cutting action which is not the same as a blunt impact.

Revision Suggestion : A more rigorous demonstration that the simplified model of the floor assembly adequately captures the impact behaviour of the detailed model for the likely impact scenarios.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Conrad Izatt <conrad.izatt@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : Conrad Izatt
Affiliation : Arup ATG
Email Address : conrad.izatt@arup.com
Phone : 02077552244
Report Number : NCSTAR1-2B
Page Number : Page 112
Paragraph : Section 5.4 Floor Assembly Component Analyses
Comment : The plow-type impactor used to test the detailed and simplified floor assembly component models appears to have a predominately upwards loading action. The impact from an engine is more likely to be a downwards impact.
Comment Reason : The loading direction from the impactor appears to be opposite to the more likely loading direction in the actual impacts.

Revision Suggestion : A more rigorous demonstration that the simplified model of the floor assembly adequately captures the impact behaviour of the detailed model for the likely impact scenarios.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Faith Wainwright <faith.wainwright@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Faith Wainwright
Affiliation : Arup ATG
Email Address : faith.wainwright@arup.com
Phone : +44 2077552051
Report Number : NCSTAR 1
Page Number : Page 201
Paragraph : Section 9.2.1 Recommendation 1
Comment : Recommendation 1a which states that progressive collapse should be prevented in buildings is supported. We make the following specific comments:

1. Progressive collapse should not be considered as the same as disproportionate collapse. Progressive collapse may not be seen as disproportionate to the cause if the damage event causing it is so extreme - indeed WTC 1 and 2 suffered progressive collapse, but this was not considered disproportionate to the causal event. We offer the following commentary and definitions:

Progressive. Progressive collapse is a term to describe the spreading of the collapse of one part of the structure to other areas that were initially not touched by the damage event, such as a fire or blast. Progressive collapse occurs where one part of the structure is reliant upon the performance of other parts which then become damaged, or where the debris from the damage overloads other parts of the structure, which then collapse under this abnormal load.

Disproportionate. Disproportionate damage occurs when the consequence of the event is far greater than expected. As such, there is a link between the event witnessed and the expectation of the damage it results in, before the extent of that damage becomes known. This is about human perception and it relates not only to buildings but also to organizations.
For buildings, □small□ damage events would generally be expected to have □small□ consequences i.e. □small□ amounts of damage. Similarly, □large□ events are expected to cause large amounts of damage, particularly if the event is rare or unforeseen. A □small event□ that results in □large□ amounts of damage would be considered disproportionate.

Disproportionate damage - a definition
Damage that is more extensive than would generally be expected in consideration of the event
Progressive collapse - a definition
The spreading of the collapse of one part of the structure to other parts that were initially not affected by the damage event.

2. Design to prevent progressive collapse can be accomplished

In

Either :

a) with prescriptive rules, determined with certain abnormal loading events in mind □ (such as has been the case in the UK post the 1968 Ronan-Point collapse until 2004)

or

b) with performance based rules, determined with certain abnormal loading events in mind which are pre-defined (eg a gas explosion of a certain magnitude, a truck impact)

or

c) with performance based rules, to be used with a building-specific risk assessment of the hazards.

For high-risk buildings, (c) should be the approach, with the risk assessment being shared amongst the design team and building owner/developer. However for other buildings, and as a minimum requirement for high risk buildings, it would be sensible to have the approach to abnormal loads well defined. This is required to enable the development of a common, checkable and enforceable approach. Such definition need not be prescriptive but should generally relate to accidental rather than malicious abnormal loads. The reasons for this is two fold, firstly quantifying the risk to a normal building from malicious acts both in terms of scale and probability is difficult and will vary both with building occupier and the general political climate. Secondly experience shows that designs which are resilient to accidental damage also have a degree of resilience to malicious acts.

3. Connection design is rightly identified as critical in designing for loads to be redistributed following loss of an element. Furthermore the need for ductility in connection design is identified. There is currently inadequate performance data on connections, to allow simple specification of connections that have adequate ductility to cope with the deformations expected after, say, loss of one column. Developing a standard set of connections, quantifying ductility demand and performance, are high priorities. Much can be gained from experience in seismic regions but significant differences in the amount of rotation and the post event load need to be understood.

We consider that issues (2) and (3) □ clarity on how the loads are established, and development of data related to different connection design, are the areas most in need of attention for the vast majority of building designs. Attention to these issues would give maximum benefit in terms of efficiency of design costs and construction costs whilst fulfilling the requirement for designing against progressive collapse.

Comment Reason :

Revision Suggestion : Many threats to buildings are common across the globe and many building owners are global organizations. Developing methodologies that provide uniform levels of safety across national boundaries should be encouraged. We therefore consider that the methodologies developed should acknowledge and inform those approaches being developed elsewhere in the world.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Jeff Tubbs <jeff.tubbs@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Jeff Tubbs
Affiliation : Arup ATG
Email Address : jeff.tubbs@arup.com
Phone : +1 508 616 9992
Report Number : NCSTAR 1
Page Number : 210
Paragraph : Recommendation 16
Comment : Arup Comment. We agree; clearly, an effective campaign could make great strides in increasing public awareness of safety procedures and could increase the likelihood of the general public making better decisions in emergency situations. Currently, a large portion of the general public likely considers film and television portrayals of disasters as reality.

This recommendation embodies several components: (1) provide better training and drills for evacuation procedures within individual buildings; (2) provide training for the general public; and (3) develop an evacuation standard (it seems to be implied within the commentary that a standard should be developed). Several issues should be addressed. First, it is unclear which public agencies and non-profit organizations should be involved and what form should the public information campaigns take (i.e. television, radio, or other media). It is suggested that roles be better defined, or suggestions for members of a steering committee should be provided. Second, it is unclear what funding mechanisms could support a consistent comprehensive nationwide educational campaign. While a comprehensive national standard for building emergency planning, and evacuation training and plans would be a marked improvement over the current fragmented bits of information, specific information should be provided so that this recommendation can be moved forward. A joint NFPA / ICC national standard, with representation from AIA, SFPE, NIBS, NCSBCS, BOMA, and CTBUH would effectively include many of the important parties. Lastly, NFPA and ICC should be included within the effected organizations.

Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Jeff Tubbs <jeff.tubbs@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Jeff Tubbs
Affiliation : Arup ATG
Email Address : jeff.tubbs@arup.com
Phone : +1 508 616 9992
Report Number : NCSTAR 1
Page Number : 211
Paragraph : Recommendation 17
Comment : We generally agree; however, we recommend that building evacuation strategies be developed through application of comprehensive risk-informed performance analyses for tall or iconic buildings, or for buildings with large populations. Consistently applying this approach could greatly improve safety within America□s buildings.

Building codes and the ADA should provide consistent policies for providing safe evacuation policies for wheel chair users and other mobility challenged occupants.

We have several additional comments regarding the implementation of this recommendation.

a) The text of NCSTAR 1-7 report does not critique egress models. The main report discusses specific issues and specific areas for improvements for egress models. We believe that issues such as better modeling merging flows, better characterizing pre-decisional times, better understanding the range of occupant mobility, and better understanding of visibility and egress through smoke and other adverse conditions be should given priority. Perhaps understanding how fatigue affects mobility, as well as fire fighter effectiveness, affect ascend/descending a large number of flights, should be given the highest priority. This is important not only in high rise buildings but also for deep basements were the flows are reversed.

b) We do not agree that models should consider tenability conditions in stairways. Specific measures should be provided to sufficiently protect stairs, so that these protected areas can be used as designed. Assuming that use of the stair could be affected introduces many possible uncertainties and may develop a wide scatter of evacuation times. This scatter would likely exceed our current understanding of key issues such as pre-decisional times and merging flows.

c) The report indicates that counter flow by emergency responders was not a significant delaying factor in the stairs (NISTNCSTAR1-7 Report Section 11.3 item 3). This recommendation seems contrary to that point. We are in favor of accounting for counter flows; however, we are not in favor of providing a dedicated stairway for responder use. During the initial evacuation, a dedicated stairway could be better used for much needed evacuation capacity. Additionally, given likely fatigue severely limiting responder capabilities after ascending many floors, we urge fire departments and standards organizations to give serious attention to elevator-based fire fighter access systems.

d) From the report, it appears that occupant movement speeds were below that found in the research literature (NISTNCSTAR1-7 Report Section 10.1.2). It is possible, and perhaps likely, that occupant fatigue contributed to this. We recommend investigating the ability of a representative mixed ability population to travel down 40 to 70 or more stories of stairs. Based upon this observation, consideration may need to be given to including rest spaces on stair landings, in locations that will not affect the overall flow of occupants.

Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Jeff Tubbs <jeff.tubbs@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Jeff Tubbs
Affiliation : Arup ATG
Email Address : jeff.tubbs@arup.com
Phone : +1 508 616 9992
Report Number : NCSTAR 1
Page Number : 212
Paragraph : Recommendation 18
Comment : We agree in principal with the recommendation; however, we would recommend a risk-informed performance approach to develop appropriate survivability criteria. We aggress that consistent layouts, standard signage and guidance are essential to facilitate way finding and to develop usable evacuation components.

Exit remoteness, in the context of extreme events, is difficult to effectively require through prescriptive criteria; meaningful separation in one event may not be effective in another type of event. The actual distance achieved depends on the size of the building, and a fixed minimum may simply be unachievable. For instance, consider a tall slender building with stairways located on opposite facades, while this scenario would work well for fires, it may cause additional exposure for external bomb threats. Therefore, while we agree in principal, we suggest Item 1 include and additional qualifier: □.. (1) to maximize remoteness of egress components (i.e., stairs, elevators, exits) while achieving appropriate balance for other building threats, such as blast, or high-wind exposures and without negatively impacting the average travel distance ..□

Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Jeff Tubbs <jeff.tubbs@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Jeff Tubbs
Affiliation : Arup ATG
Email Address : jeff.tubbs@arup.com
Phone : +1 508 616 9992
Report Number : NCSTAR 1
Page Number : 213
Paragraph : Recommendation 19
Comment : One of the clearest messages from the NCSTAR 1-7 report is that more people might have survived if it had been possible for incident management to have gathered a better overall view of the situation, and to have given unambiguous evacuation instructions to occupants. Therefore, we agree with this recommendation. However, we do caution on providing too much information, as this may cause longer pre-decisional times for evacuation. Also, it is imperative that coordinated and consistent information be provided across all media. Due to costs issues associated with the process of listing devices, some of the suggested devices would likely need to be non-listed supplementary devices. Some readers may not appreciate this, so we would recommend providing a brief discussion. We would also suggest including more detail as to what types of messages and updates, or perhaps recommending a task force to make these recommendations.
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Jeff Tubbs <jeff.tubbs@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Jeff Tubbs
Affiliation : Arup ATG
Email Address : jeff.tubbs@arup.com
Phone : +1 508 616 9992
Report Number : NCSTAR 1
Page Number : 214
Paragraph : Recommendation 20
Comment : We agree that all emerging technologies should be given appropriate review. We advocate that protected elevators should be considered for tall buildings. If this moves forward on a wide scale, then it is imperative that building occupants, as well as the public in general, be trained to correctly use the systems. Consideration should be given to joint training exercises with the emergency services so that all better understand and experience how the system works and what information needs to be transferred. We would caution that emerging technologies pass this rigors imposed by listing agencies before being installed within buildings.
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Jim Quiter <jim.quiter@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Jim Quiter
Affiliation : Arup ATG
Email Address : jim.quiter@arup.com
Phone : 415 957 9445
Report Number : NCSTAR 1
Page Number : 224
Paragraph : Table 9b
Comment : IBC, IEBC, IFC and NFPA 5000 are affected by more than Group 2 and 7 comments
Comment Reason : to clarify roles for moving forward

Revision Suggestion : Include the following groups for IBC, IEBC, IFC and NFPA 5000:
2. Enhanced Fire Resistance of Structures
3. New Methods for Fire Resistance Design of Structures
4. Enhanced Active Fire Protection
5. Improved Building Evacuation
7. Improved Procedures and Practices

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Jim Quiter <jim.quiter@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Jim Quiter
Affiliation : Arup ATG
Email Address : jim.quiter@arup.com
Phone : 415 957 9445
Report Number : NCSTAR 1
Page Number : 210
Paragraph : 9.2.5 / Recommendation 16
Comment : (1) It is suggested that roles be better defined, or recommendations for a national steering committee be provided to develop better define roles should be provided for developing emergency planning, evacuation plans, and occupant emergency / evacuation training, as well as the overall national public information campaign. A joint NFPA / ICC national standard, with representation from AIA, ASME, ASCE, BOMA, CTBUH, IAFC, NCSBCS, NIBS, NASFM and SFPE would be a first pass at include many of the important parties.
(2) Additionally, specific funding mechanisms should be suggested.
(3) NFPA and ICC should be included within the effected organizations.

Comment Reason : (1) It is unclear which public agencies and non-profit organizations should be involved and what form should the public information campaigns take (i.e. television, radio, or other media). While a comprehensive national standard for building emergency planning, and evacuation training and plans would be a marked improvement over the current fragmented bits of information, specific information should be provided so that this recommendation can be moved forward.
(2) It is also unclear what funding mechanisms could support a consistent comprehensive nationwide educational campaign.
(3) NFPA and ICC are affected by this comment

Revision Suggestion : (1) Define roles or recommend steering committee to define roles □ a joint NFPA / ICC national standard, with representation from AIA, ASHRAE, SFPE, NIBS, NCSBCS, BOMA, CTBUH and other industry representatives could form an initial steering committee
(2) Specific funding mechanisms should be provided
(3) Include NFPA and ICC within the effected organizations

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Jim Quiter <jim.quiter@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Jim Quiter
Affiliation : Arup ATG
Email Address : jim.quiter@arup.com
Phone : 415 957 9445
Report Number : NCSTAR 1
Page Number : 211
Paragraph : 9.2.5 / Recommendation 17
Comment : (1) The following egress simulation issues should reviewed: better simulation of merging flows, better characterizing pre-decisional times, better understanding the range of occupant mobility, better understanding of visibility and egress through smoke and other adverse conditions be should given priority, and better understanding of how fatigue affects mobility, as well as fire fighter effectiveness, affect ascend/descending a large number of flights. Further, It is recommended that stairs be designed to resist becoming affected by smoke and other contaminants, rather than investigating evacuation through smoke filled stairs.

(2) Clarify counter flow suggestion.

(3) It is recommended that the suggestion for a dedicated stair for fire fighter access be removed.

(4) Occupant fatigue may have contributed to reported occupant movement speeds being less than that in the literature.

Comment Reason : (1) Better simulation of merging flows, better characterizing pre-decisional times, better understanding the range of occupant mobility, better understanding of visibility and egress through smoke and other adverse conditions be should given priority, and better understanding of how fatigue affects mobility, as well as fire fighter effectiveness, affect ascend/descending a large number of flights would likely have a greater effect upon egress simulation times than those stated.

(2) The report indicates that counterflow by emergency personnel did not significantly affect occupant flow (NISTNCSTAR1-7 Report Section 11.3 item 3); however Section 10.3.8 suggests that counterflow can pose a significant issue. This is conflicting.

(3) Recommendation 17 suggests accounting for counterflow through providing a dedicated stairway for emergency responders. During the initial phase of an evacuation, a dedicated stair could provide much needed egress capacity.

(4) From Section 10.1.2 of the NISTNCSTAR1-7 Report, occupant egress speeds on September 11th were below published speeds. It is possible, and perhaps likely, that occupant fatigue contributed to this. We recommend investigating the ability of a representative mixed ability population to travel down 40 to 70 or more stories of stairs. Based upon this observation, consideration may need to be given to including rest spaces on stair landings, in locations that will not affect the overall flow of occupants.

Revision Suggestion : (1) Substitute □better simulation of merging flows, better characterizing pre-decisional times, better understanding the range of occupant mobility, better understanding of visibility and egress through smoke and other adverse conditions be should given priority, and better understanding of how fatigue affects mobility, as well as fire fighter effectiveness, affect ascend/descending a large number of flights□ for the listed human factors to be analyzed.

(2) Add additional discussion to justify accounting for counterflows.

(3) Delete discussion related to dedicated fire fighter access stairway

(4) Add comment related to occupant travel speeds traversing down or up large number of stair flights.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Jim Quiter <jim.quiter@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Jim Quiter
Affiliation : Arup ATG
Email Address : jim.quiter@arup.com
Phone : 415 957 9445
Report Number : NCSTAR 1
Page Number : 212
Paragraph : 9.2.5 / Recommendation 18
Comment : Recommendation 18 seems to primarily address exit remoteness for fires, rather than the full spectrum of extreme events. This conflicts with recommendation 18.
Comment Reason : Exit remoteness, in the context of extreme events, is difficult to effectively require through prescriptive criteria; meaningful separation in one event may not be effective in another type of event. The actual distance achieved depends on the size of the building, and a fixed minimum may simply be unachievable. For instance, consider a tall slender building with stairways located on opposite facades, while this scenario would work well for fires, it may cause additional exposure for external bomb threats.

Revision Suggestion : Change item (1) as follows □.. to maximize remoteness of egress components (i.e., stairs, elevators, exits) while achieving appropriate balance for other building threats, such as blast, or high-wind exposures and without negatively impacting the average travel distance ..□

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Jim Quiter <jim.quiter@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Jim Quiter
Affiliation : Arup ATG
Email Address : jim.quiter@arup.com
Phone : 415 957 9445
Report Number : NCSTAR 1
Page Number : 213
Paragraph : 9.2.5 / Recommendation 19
Comment : This recommendation is vague. Additional detail describing the types of messages and updates, or perhaps recommending a task force to make these recommendations should be provided.
Comment Reason : While this recommendation is important, it is very board and vague. With the wide range of possible solutions, the overall industry response for this could become uncoordinated within a single focus.

Revision Suggestion : Provide additional details describing the types of messages and updated or recommend a task force to carry this forward.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Jim Quiter <jim.quiter@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Jim Quiter
Affiliation : Arup ATG
Email Address : jim.quiter@arup.com
Phone : 415 957 9445
Report Number : NCSTAR 1
Page Number : Appendix D
Paragraph : Appendix D
Comment : The □stop and go□ methodology is described in various locations throughout Appendix D. Section D.4.4 states that this simulation technique was used to account for □leaving/changing stairs (sometimes occupants did this multiple times) for various reasons, resting on the stairs, helping, waiting behind larger or disabled occupants, superflow, firefighter counterflow, etc,□ as EXIT89 and buildingEXODUS does not include the capability to simulate these. It is possible with STEPS to simulate counterflows, occupant resting on stairs, occupants waiting behind disabled occupant and debris blockages, although several minor code changes would simplify that process. Additionally, the physics of the model would support simulating superflows and leaving/changing stairs with some minor code modifications.
Comment Reason : A large set of simulations with varying ranges of possible flow stoppages would more closely model the actual phenomena and may lead to developing better design methodologies for extreme events.

Revision Suggestion : Extend the egress simulation task to include STEPS.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Jim Quiter <jim.quiter@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-7

Information Submitted on: 8/1/2005.

Name : Jim Quiter
Affiliation : Arup ATG
Email Address : jim.quiter@arup.com
Phone : 415 957 9445
Report Number : NCSTAR1-7
Page Number : Appendix D
Paragraph : Appendix D
Comment : EXIT89 and buildingEXODUS develop differing predictions of evacuation time. Little discussion is provided regarding these differences.
Comment Reason : Users of evacuation simulation programs would benefit from a discussion of why these models provided differing results.

Revision Suggestion : Include additional discussion of differing results between EXIT89 and buildingEXODUS.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Jim Quiter <jim.quiter@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-7

Information Submitted on: 8/1/2005.

Name : Jim Quiter
Affiliation : Arup ATG
Email Address : jim.quiter@arup.com
Phone : 415 957 9445
Report Number : NCSTAR1-7
Page Number : Appendix D
Paragraph : Appendix D
Comment : The □stop and go□ methodology is described in various locations throughout Appendix D. Section D.4.4 states that this simulation technique was used to account for □leaving/changing stairs (sometimes occupants did this multiple times) for various reasons, resting on the stairs, helping, waiting behind larger or disabled occupants, superflow, firefighter counterflow, etc,□ as EXIT89 and buildingEXODUS does not include the capability to simulate these. It is possible with STEPS to simulate counterflows, occupant resting on stairs, occupants waiting behind disabled occupant and debris blockages, although several minor code changes would simplify that process. Additionally, the physics of the model would support simulating superflows and leaving/changing stairs with some minor code modifications.
Comment Reason : A large set of simulations with varying ranges of possible flow stoppages would more closely model the actual phenomena and may lead to developing better design methodologies for extreme events.

Revision Suggestion : Extend the egress simulation task to include STEPS

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 300
Paragraph : Finding 19
Comment : The post impact state of the building has not been assessed rigorously. It would have been useful to see how the DCR□s based on estimated actual loads at the time had changed as a result of the impact damage and re-distributed loads paths □ we believe this was part of the scope of work was identified in the solicitation notice. This is discussed further in our comments on Report 1.
Comment Reason : The significance of load redistribution and effects of the sway have not been assessed using the global modes.

Revision Suggestion : Justifications for not examining load redistribution and sway effects need to be stated or further analysis is needed.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page xliv E-3
Paragraph : Summary of Findings bullet 4
Comment : The implication in Report 1-2A (see page 350) is that stairwell 3 was impassable. This paragraph suggests otherwise.

Comment Reason : .Contradiction with Report 1-2A (page 350)

Revision Suggestion : Clarify

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page 41
Paragraph : Section 3.3 Paragraph 1
Comment : The number of core columns severed (9) and heavily damaged (1) do not tie up with the numbers identified in Report 1-2B, page 365 (5 failed, 4 heavy damaged)?
Comment Reason : Contradiction with other reports

Revision Suggestion : Clarify

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@NIST.GOV
Cc: dlowe@NIST.GOV
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page 41
Paragraph : Section 3.3 second Section 3.3 second bullet
Comment : The numbers of core columns severed do not tie up with paragraph 1 on page 41. (or Report 1-2B page 365)
Comment Reason : Contradiction

Revision Suggestion : Clarify

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR 1
Page Number : Page 99
Paragraph : Section 6.6.4 sub section Core Framing, bullets 1-3
Comment : The analyses undertaken suggest that the condition of the core is key to identifying what margins existed immediately following the impact. The analysis does not seems to account for the swaying of the building following impact or examine the reserve or DCRs using estimated □actual□ loads on the building at the time of the impact. Similarly, as the analysis was essentially done statically no assessment seems to have been done to examine the way the loads re-distributed as columns were removed.
Comment Reason : While the response of the building is such that it will not influence the damage caused by the aircraft impact, the response will be significant in assessing the redistribution of loads or any additional damage induced by the building swaying. As the building was show to be unstable when gravity loads were applied in Case B severe impact damage, it would have been prudent to check the analysis model further by examining the effects of the sway and loads redistribution.

Revision Suggestion : We suggest sway and load redistribution are examined to demonstrate how much these potentially adverse effects influence the stability of the tower.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR 1
Page Number : Page 102
Paragraph : The Aircraft Structural Model
Comment : Our understanding is that no detailed information concerning the construction of the aircraft was released by Boeing. Was any attempt made by NIST to get Boeing to comment on the accuracy for the model? Significant portions of the aircraft appear to have been modelled using uncertain data.
Comment Reason : While it is likely for many parts the lack of precise details would not have been too significant, areas such as the wing spars and undercarriage support structure would be critical to assessing core column damage. Any analysis relies on the quality of input data to achieve It seems rather

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552051
Report Number : NCSTAR 1
Page Number : Page 203
Paragraph : Recommendation 3
Comment : While this is a reasonable suggestion, limiting sway deflections may have an adverse effect on energy absorption in impact events and almost certainly will have economic cost implications.
Comment Reason : Further work should be done to substantiate the cost benefits of this recommendation.

Revision Suggestion : Remove this recommendation until further research has been undertaken.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page lx
Paragraph : Table E-3

Comment : The impact speeds, lateral approach angles, vertical and lateral fuselage orientations in Table E-3 don□t tie up with those shown in Tables E-6 & E-7
Comment Reason : Apparent inconsistency between tables E-3, E-6 and E-7

Revision Suggestion : Clarification in the terms refined aircraft impact conditions and baseline terms.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page lx
Paragraph : Table E-3
Comment : The impact speeds, lateral approach angles, vertical and lateral fuselage orientations in Table E-3 don□t tie up with those shown in Tables E-6 & E-7
Comment Reason : Apparent inconsistency between tables E-3, E-6 and E-7

Revision Suggestion : Clarification in the terms refined aircraft impact conditions and baseline terms.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Pg 40
Paragraph : Section 3.2.1 Core Model Development
Comment : What allowances were made for elevator guide rails, cables, counterweights & cars? We believe only the structural steel is assumed in the model?
Comment Reason : No reference regarding how the elevator components were accounted for within the core.

Revision Suggestion : Check what these components were and, if necessary, re-examine to include additional structure in core model.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@NIST.GOV
Cc: dlowe@NIST.GOV
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : pg 52
Paragraph : Section 3.2.4 Interior Contents Model Development, third paragraph, last sentence.
Comment : Why were the superimposed dead loads also applied to columns - it is not usual to do so?
Comment Reason : This would potentially alter the results of the analysis as the effective mass of the columns would be increased.

Revision Suggestion : Check input data and if this statement is true re-run analyses without superimposed loads applied to the column.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup- London
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Pg 75
Paragraph : Section 4.3.1 Airframe Model Development
Comment : The main landing gear support structure and wheel well bulkhead are comparatively more substantial components than the fuselage. Was any attempt made to obtained detailed engineering design drawings of these components?
Comment Reason : The main landing gear support structure is a large component of strength comparable to or exceeding the wing box. Any breach made by the fuselage, nose landing gear and other components prior to the main landing gear components arriving at the external walls would have given the main landing gear support structure a relatively easy path through to the core. We argue that the input data used for the landing gear support structure components therefore would be critical to estimating the core damage. Because of the limited description of the model details and we believe the lack of engineering drawings made available by Boeing, we question the accuracy of the data used for these components.

Revision Suggestion : Clarify the data used for these components and check with Boeing for accuracy.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : 77
Paragraph : Table 4-4
Comment : We note the dry weight differences between GE CF6 and PWJT9D engines were not included in the respective WTC1 and WTC2 aircraft models □ were any runs done with the heavier GE CF6 engine weights?
Comment Reason : The engines were identified as potential damaging component so the correct (known) engine weights should have been used for each analysis.

Revision Suggestion : Justify that the heavier engine would not have altered the results of the analysis.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 89
Paragraph : General Comment on chapter 5
Comment : Was any attempt made to check the aircraft model by examining an impact with an immovable wall and comparing forces with methods based on rate of change of momentum models such as that developed by Riera as described in Chapter 10 page 367?
Comment Reason : No validation of the model is presented in the report to show how the overall forces generated by the model compare with other established methods.

Revision Suggestion : Demonstrate model robustness and overall forces are reasonable.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup- London
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : page 175
Paragraph : Chapter 8 Uncertainty analysis
Comment : The solicitation notice requested a formal, integrate approach was followed and include references outlining the procedure. The approach used here is considerably simpler. Why was the approach modified?
Comment Reason : The approach used falls short of the original ambitions required by NIST

Revision Suggestion : Clarification that the approach used in not as rigorous as originally intended.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 178
Paragraph : Table 8.1
Comment : The strength variations used seems rather low compared to the variations shown in Report 1-1, (page 67/68 of that report show measured/specified ratio in 10% - 30% range see Table 5.4 column data).

It is unclear whether the baseline values for material properties used were nominal or as per the values obtained from test data?

Why are the minimum values for horizontal and vertical locations the same as the baseline?

Exactly what is meant by varying strain rate effects by 1000%?

Comment Reason : Unclear

Revision Suggestion : Clarification needed

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 180
Paragraph : Section 8.2.1 Engine-Core Column Component Analysis, paragraph 1
Comment : The characterisation of the deformed columns takes no account of the building movements following the impact. While we agree gravity loads in the columns make little difference during the aircraft impact, were axial loads and P-Δ effects induced by the response of the building after the impact considered?
Comment Reason : We think this needs to be examined both at a component analysis and global level

Revision Suggestion : Demonstrate by analysis that the response of the building does not cause further damage or additional deformations.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 183
Paragraph : Table 8-3
Comment : We question the large value used for the weight factors used in the wing parameters. Information from Boeing or detailed measurements could have been able to eliminate this uncertainty.
Comment Reason : Wing weight has a high response value in the uncertainty analysis.

Revision Suggestion : Examine why such a high variation was used.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 190
Paragraph : Figure 8-10 and also page 111 paragraph 1, sentence 4
Comment : Figure 8-10 would imply the engine trajectory was mainly horizontal on exit. Intuitively this feels incorrect.
Comment Reason : We question whether the workstations and the relatively lightweight concrete/steel composite floor would have been able to deflect a 4 ton engine travel at speed. Our own work examining penetrations of components on composite floor suggest that the contribution from the metal decking can significantly enhance the impact performance when compared with concrete slabs. (see Assessing perforation limits of steel section impacts on reinforced concrete slabs -Technical Note, The Structural Engineer, IStructE, December 2004). This is contrary to the findings page 111, first paragraph.

Revision Suggestion : Re-analysis using better representation of concrete/steel decking composite floor model.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 191
Paragraph : Section 8.3 Global Impact Analyses Parameter Selection, Paragraph 2

Comment : Although the report notes that the vertical impact position was significant in the subassembly analysis, the vertical impact location was not varied for the global analysis.
Comment Reason : It is difficult to understand the logic used not to investigate this further.

Revision Suggestion : Include vertical impact variations in the global analysis

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 192
Paragraph : Section 8.3 Global Impact Analyses Parameter Selection, Paragraph 1
Comment : The validity of the statement concerning the coupling effect of increasing strength and ductility increasing energy absorption is questioned.
Comment Reason : In conventional steels, higher yield strength only marginally increases energy absorption as the ductility of higher yield steels tends to decrease.

Revision Suggestion : Clarify by revising paragraph 1

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page 195
Paragraph : 9.2 Assumptions and Limitations Paragraph 1
Comment : Please see our comments on Nist Report NIST NCSTRA 1-2, Page 93, Section 5.1 Introduction concerning limitations.
Comment Reason : As per page 93

Revision Suggestion : Re-assess the models using 64 bit precision.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 195
Paragraph : 9.2 Assumptions and Limitations Paragraph 1

Comment : Please see our comments on Nist Report NIST NCSTRA 1-2, Page 93, Section 5.1 Introduction concerning limitations.
Comment Reason : As per page 93

Revision Suggestion : Re-assess the models using 64 bit precision.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 196
Paragraph : 9.2 Assumptions and Limitations second Paragraph (first bullet)
Comment : What effect would the window weight have if it had been included in the external columns?
Comment Reason : The additional mass of windows on the external columns would have altered the response and deformations of the columns.

Revision Suggestion : Justification for leaving the mass of the windows out of the impact models. Justification for not including them in the impact models to show containment of fuel.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : 0+44 077552195
Report Number : NCSTAR1-2B
Page Number : Page 206
Paragraph : Figure 9-7b
Comment : A scale on this figure would be useful?
Comment Reason : The figure is meaningless without any scale

Revision Suggestion : Add scale

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page 210
Paragraph : Subsection Floor Truss and Slab Damage, second paragraph
Comment : Part of the requirements of the original solicitation was to examine the stability of two towers after losing the columns and show that the towers stood up after the event (Page 10 of SB1341-03-Q-0334).
Comment Reason : See also our previous comments concerning natural frequency, we do believe the method used takes account of possible damage that may occur during the post impact sway and therefore subsequent stability.

Revision Suggestion : Re-assess to take account of any damage resulting from post impact sway response.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page 218
Paragraph : Paragraphs 3 and 4
Comment : What technical validation has been done regarding the modelling of fuel dispersion?
Comment Reason : We recognise that the fuel dispersal simulation is technically challenging. It is therefore sensible to undertake some validations using simple experiments before embarking on a complex study such as this.

Revision Suggestion : Clarify what level of confidence there is in the fuel dispersion work?

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 234
Paragraph : Figure 9-29
Comment : Figure 9-29 b) identifies debris at time=0.715s. Page 227 states that this model only ran to 0.62s.

Also a scale on diagram b) might be useful.

Comment Reason : We think the time note on diagram b) is erroneous

Revision Suggestion : Modify time and add scale

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page 343
Paragraph : Second paragraph
Comment : Very little information about debris found beyond the vicinity of the towers seems to have been made available to NIST. For example, the size of panel and mass of landing gear shown in figure 9-123 is unknown. How could this collection of this data following a tragedy be improved?
Comment Reason : Improved process for data collection of debris needed.

Revision Suggestion : It would be useful to make sure some comment about debris collection/recording is put in findings.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 361
Paragraph : Section 9.11.3 Comparison with Observables Paragraph 2
Comment : Recognising that the overall trajectories are a difficult thing to predict, the trajectories of components as they left the building were poorly predicted in the simulations. As this is critical to establishing the damage to the core it would have been useful to discuss the reasons for this in more detail.
Comment Reason : Critical to establishing the core damage key objective

Revision Suggestion : Discussion concerning the reasons for poor correlation of analysis with observables.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : v
Paragraph : Paragraph 2 last sentence
Comment : The SPH approach used by ARA in the analysis for the fuel dispersion following the impact is relatively untried and is not well validated through experiments. Could the researchers clarify what level of confidence they have in the accuracy of predicting fuel dispersion and how this might have influenced the subsequent fire analysis?
Arup□s experience in the modelling fluids suggests fuel dispersion an exceedingly difficult thing to predict and an area where any analysis needs to be considered carefully and supported by laboratory based experimental validation. Given the importance of this study, we believe some testing should have been carried out to confirm the analytical models used prior to assuming dispersal patterns are adequate or correct.

Comment Reason : The report does not adequately explain the limitations of the technical approach taken.

Revision Suggestion : Clarification of the level of confidence or uncertainty in these results.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : x1vi
Paragraph : E.2.1 Global Models of Towers
Comment : Was any attempt made to correlate the total weight of the building with the debris removed?
Comment Reason : While accepting that this would have been an approximation, the data could have been used to estimate the overall loads on the building at the time of impact. This would have given greater confidence in the levels of reserve available at the time of the impact.

Revision Suggestion : Compare amount of debris known to have been removed during the clear operation with the mass used in the global analysis models.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1iv and 1v
Paragraph : Demand Capacity Ratios (DCRs) Paragraph 2
Comment : The baseline analysis examines the DCRs for design loads on the complete tower (figures E-5 and E6). Given that the actual building would typically see less load than this, has any estimate of the actual DCRs for the building in its Sept 11 2001 states? Given that the corners, which general had DCRs in excess of 1, were shown to buckle during the building collapses it might be useful quantify the reserve capacity in the column by checking the DCRs for actual loads on the day for pre and (immediately) post impact states and check these were less than unity.
Comment Reason : Looking a actual DCR□s would provide better estimate of the condition of the building post impact, a main objective of project 2.

Revision Suggestion : Re- analyse using actual loads

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1viii
Paragraph : Section E.5.1 Development of Tower Impact Models
Comment : We believe the global model (of the type shown in figure E-11) had no initial stress in the column and that this was justified by some simple tests using column models. The global model also ignored the overall response of the structure, presumably on the basis that the duration of the impact event was significantly less than the natural period of the building. Could NIST clarify how any P-Δ effects (as a result of the swaying) in the post impact condition were accounted for? From the work reported, post impact P-Δ effects before the fire took hold seem to have been neglected but there is no justification is given. Could P-Δ effects as a result of the significant swaying of the building after impact have influenced the severity of the column damage?
Comment Reason : Inadequancy in the analysis

Revision Suggestion : Justification for neglecting this or re-analysis taking load re-distribution and P-Δ effects into account.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xv
Paragraph : Section E.5.2 Development of Aircraft Impact Models, Paragraph 1
Comment : The report is vague as to exact details of the aircraft data used □ much of the aircraft model seems to have been developed without detailed engineering drawings or more than some cursory measurements. Whilst it might be argued that the strength of the fuselage is not that significant, the 1-2B report (page 368, section 10.2, last paragraph) notes, and we agree, that the strength of some of the denser elements are significant. Recognising Boeing□s desire to retain proprietary information, have Boeing engineers scrutinised the component masses, thicknesses and dimensions used in these models? Have other LS-Dyna experts checked the aircraft impact model in the same way that SOM checked the building models?
Comment Reason : The limited data used to develop the aircraft models may not have been adequately bounded by the uncertainty analysis. Given that the structure of a B767 aircraft is known it seems sensible to check this data where possible.

Revision Suggestion : Clarification regarding the level of checking used in developing the aircraft data.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxviii
Paragraph : Section E7.1 WTC1 Base Case Analysis, Paragraph 2
Comment : As noted previously (see comments on pg lxv) the aircraft models appears to be based on relatively sparse engineering data □ this is surprising, given that B767 design data exists and any inaccuracies in the aircraft model would increase the level of uncertainty in the result. Our concern relates to the limited details in the report about the undercarriage structure and assembly and wing supports (typical weighing 10-12tons)?
Comment Reason : These would have been critical elements determining the state of the core.

Revision Suggestion : Clarify what detailed information was used to model this component and how was this data collected?

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxixx
Paragraph : Section E.7.1 WTC1 Base Case Analysis, sub section External Wall Damage, Paragraph 2
Comment : How were gravity and aero-elastic forces on the wing applied? It seems the wing deflections in flight were accounted for but the report if unclear how this was done?
Comment Reason : Limited information in report

Revision Suggestion : Clarification

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxxv
Paragraph : Section E.7.1 WTC1 Base Case Analysis, sub section Fuel and Debris Distribution Paragraph 1,
Comment : Limited experimental validation work that has been carried out using this method for fuel dispersion. As the analysis ignored the containing effect of the windows, wetting and the multi phase nature of the fuel combustion process during impact, the actual results are at best subjective.
Comment Reason : Inadequacy in the analysis

Revision Suggestion : Clarification regarding the accuracy and level of the uncertainty in the fuel dispersion.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : ci
Paragraph : E.7.2 WTC2 Base Case Analysis, sub section Fuel and Debris Distribution Paragraph 2,
Comment : See previous comments on (pg lxxxv above) regarding the use of SPH to model fuel dispersal.
(The report notes that the work could not reconcile the fuel getting through 200/300 sides.)

Comment Reason : Inadequacy in the analysis

Revision Suggestion : Clarification regarding the accuracy and level of the uncertainty in the fuel dispersion.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : cix
Paragraph : Section E.7.7
Comment : Detailed comparison of damage on □back□ walls (ie south wall of WTC1 and north face of WTC2) between observables and analysis are not shown. The reports notes later that correlation between the impacts and analyses are poor on these faces.
Comment Reason : Limited information in report

Revision Suggestion : Clarification of impact damage estimates

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 6
Paragraph : Section 1.3 Aircraft Impact Damage Analysis Bullet 2
Comment : The sensitivity analysis seems to neglect much of the uncertainty in the aircraft data used in the model. (see our previous comments relating to Page lxxvii)
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 93
Paragraph : Section5.1 Introduction
Comment : We have often found in large civil and building engineering models, used to explicitly simulate impact and seismic events in real time, variation of results between LS-Dyna analyses using 32 bit and the higher precision 64 bit software. We have occasionally seen significant rounding errors on 32 bit computer software when representing physically large dimensions where relatively small displacements in elements trigger failures. Were any of the results models checked using 64 bit precision to test the accuracy of results? The limitations on models size noted in the report are related to 32 bit operating systems. If the impact models had been run on 64 bit operating systems we believe the limitations on model size would have been avoided.

Comment Reason : One dimensionally large model the accuracy of the analysis results needs to be checked using double precision.
The original NIST objective of using state of the art analyses for the Project 2 seems to have been missed. The limitation on model size could have been avoided by using computers with 64 bit operating systems.

Revision Suggestion : Re-analysis of a few of the larger models using 64 bit software.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 269
Paragraph : Section 7.10.1 , Comparison with Observables on WTC1 Landing gear Trajectory
Comment : We accept that the trajectory calculations are difficult. Our calculations show this to be 120mph if no rolling occurred. Was there any evidence of rolling or ricocheting down the road?
Comment Reason : Limited information concerning the observables

Revision Suggestion : Comments regarding the processes used for recording debris data.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 281
Paragraph : Section 7.10.2, Comparison with Observables on WTC2, Engine Trajectory Comparison
Comment : Could the crash investigators tell whether this was a starboard or port engine?
Comment Reason : Limited information

Revision Suggestion : Clarifcation

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 289
Paragraph : Section 7.11.1 Comparison of External Wall Damage
Comment : See our previous comments about the modelling of fuel in the impact.
Was any sensitivity study carried out using the SPHs to correlate this with
fuel falling out of the building?
Comment Reason : Shortcoming in SPH method

Revision Suggestion : Clarification of limitations

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 298
Paragraph : Finding 11
Comment : Although conventional office buildings tend not to consider aircraft impact as a foreseeable hazard, nuclear facilities in the US and elsewhere do. The finding that an aircraft impact was considered at the time of the design of the WTC1 and 2 demonstrates that the possibility of impacts whether accidental or deliberate may need to be considered in some circumstances. Although current building codes don□t consider aircraft impact, it seems reasonable to assume that tall buildings or iconic architecture can be considered targets. The work carried out here should be developed to provide useful information to assist those wishing to design more robust buildings and other facilities irrespective of the building codes.
Comment Reason : General observation

Revision Suggestion : None

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 298
Paragraph : Finding 13
Comment : While generally in agreement that this could be the case, the SPH methodology used should be properly validated. Whether or not this has been done as part of this investigation is unclear.
Comment Reason : There is limited information in the reports to support this finding

Revision Suggestion : Clarification

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: j <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : j
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 300
Paragraph : Finding 18
Comment : The implication that the tower had sufficient reserve capacity because the natural frequency of the buildings post impact was similar to the undamaged state is incorrect. Because the construction of the towers is essentially tube like, the natural frequencies would not alter significantly even if the core was severely damaged. The following simple FE models demonstrate the insignificance of the core:
Simplistic Model Results

Results from five simple finite element models (of roughly the same geometric proportions as WTC1 and WTC2) demonstrate that a large hole in the side of a tube and the missing parts of the core do not significantly influence the natural frequency (see table 1).

Table 1 Variation of Natural Frequency (in Hz)

	Model 1	2	3	4	5
Bending	0.1653	0.1647	0.1643	0.1636	0.1637
Torsion	0.5981	0.5889	0.5981	0.5891	0.5889

Model 1

Tube & core
No holes Model 2

Large hole in side & no core. Model 3

No hole with core Model 4.

Large hole in side with core Model 5

Large hole in side and core missing at same level

Comment Reason : The stability of the towers immediately following the impact has not really been proven by the impact analysis. Simply taking the results of the impact damaged structure and loading it statically effectively ignores and damage that may have resulted due to swaying.

Revision Suggestion : Provide a more detailed analysis to take account of load path re-distribution in the core and the P-Δ effects of sway following the impact.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : v
Paragraph : Paragraph 2 last sentence
Comment : The SPH approach used by ARA in the analysis for the fuel dispersion following the impact is relatively untried and is not well validated through experiments. Could the researchers clarify what level of confidence they have in the accuracy of predicting fuel dispersion and how this might have influenced the subsequent fire analysis?
Arup□s experience in the modelling fluids suggests fuel dispersion an exceedingly difficult thing to predict and an area where any analysis needs to be considered carefully and supported by laboratory based experimental validation. Given the importance of this study, we believe some testing should have been carried out to confirm the analytical models used prior to assuming dispersal patterns are adequate or correct.

Comment Reason : The report does not adequately explain the limitations of the technical approach taken.

Revision Suggestion : Clarification of the level of confidence or uncertainty in these results.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : x1vi
Paragraph : E.2.1 Global Models of Towers
Comment : Was any attempt made to correlate the total weight of the building with the debris removed?
Comment Reason : While accepting that this would have been an approximation, the data could have been used to estimate the overall loads on the building at the time of impact. This would have given greater confidence in the levels of reserve available at the time of the impact.

Revision Suggestion : Compare amount of debris known to have been removed during the clear operation with the mass used in the global analysis models.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1iv and 1v
Paragraph : Demand Capacity Ratios (DCRs) Paragraph 2
Comment : The baseline analysis examines the DCRs for design loads on the complete tower (figures E-5 and E6). Given that the actual building would typically see less load than this, has any estimate of the actual DCRs for the building in its Sept 11 2001 states? Given that the corners, which general had DCRs in excess of 1, were shown to buckle during the building collapses it might be useful quantify the reserve capacity in the column by checking the DCRs for actual loads on the day for pre and (immediately) post impact states and check these were less than unity.
Comment Reason : Looking a actual DCR□s would provide better estimate of the condition of the building post impact, a main objective of project 2.

Revision Suggestion : Re- analyse using actual loads

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1viii
Paragraph : Section E.5.1 Development of Tower Impact Models
Comment : We believe the global model (of the type shown in figure E-11) had no initial stress in the column and that this was justified by some simple tests using column models. The global model also ignored the overall response of the structure, presumably on the basis that the duration of the impact event was significantly less than the natural period of the building. Could NIST clarify how any P-Δ effects (as a result of the swaying) in the post impact condition were accounted for? From the work reported, post impact P-Δ effects before the fire took hold seem to have been neglected but there is no justification is given. Could P-Δ effects as a result of the significant swaying of the building after impact have influenced the severity of the column damage?
Comment Reason : Inadequancy in the analysis

Revision Suggestion : Justification for neglecting this or re-analysis taking load re-distribution and P-Δ effects into account.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xv
Paragraph : Section E.5.2 Development of Aircraft Impact Models, Paragraph 1
Comment : The report is vague as to exact details of the aircraft data used □ much of the aircraft model seems to have been developed without detailed engineering drawings or more than some cursory measurements. Whilst it might be argued that the strength of the fuselage is not that significant, the 1-2B report (page 368, section 10.2, last paragraph) notes, and we agree, that the strength of some of the denser elements are significant. Recognising Boeing□s desire to retain proprietary information, have Boeing engineers scrutinised the component masses, thicknesses and dimensions used in these models? Have other LS-Dyna experts checked the aircraft impact model in the same way that SOM checked the building models?
Comment Reason : The limited data used to develop the aircraft models may not have been adequately bounded by the uncertainty analysis. Given that the structure of a B767 aircraft is known it seems sensible to check this data where possible.

Revision Suggestion : Clarification regarding the level of checking used in developing the aircraft data.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxviii
Paragraph : Section E7.1 WTC1 Base Case Analysis, Paragraph 2
Comment : As noted previously (see comments on pg lxv) the aircraft models appears to be based on relatively sparse engineering data □ this is surprising, given that B767 design data exists and any inaccuracies in the aircraft model would increase the level of uncertainty in the result. Our concern relates to the limited details in the report about the undercarriage structure and assembly and wing supports (typical weighing 10-12tons)?
Comment Reason : These would have been critical elements determining the state of the core.

Revision Suggestion : Clarify what detailed information was used to model this component and how was this data collected?

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxixx
Paragraph : Section E.7.1 WTC1 Base Case Analysis, sub section External Wall Damage, Paragraph 2
Comment : How were gravity and aero-elastic forces on the wing applied? It seems the wing deflections in flight were accounted for but the report if unclear how this was done?
Comment Reason : Limited information in report

Revision Suggestion : Clarification

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxxv
Paragraph : Section E.7.1 WTC1 Base Case Analysis, sub section Fuel and Debris Distribution Paragraph 1,
Comment : Limited experimental validation work that has been carried out using this method for fuel dispersion. As the analysis ignored the containing effect of the windows, wetting and the multi phase nature of the fuel combustion process during impact, the actual results are at best subjective.
Comment Reason : Inadequacy in the analysis

Revision Suggestion : Clarification regarding the accuracy and level of the uncertainty in the fuel dispersion.

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From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : ci
Paragraph : E.7.2 WTC2 Base Case Analysis, sub section Fuel and Debris Distribution Paragraph 2,
Comment : See previous comments on (pg lxxxv above) regarding the use of SPH to model fuel dispersal.
(The report notes that the work could not reconcile the fuel getting through 200/300 sides.)

Comment Reason : Inadequacy in the analysis

Revision Suggestion : Clarification regarding the accuracy and level of the uncertainty in the fuel dispersion.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : cix
Paragraph : Section E.7.7
Comment : Detailed comparison of damage on □back□ walls (ie south wall of WTC1 and north face of WTC2) between observables and analysis are not shown. The reports notes later that correlation between the impacts and analyses are poor on these faces.
Comment Reason : Limited information in report

Revision Suggestion : Clarification of impact damage estimates

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
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Cc: dlowe@nist.gov
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Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 6
Paragraph : Section 1.3 Aircraft Impact Damage Analysis Bullet 2
Comment : The sensitivity analysis seems to neglect much of the uncertainty in the aircraft data used in the model. (see our previous comments relating to Page lxxvii)
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 93
Paragraph : Section5.1 Introduction
Comment : We have often found in large civil and building engineering models, used to explicitly simulate impact and seismic events in real time, variation of results between LS-Dyna analyses using 32 bit and the higher precision 64 bit software. We have occasionally seen significant rounding errors on 32 bit computer software when representing physically large dimensions where relatively small displacements in elements trigger failures. Were any of the results models checked using 64 bit precision to test the accuracy of results? The limitations on models size noted in the report are related to 32 bit operating systems. If the impact models had been run on 64 bit operating systems we believe the limitations on model size would have been avoided.

Comment Reason : One dimensionally large model the accuracy of the analysis results needs to be checked using double precision.
The original NIST objective of using state of the art analyses for the Project 2 seems to have been missed. The limitation on model size could have been avoided by using computers with 64 bit operating systems.

Revision Suggestion : Re-analysis of a few of the larger models using 64 bit software.

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Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 269
Paragraph : Section 7.10.1 , Comparison with Observables on WTC1 Landing gear Trajectory
Comment : We accept that the trajectory calculations are difficult. Our calculations show this to be 120mph if no rolling occurred. Was there any evidence of rolling or ricocheting down the road?
Comment Reason : Limited information concerning the observables

Revision Suggestion : Comments regarding the processes used for recording debris data.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 281
Paragraph : Section 7.10.2, Comparison with Observables on WTC2, Engine Trajectory Comparison
Comment : Could the crash investigators tell whether this was a starboard or port engine?
Comment Reason : Limited information

Revision Suggestion : Clarifcation

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
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Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 289
Paragraph : Section 7.11.1 Comparison of External Wall Damage
Comment : See our previous comments about the modelling of fuel in the impact. Was any sensitivity study carried out using the SPHs to correlate this with fuel falling out of the building?
Comment Reason : Shortcoming in SPH method

Revision Suggestion : Clarification of limitations

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 298
Paragraph : Finding 11
Comment : Although conventional office buildings tend not to consider aircraft impact as a foreseeable hazard, nuclear facilities in the US and elsewhere do. The finding that an aircraft impact was considered at the time of the design of the WTC1 and 2 demonstrates that the possibility of impacts whether accidental or deliberate may need to be considered in some circumstances. Although current building codes don□t consider aircraft impact, it seems reasonable to assume that tall buildings or iconic architecture can be considered targets. The work carried out here should be developed to provide useful information to assist those wishing to design more robust buildings and other facilities irrespective of the building codes.
Comment Reason : General observation

Revision Suggestion : None

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
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Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 298
Paragraph : Finding 13
Comment : While generally in agreement that this could be the case, the SPH methodology used should be properly validated. Whether or not this has been done as part of this investigation is unclear.
Comment Reason : There is limited information in the reports to support this finding

Revision Suggestion : Clarification

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Information Submitted on: 8/1/2005.

Name : j
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 300
Paragraph : Finding 18
Comment : The implication that the tower had sufficient reserve capacity because the natural frequency of the buildings post impact was similar to the undamaged state is incorrect. Because the construction of the towers is essentially tube like, the natural frequencies would not alter significantly even if the core was severely damaged. The following simple FE models demonstrate the insignificance of the core:
Simplistic Model Results

Results from five simple finite element models (of roughly the same geometric proportions as WTC1 and WTC2) demonstrate that a large hole in the side of a tube and the missing parts of the core do not significantly influence the natural frequency (see table 1).

Table 1 Variation of Natural Frequency (in Hz)

	Model 1	2	3	4	5
Bending	0.1653	0.1647	0.1643	0.1636	0.1637
Torsion	0.5981	0.5889	0.5981	0.5891	0.5889

Model 1

Tube & core
No holes   Model 2

Large hole in side & no core.   Model 3

No hole with core   Model 4.

Large hole in side with core   Model 5

Large hole in side and core missing at same level

Comment Reason : The stability of the towers immediately following the impact has not really been proven by the impact analysis. Simply taking the results of the impact damaged structure and loading it statically effectively ignores and damage that may have resulted due to swaying.

Revision Suggestion : Provide a more detailed analysis to take account of load path re-distribution in the core and the P-Δ effects of sway following the impact.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 300
Paragraph : Finding 19
Comment : The post impact state of the building has not been assessed rigorously. It would have been useful to see how the DCR□s based on estimated actual loads at the time had changed as a result of the impact damage and re-distributed loads paths □ we believe this was part of the scope of work was identified in the solicitation notice. This is discussed further in our comments on Report 1.
Comment Reason : The significance of load redistribution and effects of the sway have not been assessed using the global modes.

Revision Suggestion : Justifications for not examining load redistribution and sway effects need to be stated or further analysis is needed.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page xliv E-3
Paragraph : Summary of Findings bullet 4
Comment : The implication in Report 1-2A (see page 350) is that stairwell 3 was impassable. This paragraph suggests otherwise.

Comment Reason : .Contradiction with Report 1-2A (page 350)

Revision Suggestion : Clarify

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page 41
Paragraph : Section 3.3 Paragraph 1
Comment : The number of core columns severed (9) and heavily damaged (1) do not tie up with the numbers identified in Report 1-2B, page 365 (5 failed, 4 heavy damaged)?
Comment Reason : Contradiction with other reports

Revision Suggestion : Clarify

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@NIST.GOV
Cc: dlowe@NIST.GOV
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page 41
Paragraph : Section 3.3 second Section 3.3 second bullet
Comment : The numbers of core columns severed do not tie up with paragraph 1 on page 41. (or Report 1-2B page 365)
Comment Reason : Contradiction

Revision Suggestion : Clarify

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR 1
Page Number : Page 99
Paragraph : Section 6.6.4 sub section Core Framing, bullets 1-3
Comment : The analyses undertaken suggest that the condition of the core is key to identifying what margins existed immediately following the impact. The analysis does not seems to account for the swaying of the building following impact or examine the reserve or DCRs using estimated □actual□ loads on the building at the time of the impact. Similarly, as the analysis was essentially done statically no assessment seems to have been done to examine the way the loads re-distributed as columns were removed.
Comment Reason : While the response of the building is such that it will not influence the damage caused by the aircraft impact, the response will be significant in assessing the redistribution of loads or any additional damage induced by the building swaying. As the building was show to be unstable when gravity loads were applied in Case B severe impact damage, it would have been prudent to check the analysis model further by examining the effects of the sway and loads redistribution.

Revision Suggestion : We suggest sway and load redistribution are examined to demonstrate how much these potentially adverse effects influence the stability of the tower.

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR 1
Page Number : Page 102
Paragraph : The Aircraft Structural Model
Comment : Our understanding is that no detailed information concerning the construction of the aircraft was released by Boeing. Was any attempt made by NIST to get Boeing to comment on the accuracy for the model? Significant portions of the aircraft appear to have been modelled using uncertain data.
Comment Reason : While it is likely for many parts the lack of precise details would not have been too significant, areas such as the wing spars and undercarriage support structure would be critical to assessing core column damage. Any analysis relies on the quality of input data to achieve It seems rather

Revision Suggestion :

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552051
Report Number : NCSTAR 1
Page Number : Page 203
Paragraph : Recommendation 3
Comment : While this is a reasonable suggestion, limiting sway deflections may have an adverse effect on energy absorption in impact events and almost certainly will have economic cost implications.
Comment Reason : Further work should be done to substantiate the cost benefits of this recommendation.

Revision Suggestion : Remove this recommendation until further research has been undertaken.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page lx
Paragraph : Table E-3

Comment : The impact speeds, lateral approach angles, vertical and lateral fuselage orientations in Table E-3 don□t tie up with those shown in Tables E-6 & E-7
Comment Reason : Apparent inconsistency between tables E-3, E-6 and E-7

Revision Suggestion : Clarification in the terms refined aircraft impact conditions and baseline terms.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page lx
Paragraph : Table E-3
Comment : The impact speeds, lateral approach angles, vertical and lateral fuselage orientations in Table E-3 don□t tie up with those shown in Tables E-6 & E-7
Comment Reason : Apparent inconsistency between tables E-3, E-6 and E-7

Revision Suggestion : Clarification in the terms refined aircraft impact conditions and baseline terms.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Pg 40
Paragraph : Section 3.2.1 Core Model Development
Comment : What allowances were made for elevator guide rails, cables, counterweights & cars? We believe only the structural steel is assumed in the model?
Comment Reason : No reference regarding how the elevator components were accounted for within the core.

Revision Suggestion : Check what these components were and, if necessary, re-examine to include additional structure in core model.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@NIST.GOV
Cc: dlowe@NIST.GOV
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : pg 52
Paragraph : Section 3.2.4 Interior Contents Model Development, third paragraph, last sentence.
Comment : Why were the superimposed dead loads also applied to columns - it is not usual to do so?
Comment Reason : This would potentially alter the results of the analysis as the effective mass of the columns would be increased.

Revision Suggestion : Check input data and if this statement is true re-run analyses without superimposed loads applied to the column.

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup- London
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Pg 75
Paragraph : Section 4.3.1 Airframe Model Development
Comment : The main landing gear support structure and wheel well bulkhead are comparatively more substantial components than the fuselage. Was any attempt made to obtained detailed engineering design drawings of these components?
Comment Reason : The main landing gear support structure is a large component of strength comparable to or exceeding the wing box. Any breach made by the fuselage, nose landing gear and other components prior to the main landing gear components arriving at the external walls would have given the main landing gear support structure a relatively easy path through to the core. We argue that the input data used for the landing gear support structure components therefore would be critical to estimating the core damage. Because of the limited description of the model details and we believe the lack of engineering drawings made available by Boeing, we question the accuracy of the data used for these components.

Revision Suggestion : Clarify the data used for these components and check with Boeing for accuracy.

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : 77
Paragraph : Table 4-4
Comment : We note the dry weight differences between GE CF6 and PWJT9D engines were not included in the respective WTC1 and WTC2 aircraft models □ were any runs done with the heavier GE CF6 engine weights?
Comment Reason : The engines were identified as potential damaging component so the correct (known) engine weights should have been used for each analysis.

Revision Suggestion : Justify that the heavier engine would not have altered the results of the analysis.

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To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 89
Paragraph : General Comment on chapter 5
Comment : Was any attempt made to check the aircraft model by examining an impact with an immovable wall and comparing forces with methods based on rate of change of momentum models such as that developed by Riera as described in Chapter 10 page 367?
Comment Reason : No validation of the model is presented in the report to show how the overall forces generated by the model compare with other established methods.

Revision Suggestion : Demonstrate model robustness and overall forces are reasonable.

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup- London
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : page 175
Paragraph : Chapter 8 Uncertainty analysis
Comment : The solicitation notice requested a formal, integrate approach was followed and include references outlining the procedure. The approach used here is considerably simpler. Why was the approach modified?
Comment Reason : The approach used falls short of the original ambitions required by NIST

Revision Suggestion : Clarification that the approach used in not as rigorous as originally intended.

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 178
Paragraph : Table 8.1
Comment : The strength variations used seems rather low compared to the variations shown in Report 1-1, (page 67/68 of that report show measured/specified ratio in 10% - 30% range see Table 5.4 column data).

It is unclear whether the baseline values for material properties used were nominal or as per the values obtained from test data?

Why are the minimum values for horizontal and vertical locations the same as the baseline?

Exactly what is meant by varying strain rate effects by 1000%?

Comment Reason : Unclear

Revision Suggestion : Clarification needed

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 180
Paragraph : Section 8.2.1 Engine-Core Column Component Analysis, paragraph 1
Comment : The characterisation of the deformed columns takes no account of the building movements following the impact. While we agree gravity loads in the columns make little difference during the aircraft impact, were axial loads and P-Δ effects induced by the response of the building after the impact considered?
Comment Reason : We think this needs to be examined both at a component analysis and global level

Revision Suggestion : Demonstrate by analysis that the response of the building does not cause further damage or additional deformations.

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 183
Paragraph : Table 8-3
Comment : We question the large value used for the weight factors used in the wing parameters. Information from Boeing or detailed measurements could have been able to eliminate this uncertainty.
Comment Reason : Wing weight has a high response value in the uncertainty analysis.

Revision Suggestion : Examine why such a high variation was used.

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 190
Paragraph : Figure 8-10 and also page 111 paragraph 1, sentence 4
Comment : Figure 8-10 would imply the engine trajectory was mainly horizontal on exit. Intuitively this feels incorrect.
Comment Reason : We question whether the workstations and the relatively lightweight concrete/steel composite floor would have been able to deflect a 4 ton engine travel at speed. Our own work examining penetrations of components on composite floor suggest that the contribution from the metal decking can significantly enhance the impact performance when compared with concrete slabs. (see Assessing perforation limits of steel section impacts on reinforced concrete slabs -Technical Note, The Structural Engineer, IStructE, December 2004). This is contrary to the findings page 111, first paragraph.

Revision Suggestion : Re-analysis using better representation of concrete/steel decking composite floor model.

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 191
Paragraph : Section 8.3 Global Impact Analyses Parameter Selection, Paragraph 2

Comment : Although the report notes that the vertical impact position was significant in the subassembly analysis, the vertical impact location was not varied for the global analysis.
Comment Reason : It is difficult to understand the logic used not to investigate this further.

Revision Suggestion : Include vertical impact variations in the global analysis

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 192
Paragraph : Section 8.3 Global Impact Analyses Parameter Selection, Paragraph 1
Comment : The validity of the statement concerning the coupling effect of increasing strength and ductility increasing energy absorption is questioned.
Comment Reason : In conventional steels, higher yield strength only marginally increases energy absorption as the ductility of higher yield steels tends to decrease.

Revision Suggestion : Clarify by revising paragraph 1

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page 195
Paragraph : 9.2 Assumptions and Limitations Paragraph 1
Comment : Please see our comments on Nist Report NIST NCSTRA 1-2, Page 93, Section 5.1 Introduction concerning limitations.
Comment Reason : As per page 93

Revision Suggestion : Re-assess the models using 64 bit precision.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 195
Paragraph : 9.2 Assumptions and Limitations Paragraph 1

Comment : Please see our comments on Nist Report NIST NCSTRA 1-2, Page 93, Section 5.1 Introduction concerning limitations.
Comment Reason : As per page 93

Revision Suggestion : Re-assess the models using 64 bit precision.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 196
Paragraph : 9.2 Assumptions and Limitations second Paragraph (first bullet)
Comment : What effect would the window weight have if it had been included in the external columns?
Comment Reason : The additional mass of windows on the external columns would have altered the response and deformations of the columns.

Revision Suggestion : Justification for leaving the mass of the windows out of the impact models. Justification for not including them in the impact models to show containment of fuel.

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : 0+44 077552195
Report Number : NCSTAR1-2B
Page Number : Page 206
Paragraph : Figure 9-7b
Comment : A scale on this figure would be useful?
Comment Reason : The figure is meaningless without any scale

Revision Suggestion : Add scale

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page 210
Paragraph : Subsection Floor Truss and Slab Damage, second paragraph
Comment : Part of the requirements of the original solicitation was to examine the stability of two towers after losing the columns and show that the towers stood up after the event (Page 10 of SB1341-03-Q-0334).
Comment Reason : See also our previous comments concerning natural frequency, we do believe the method used takes account of possible damage that may occur during the post impact sway and therefore subsequent stability.

Revision Suggestion : Re-assess to take account of any damage resulting from post impact sway response.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page 218
Paragraph : Paragraphs 3 and 4
Comment : What technical validation has been done regarding the modelling of fuel dispersion?
Comment Reason : We recognise that the fuel dispersal simulation is technically challenging. It is therefore sensible to undertake some validations using simple experiments before embarking on a complex study such as this.

Revision Suggestion : Clarify what level of confidence there is in the fuel dispersion work?

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 234
Paragraph : Figure 9-29
Comment : Figure 9-29 b) identifies debris at time=0.715s. Page 227 states that this model only ran to 0.62s.

Also a scale on diagram b) might be useful.

Comment Reason : We think the time note on diagram b) is erroneous

Revision Suggestion : Modify time and add scale

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page 343
Paragraph : Second paragraph
Comment : Very little information about debris found beyond the vicinity of the towers seems to have been made available to NIST. For example, the size of panel and mass of landing gear shown in figure 9-123 is unknown. How could this collection of this data following a tragedy be improved?
Comment Reason : Improved process for data collection of debris needed.

Revision Suggestion : It would be useful to make sure some comment about debris collection/recording is put in findings.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 361
Paragraph : Section 9.11.3 Comparison with Observables Paragraph 2
Comment : Recognising that the overall trajectories are a difficult thing to predict, the trajectories of components as they left the building were poorly predicted in the simulations. As this is critical to establishing the damage to the core it would have been useful to discuss the reasons for this in more detail.
Comment Reason : Critical to establishing the core damage key objective

Revision Suggestion : Discussion concerning the reasons for poor correlation of analysis with observables.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : v
Paragraph : Paragraph 2 last sentence
Comment : The SPH approach used by ARA in the analysis for the fuel dispersion following the impact is relatively untried and is not well validated through experiments. Could the researchers clarify what level of confidence they have in the accuracy of predicting fuel dispersion and how this might have influenced the subsequent fire analysis?
Arup□s experience in the modelling fluids suggests fuel dispersion an exceedingly difficult thing to predict and an area where any analysis needs to be considered carefully and supported by laboratory based experimental validation. Given the importance of this study, we believe some testing should have been carried out to confirm the analytical models used prior to assuming dispersal patterns are adequate or correct.

Comment Reason : The report does not adequately explain the limitations of the technical approach taken.

Revision Suggestion : Clarification of the level of confidence or uncertainty in these results.

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From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : x1vi
Paragraph : E.2.1 Global Models of Towers
Comment : Was any attempt made to correlate the total weight of the building with the debris removed?
Comment Reason : While accepting that this would have been an approximation, the data could have been used to estimate the overall loads on the building at the time of impact. This would have given greater confidence in the levels of reserve available at the time of the impact.

Revision Suggestion : Compare amount of debris known to have been removed during the clear operation with the mass used in the global analysis models.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1iv and 1v
Paragraph : Demand Capacity Ratios (DCRs) Paragraph 2
Comment : The baseline analysis examines the DCRs for design loads on the complete tower (figures E-5 and E6). Given that the actual building would typically see less load than this, has any estimate of the actual DCRs for the building in its Sept 11 2001 states? Given that the corners, which general had DCRs in excess of 1, were shown to buckle during the building collapses it might be useful quantify the reserve capacity in the column by checking the DCRs for actual loads on the day for pre and (immediately) post impact states and check these were less than unity.
Comment Reason : Looking a actual DCR□s would provide better estimate of the condition of the building post impact, a main objective of project 2.

Revision Suggestion : Re- analyse using actual loads

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1viii
Paragraph : Section E.5.1 Development of Tower Impact Models
Comment : We believe the global model (of the type shown in figure E-11) had no initial stress in the column and that this was justified by some simple tests using column models. The global model also ignored the overall response of the structure, presumably on the basis that the duration of the impact event was significantly less than the natural period of the building. Could NIST clarify how any P-Δ effects (as a result of the swaying) in the post impact condition were accounted for? From the work reported, post impact P-Δ effects before the fire took hold seem to have been neglected but there is no justification is given. Could P-Δ effects as a result of the significant swaying of the building after impact have influenced the severity of the column damage?
Comment Reason : Inadequancy in the analysis

Revision Suggestion : Justification for neglecting this or re-analysis taking load re-distribution and P-Δ effects into account.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xv
Paragraph : Section E.5.2 Development of Aircraft Impact Models, Paragraph 1
Comment : The report is vague as to exact details of the aircraft data used □ much of the aircraft model seems to have been developed without detailed engineering drawings or more than some cursory measurements. Whilst it might be argued that the strength of the fuselage is not that significant, the 1-2B report (page 368, section 10.2, last paragraph) notes, and we agree, that the strength of some of the denser elements are significant. Recognising Boeing□s desire to retain proprietary information, have Boeing engineers scrutinised the component masses, thicknesses and dimensions used in these models? Have other LS-Dyna experts checked the aircraft impact model in the same way that SOM checked the building models?
Comment Reason : The limited data used to develop the aircraft models may not have been adequately bounded by the uncertainty analysis. Given that the structure of a B767 aircraft is known it seems sensible to check this data where possible.

Revision Suggestion : Clarification regarding the level of checking used in developing the aircraft data.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxviii
Paragraph : Section E7.1 WTC1 Base Case Analysis, Paragraph 2
Comment : As noted previously (see comments on pg lxv) the aircraft models appears to be based on relatively sparse engineering data □ this is surprising, given that B767 design data exists and any inaccuracies in the aircraft model would increase the level of uncertainty in the result. Our concern relates to the limited details in the report about the undercarriage structure and assembly and wing supports (typical weighing 10-12tons)?
Comment Reason : These would have been critical elements determining the state of the core.

Revision Suggestion : Clarify what detailed information was used to model this component and how was this data collected?

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxixx
Paragraph : Section E.7.1 WTC1 Base Case Analysis, sub section External Wall Damage, Paragraph 2
Comment : How were gravity and aero-elastic forces on the wing applied? It seems the wing deflections in flight were accounted for but the report if unclear how this was done?
Comment Reason : Limited information in report

Revision Suggestion : Clarification

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxxv
Paragraph : Section E.7.1 WTC1 Base Case Analysis, sub section Fuel and Debris Distribution Paragraph 1,
Comment : Limited experimental validation work that has been carried out using this method for fuel dispersion. As the analysis ignored the containing effect of the windows, wetting and the multi phase nature of the fuel combustion process during impact, the actual results are at best subjective.
Comment Reason : Inadequacy in the analysis

Revision Suggestion : Clarification regarding the accuracy and level of the uncertainty in the fuel dispersion.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : ci
Paragraph : E.7.2 WTC2 Base Case Analysis, sub section Fuel and Debris Distribution Paragraph 2,
Comment : See previous comments on (pg lxxxv above) regarding the use of SPH to model fuel dispersal.
(The report notes that the work could not reconcile the fuel getting through 200/300 sides.)

Comment Reason : Inadequacy in the analysis

Revision Suggestion : Clarification regarding the accuracy and level of the uncertainty in the fuel dispersion.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : cix
Paragraph : Section E.7.7
Comment : Detailed comparison of damage on □back□ walls (ie south wall of WTC1 and north face of WTC2) between observables and analysis are not shown. The reports notes later that correlation between the impacts and analyses are poor on these faces.
Comment Reason : Limited information in report

Revision Suggestion : Clarification of impact damage estimates

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 6
Paragraph : Section 1.3 Aircraft Impact Damage Analysis Bullet 2
Comment : The sensitivity analysis seems to neglect much of the uncertainty in the aircraft data used in the model. (see our previous comments relating to Page lxxvii)
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 93
Paragraph : Section5.1 Introduction
Comment : We have often found in large civil and building engineering models, used to explicitly simulate impact and seismic events in real time, variation of results between LS-Dyna analyses using 32 bit and the higher precision 64 bit software. We have occasionally seen significant rounding errors on 32 bit computer software when representing physically large dimensions where relatively small displacements in elements trigger failures. Were any of the results models checked using 64 bit precision to test the accuracy of results? The limitations on models size noted in the report are related to 32 bit operating systems. If the impact models had been run on 64 bit operating systems we believe the limitations on model size would have been avoided.

Comment Reason : One dimensionally large model the accuracy of the analysis results needs to be checked using double precision.
The original NIST objective of using state of the art analyses for the Project 2 seems to have been missed. The limitation on model size could have been avoided by using computers with 64 bit operating systems.

Revision Suggestion : Re-analysis of a few of the larger models using 64 bit software.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 269
Paragraph : Section 7.10.1 , Comparison with Observables on WTC1 Landing gear Trajectory
Comment : We accept that the trajectory calculations are difficult. Our calculations show this to be 120mph if no rolling occurred. Was there any evidence of rolling or ricocheting down the road?
Comment Reason : Limited information concerning the observables

Revision Suggestion : Comments regarding the processes used for recording debris data.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 281
Paragraph : Section 7.10.2, Comparison with Observables on WTC2, Engine Trajectory Comparison
Comment : Could the crash investigators tell whether this was a starboard or port engine?
Comment Reason : Limited information

Revision Suggestion : Clarifcation

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 289
Paragraph : Section 7.11.1 Comparison of External Wall Damage
Comment : See our previous comments about the modelling of fuel in the impact.
Was any sensitivity study carried out using the SPHs to correlate this with
fuel falling out of the building?
Comment Reason : Shortcoming in SPH method

Revision Suggestion : Clarification of limitations

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 298
Paragraph : Finding 11
Comment : Although conventional office buildings tend not to consider aircraft impact as a foreseeable hazard, nuclear facilities in the US and elsewhere do. The finding that an aircraft impact was considered at the time of the design of the WTC1 and 2 demonstrates that the possibility of impacts whether accidental or deliberate may need to be considered in some circumstances. Although current building codes don□t consider aircraft impact, it seems reasonable to assume that tall buildings or iconic architecture can be considered targets. The work carried out here should be developed to provide useful information to assist those wishing to design more robust buildings and other facilities irrespective of the building codes.
Comment Reason : General observation

Revision Suggestion : None

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 298
Paragraph : Finding 13
Comment : While generally in agreement that this could be the case, the SPH methodology used should be properly validated. Whether or not this has been done as part of this investigation is unclear.
Comment Reason : There is limited information in the reports to support this finding

Revision Suggestion : Clarification

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: j <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : j
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 300
Paragraph : Finding 18
Comment : The implication that the tower had sufficient reserve capacity because the natural frequency of the buildings post impact was similar to the undamaged state is incorrect. Because the construction of the towers is essentially tube like, the natural frequencies would not alter significantly even if the core was severely damaged. The following simple FE models demonstrate the insignificance of the core:
Simplistic Model Results

Results from five simple finite element models (of roughly the same geometric proportions as WTC1 and WTC2) demonstrate that a large hole in the side of a tube and the missing parts of the core do not significantly influence the natural frequency (see table 1).

Table 1 Variation of Natural Frequency (in Hz)

	Model				
	1	2	3	4	5
Bending	0.1653	0.1647	0.1643	0.1636	0.1637
Torsion	0.5981	0.5889	0.5981	0.5891	0.5889

Model 1

Tube & core
No holes Model 2

Large hole in side & no core. Model 3

No hole with core Model 4.

Large hole in side with core Model 5

Large hole in side and core missing at same level

Comment Reason : The stability of the towers immediately following the impact has not really been proven by the impact analysis. Simply taking the results of the impact damaged structure and loading it statically effectively ignores and damage that may have resulted due to swaying.

Revision Suggestion : Provide a more detailed analysis to take account of load path re-distribution in the core and the P-Δ effects of sway following the impact.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6A

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6A
Page Number : 29
Paragraph : Table 2.2
Comment : Is the thermally equivalent thickness for bridging
□ two way a misprint? How can an in-place thickness
of 0.38" have an equivalent thickness of 0.6"?
Comment Reason : Possible error

Revision Suggestion : Insert correct value if an error has occurred.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6A

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6A
Page Number : 17
Paragraph : Fig 2-2
Comment : A demonstration of the application of an unspecified Monokote material is in progress.
How does this relate to the Cafco Blaze-Shield material?
Comment Reason : Unclear if this material is similar to the Blaze shield.

Revision Suggestion : Make comment if it is similar, or application techniques are the same.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6A

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6A
Page Number : 21
Paragraph : Section 2.2.9. Para 2 & 3.
Comment : Qualitatively how weak was the SFRM from the samples made in the course of the investigation?
Comment Reason : It would help readers put the strength of the SFRM into context. Qualitative information like this would be useful in building up a picture of how it may have behaved on 9-11-2001

Revision Suggestion : Add comments about how easily dented or crushed the materials could be.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6A

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6A
Page Number : 31
Paragraph : Section 2.6.4/Para 4
Comment : Were the US Gypsum Co panels the same as those used in the WTC towers? Or were they chosen as typical materials so would be representative of those used to insulate the core columns?
Comment Reason : Useful context.

Revision Suggestion : State why those gypsum panels were chosen.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6A

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6A
Page Number : 34
Paragraph : Section 2.7.2. Paragraph 2/Sentence 8
Comment : It is unclear how if 'the first test resulted in cohesive failure, the second test measured adhesive strength' -Could another cohesive failure not have occurred?
Comment Reason : Reason for the assumption is unclear.

Revision Suggestion : Please explain why this assumption is correct, or state that either adhesive or cohesive failure could have occured.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6A

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6A
Page Number : 34
Paragraph : Paragraph 5/Sentence 2
Comment : The implications of the comment that 'two thirds of the specimens with the thicker SFRM had no adhesion to the coated steel plates' seems to have been underestimated.
This implies that all the SFRM in the vicinity of the plane impact on WTC1 could have easily come off the bulk of the columns and some of the flat sections in the trusses.
Comment Reason : This seems to have been ignored in the flat plate calculation for acceleration required to cause debonding.

Revision Suggestion : Make more of the fact that large areas of SFRM could have

been debonded before the time of the impact on WTC1 where the thicker SFRM had been applied to painted steelwork.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 39
Paragraph : Section 3.2.2, Paragraph 2/Sentences 1 and 2
Comment : While the average of the limited measurements made in 1994 may be 3/4", this is not the critical SFRM thickness.
As noted in NCSTAR 1-6A, the minimum observed SFRM thickness was 0.52 inches.
This value, whether over the full length of a truss or in a localized area, would be the critical thickness.
Justification for assuming 3/4 inches has not been provided.
Applying 3/4" of SFRM could lead to misleading results regarding the actual performance of the WTC trusses as they were installed.
Comment Reason : Justification and clarification required.

Revision Suggestion : Include discussion and justification regarding the application of the average observed SFRM thickness rather than the minimum (critical) thickness.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 55
Paragraph : Section 3.7
Comment : The summary does not specifically address the four purpose statements included in Section 3.1.2.

Comment Reason : The purpose statements should be specifically addressed in the conclusion in order to show how the purposes of the testing were achieved and to answer the questions asked in the purpose statements.

Revision Suggestion : Add specific discussion relating the testing results to the purpose statements of Section 3.1.2.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6B
Page Number : 2
Paragraph : Section 1.2, Paragraph 1 including bullet points
Comment : The purpose statements listed here do not correspond with the purpose statements laid out in NCSTAR 1-6, Chapter 3.

Comment Reason : Purpose statements are inconsistent between this report and NCSTAR 1-6.

Revision Suggestion : Add a fourth bullet as follows:
"to determine whether there was an adequate technical basis for the original fireproofing specification"

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6B
Page Number : 3
Paragraph : Section 1.4, Paragraph 3/Sentences 1 and 2
Comment : The term "unconstrained" is used here but nowhere else in the report.

It is assumed that this implies "unrestrained," which is used elsewhere.

Comment Reason : Terminology should be kept consistent throughout the report in order to ensure clarity.
In this case, it should also correspond to the test standard

Revision Suggestion : Change two instances of "unconstrained" to "unrestrained"

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6B
Page Number : 4
Paragraph : Section 1.4, Paragraph 5/Sentence 2
Comment : Given the variability in thickness of SFRM observed on the main trusses of WTC 2, how confident can NIST be that 3/8" is the average value for SFRM thickness on the bridging trusses?
Was variation of this SFRM thickness considered, and what would the impact be?
Comment Reason : Clarification needed.

Revision Suggestion : Add discussion regarding the confidence in the SFRM thickness value, and the possible impact of variability here.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6B
Page Number : 10
Paragraph : Section 4.1.5, Paragraph 2/Sentence 5
Comment : It is stated that the test assemblies were designed to AISC standards of 1989, while the AISC standard current when the WTC towers were designed was the 1963 version.
These versions differ significantly in some areas.
What is the rationale behind designing the assemblies to the 1989 standard?
Comment Reason : Clarification and justification needed.

Revision Suggestion : Clarification and justification needed. Provide discussion of and justification for designing the test assemblies to 1989 standards rather than 1963 standards.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6B
Page Number : 10
Paragraph : Section 4.1.5, Paragraph 2/Sentence 5
Comment : The 1989 AISC Specification for Structural Steel Buildings referenced here is not included in the References list in Chapter 7.
Comment Reason : Missing reference.

Revision Suggestion : Include full reference in Chapter 7.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6B
Page Number : 12
Paragraph : Section 4.2.3, Paragraph 1/Sentences 4 and 5
Comment : It is stated that the MIG welds used in fabricating the test assemblies were designed to meet 2001 AISC strength requirements.
The replacement of SMA welds with MIG welds has not been technically justified.
Also, it is unclear how the 2001 strength requirements compare to the strength requirements imposed on the original WTC design.
Comment Reason : Clarification and justification required.

Revision Suggestion : Provide technical justification for using MIG welds instead of SMA welds.
Provide comparison of 2001 weld strength standards with ~1963 weld strength standards.
Provide discussion of the impact of variation between the weld strength standards.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6B
Page Number : 12
Paragraph : Section 4.2.4, Paragraph 1/Sentence 5
Comment : The report does not state how it was determined that seaming the metal deck longitudinally would be acceptable given that the original deck in the WTC towers was not seamed in this way.
The strength of a seamed deck is not likely equivalent to an unseamed deck of the same span.
Failure of the seam, as was observed in the tests of Assembly 1 and Assembly 3, can lead to negative effects, such as spalling, more rapid heat transfer through the slab, and loss of support of the slab.
Comment Reason : The seamed metal deck does not necessarily represent the in-place conditions in the WTC towers.
Also, failure of the seams was observed in two of the 4 tests, and this effect could not have occurred in the original WTC assemblies.

Revision Suggestion : Provide justification for using seamed decking.
If possible, provide analysis of the impact of the seaming and discussion of the seam failures in Assemblies 1 and 3.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6B
Page Number : 19
Paragraph : Section 4.2.8, Paragraph 1/Sentence 1
Comment : BLAZE-SHIELD Type DC/F SFRM was used in the test assemblies, while the SFRM used in the WTC towers was Cafco Type D.
There is no discussion regarding this deviation from the original design.
Comment Reason : Different SFRM materials can have different performance characteristics, including adherability during fire and fire protection performance.

Revision Suggestion : Provide data regarding composition and performance of both Cafco Type D and BLAZE-SHIELD Type DC/F.
Provide justification for this substitution.
Discuss possible impacts of this substitution.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6B
Page Number : 28
Paragraph : Section 4.3.1, Table 4-3
Comment : A large variation between the compressive strengths of the concrete slabs for Assemblies 1 and 2 was observed but not discussed.
Also, additional water was added to Assembly 1 but not discussed.
These were intended to have an identical mix design, but ultimately were significantly different.

Comment Reason : Additional information needed.

Revision Suggestion : Provide additional information regarding the pouring and strength testing of Assemblies 1 and 2.
Provide discussion of the impact of the different compressive strength measurements.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6B
Page Number : 47
Paragraph : Chapter 5, Paragraph 1/Sentence 1
Comment : The introduction to Chapter 5 states that the tests were carried out in accordance with the 2000 version of ASTM E 119.
The 2000 version differs significantly from the 1961 version, for instance in terms of member restraint.
The use of the 2000 version is acceptable for determining the assembly performance that would currently be expected based on the standard test, however it is not appropriate for determining the performance that would have been expected of the assembly given the standard test of 1961.
Comment Reason : The use of the 2000 test standard may negate conclusions regarding what performance would have been predicted had the assembly been tested in the 1960's.

Revision Suggestion : Include a comparison of the 1961 and 2000 versions of ASTM E 119 and discuss whether or not the differences would lead to variations in the prediction of performance.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6B
Page Number : 99
Paragraph : Section 6.1.3, Paragraph 3/Sentence 5
Comment : Reference to Figure 5-50 is incorrect.
This should refer to Figure 5-53.
Comment Reason : Incorrect figure reference.

Revision Suggestion : Replace Figure 5-50 with 5-53

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6B
Page Number : 104
Paragraph : Section 6.2, Bullet 2
Comment : The bullet states that in the reduced-scale unrestrained test, the load was maintained for 3 1/2 h without collapsing.
Neither of the reduced-scale tests was conducted in the unrestrained condition.
We think this is referring to Test 3.
Comment Reason : Incorrect reference to test condition.

Revision Suggestion : Change "reduced-scale unrestrained test" to "reduced-scale test with 3/4 inch thick spray-applied fire resistive material"

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6C

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6C
Page Number : 72
Paragraph : paragraph 1 / sentences 1-5
Comment : There is only a small amount of written text describing the basis of the temperatures used for the truss model, particularly differential temperatures between elements and through the slab thickness
Comment Reason : The temperature regime used in this calculation is approximate and described as not being based on the fire analysis. As a result of the temperatures used, there are early failures of studs, straps and knuckles, with chord yielding. These are as a result of restraints and temperature differences between steel and slab. Although it may not be possible to cover all real fire scenarios in this analysis, it would be valuable to test the sensitivity of the results to variations in the assumptions regarding temperature variation through the slab with time, temperature variation between the truss chords and the slab, and between the upper and lower truss chords. This would take account of the likelihood that, in cases near impact zones, where all fire proofing was estimated to be lost, the upper chord may be cooler than the lower chord, due to thermal mass and contact with the slab. It would also affect the deflection pattern if higher temperatures on the lower chord result in further bowing.

Revision Suggestion : We recommend further discussion on the basis of the temperatures used for the truss model, particularly differential temperatures between elements and through the slab thickness.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6C

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6C
Page Number : 70
Paragraph : Section 5.4.3 sentence 1, Figure 5.26
Comment : Recommend assessing sensitivity of results to changes of assumed boundary conditions in the truss model.
Comment Reason : The boundary conditions for this analysis involved rigid fixity at the ends of columns above and below the truss modelled, and fixed support at the core. This would represent an upper bound on this stiffness, since in all real cases the storeys above will not represent a fixed support, but will form a spring restraint, and will also moving outwards in the case that several floors are being heated. Hence the boundary conditions that were assumed would tend to lead to an overestimate of forces pushing outward, and would change the inward forces as the floor sags into catenary action. This is a complex effect based on difference in stiffness, expansion and deflection. We note that the issue of inward and outward force transfers from floors to walls was one where some difficulties were found in achieving correlation of analysis with observed results. Hence it would be useful to explore this effect by testing sensitivity of the results to the variation of boundary conditions.

Revision Suggestion : Recommend assessing sensitivity of results to changes of assumed boundary conditions in the truss model.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6C

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6C
Page Number : 116
Paragraph : Section 5.58 Paragraph 1/Sentences 1-5
Comment : Further disccusion and assessment needed of force transfers between floors and walls, in relation to the boundary conditions.
Comment Reason : It is noted that, as with the simplified truss models, the full floor models included rigid fixity of columns one storey above and below the floors modelled. This is an overestimate of actual restraint, and would be expected to change the calculated pulling and pushing forces between the floors and the walls. It would also change the deflection of the walls, and the time at which truss seat walk-off occurs, leading to collapse of a truss. It is understood and accepted that the boundary conditions for these single floor models cannot fully represent the true interactions across several floors, however further tests to explore bounds on this issue by testing less rigid boundaries would be beneficial, since they are critical in overall behaviour.

Revision Suggestion : Further disccusion and assessment needed of force transfers between floors and walls, in relation to the boundary conditions.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6C

Information Submitted on: 8/3/2005.

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Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6C
Page Number : 153
Paragraph : Section 5.5.17 Paragraph 2/Sentences 1-2
Comment : There appears to be no reason given for why pull-in forces were not observed as expected, and different between WTC1 and WTC2.
Comment Reason : The transfer of horizontal forces between floors and vertical structures is a critical interaction. If analyisis is to be valid, the load paths and performance of the models needs to be understood and rationalised, to ensure that critical aspects of the performance have been captured.

Revision Suggestion : Provide comment on reason why pull-in forces were not observed as expected, and different between WTC1 and WTC2.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6C

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6C
Page Number : 155
Paragraph : Section 6 Paragraph 1/Sentence 1 & bullet points
Comment : There appears to be no discussion on the relationship of the assumptions made for the size of the model, and the number of disconnected floors, to the observed/calculated interactions of the walls and the floors.
Comment Reason : Buckling failure of unrestrained columns with pull-in forces highlights the sensitivity of the interaction of floor structures and columns, and transfer of forces. The material in the report appears to be testing a range of conditions against column performance, without clearly relating them to actual patterns of damage either from the floor models or observation, so that failure loads can be determined.

Revision Suggestion : Provide discussion on the relationship of the assumptions made for the size of the model, and the number of disconnected floors, to the observed/calculated interactions of the walls and the floors.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6C

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6C
Page Number : 199
Paragraph : Chapter 7 paragraph 3 / sentences 1-2
Comment : It is noted that as described, the global models would not capture any effects resulting from the interaction of floors and columns, unless they are directly derived from the subassembly models or actual observations, and imposed on the global model as applied damage or forces. Hence it is important that all relevant bounds relating to the interactions between floors and vertical structure are explored at the level of the floor and other subassembly models.

There appears to have been no model in which floor structures, modelled in a way which captures their main actions, including thermal expansion, sagging, change of action from bending to bending/catenary, and support failure, can interact with the vertical structures over a number of storeys, if not the whole building. Hence it is of concern that some primary modes of building failure are reliant only on adjustment of the global models based on observation, rather than calculated interaction of the parts.

Comment Reason : Uncertainty in the effects of floor / wall interaction as modelled.

Revision Suggestion : Include more accurate floor models or state that this is a shortcoming and requries further research to justify collapse mechanisms.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 121
Paragraph : Paragraph 2/Sentence 5
Comment : Two rates of damage estimates are selected per Tower from the analysis. These impact damage results are then used in the fire dynamics analysis, thermal analysis and the structural response analysis. However the report does not state what the criteria for damage assessment are, how they are set and evaluated. Would it be physical damage to the core columns, perimeter columns, facade or to where damage would have the largest effect on the structural fire performance of the towers?
Comment Reason : Because this analysis is the basis for all further analyses the assumptions, results and report should be as clear as possible.

Revision Suggestion : Report contents could be further clarified.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 121
Paragraph : Paragraph 4/Sentence 5
Comment : The statement that the effect of the fire proofing of the floor framing has limited effect on the structural fire behaviour should be supported by structural fire engineering analysis at elevated temperatures.
Comment Reason : Statement should be supported by calculations.

Revision Suggestion : Cross reference structural fire calculations which justify this statement.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 122
Paragraph : Paragraph 4/Sentence 2
Comment : It should be clarified how a comparison between the observed and predicted damage can be made. It is unclear what modes are analysed and how magnitudes are compared.
Comment Reason : It should be clarified how a comparison between analysis and observations are obtained. Mode and magnitudes should be explained in this section or references should be added to the text.

Revision Suggestion : A more detailed explanation of failure modes and magnitudes requried.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 124
Paragraph : Paragraph 1/Sentence 5
Comment : The column fire behaviour would be affected by visible local distortions of the column cross section (e.g local flange bending).
Specifically restrained thermal expansion effects and rotations at connections would further reduce the capacity of the column in fire.
Comment Reason : The core column structural fire behaviour could have had a major impact on the global behaviour of the WTC towers. These assumptions could have had a major effect on the global behaviour and even collapse sequence of the tower. It is suggested that the column strength / buckling capacity of moderate damaged columns could have been modified to better represent the damage in the global model.

Revision Suggestion : Please explain why retaining moderately damaged core columns without modification are believed to be reasonable.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 129
Paragraph : Paragraph 7/Sentence 1
Comment : It should be explained why it is conservative to ignore large parts of fire protection being dislodged in determining the structural fire behaviour of the towers. It is unclear why damage to fire protection due to vibrations in the building is not investigated, since the presence of fire protection material is a critical factor in the global structural fire analysis.
Comment Reason : The fire behaviour is mainly driven by thermal expansion and material degradation at elevated temperatures and our main concern is more steel is cool than may have occurred and this is not conservative for a failure analysis.

Revision Suggestion : Explain how this estimation is conservative in the report.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 130
Paragraph : Paragraph 1/Sentence 3-9
Comment : It should be explained why damage to fire protection due to the impact of jet fuel is not investigated, since the presence of fire protection material is a critical factor in the global structural fire analysis.
Comment Reason : The fire behaviour is mainly driven by thermal expansion and material degradation at elevated temperatures and therefore an accurate estimation of heating to structural elements is crucial to get reliable and realistic results.

Revision Suggestion : Explain how this estimation is conservative in the report.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 186
Paragraph : Section 7.2.2
Paragraph 2/Sentence 4
Comment : The report should state if Case A impact damage and Case B temperature history happen at the same time?

Comment Reason : If they do not happen in the same event, what is the physical meaning for combining these two together. Even if the result showed better correlation with the real case, it did not represent the real structural behavior.

Revision Suggestion : Clarification needed.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 192
Paragraph : Section 7.3.1
Paragraph 1/Sentence 5
Comment : It is not clear how the strain of the concrete was modelled, especially for the tension zone?
Comment Reason : The report mentioned that the concrete material model used the compressive strength as the yield point, with the same yield strength in both tension and compression. It is not clear how the strain of the concrete was modelled. Was the strain of conrete in the tension zone the same as the bilinear stress-strain constitutive model assumed for the compressive zone, in which case it is not considered as an appropriate material model for simulating concrete behavior.

Revision Suggestion : Provide detailed clarification of concrete model.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

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Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 209
Paragraph : Section 7.4.1
Paragraph 6/Sentence 1
Comment : Inward pull in forces were estimated based on trial and error procedures to match photos.

Comment Reason : Simply showing a good comparison with the observation is not enough for this highly complex problem and can not prove the assumptions made about the pulling forces.

Revision Suggestion : A full non-linear analysis with thermal expansion and non-linear inelastic material properties is the only way to justify the estimated magnitude and distribution of the pulling forces. Further research projects may need ot be proposed.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 221
Paragraph : Section 7.5
Paragraph 3/Sentence 1
Comment : Justification needed.
Comment Reason : For a 60ft span beam, the thermal expansion at 200C will be larger than the elongation caused by the floor sagging of 25in. Therefore, it could be in compression due to restrained thermal expansion, not in tension.

Revision Suggestion : Greater justification for inward pull forces is required.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 170
Paragraph : Paragraph 4-6
Comment : An elastic super element to model the hat truss of WTC 2 is of concern.
Comment Reason : We would have thought that it would become inelastic near failure if this is a key load carrying path.
Load transfer via the hat truss is captured by the WTC1 model but as super elements were used in WTC 2 accuracy in any load transfer near failure is difficult to justify.

Revision Suggestion : Repeat analysis or flag as a research study for the future.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 165
Paragraph : Paragraph 1, Sentence 1-2
Comment : Incorporating trusses in the floor slab as a smeared model is of concern.
Comment Reason : Incorporating trusses in the floor slab as a smeared model is of concern.

Revision Suggestion : Repeat analysis with trusses modelled explicitly or flag as a research study for the future.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 170
Paragraph : Paragraph 2-3
Comment : It is of concern that thermal expansion is not included in the floors of the main models.
Comment Reason : As modelled the floors cannot be expected to push or pull on the columns as they expand and bow in the real fire. This means the real structural response in fire is not captured.

Revision Suggestion : Repeat analysis with thermal expansion included or flag as a research study for the future.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 170
Paragraph : Paragraph 1/Sentence 1-5
Comment : It is of concern that the axial degree of freedom was released on the spandrels because visual inspection showed that buckling of the spandrels played little role in the collapse sequence.
Load transfer via vierendeel action along the length of the exterior walls may have been affected by the omission of the spandrel beams this needs to be justified. This would be of more importance if wind load had been included.

Comment Reason : They could play a significant role in load transfer along the column walls therefore the force distribution in the model.

Revision Suggestion : Justify omission in context of load transfer during the fire.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 170
Paragraph : Paragraph 2-3
Comment : It is of concern that thermal expansion is not included in the floors of the main models.
Comment Reason : As modelled the floors cannot be expected to push or pull on the columns as they expand and bow in the real fire. This means the real structural response in fire is not captured.

Revision Suggestion : Repeat analysis with thermal expansion included or flag as a research study for the future.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 170
Paragraph : Paragraph 1/Sentence 1-5
Comment : It is of concern that the thermal expansion of the spandrels was set to zero.
Comment Reason : Any forces generated as a result of this expansion are not calculated by the model. This will effect overall structural response to fire during the fires when loads are transferred via the exterior walls.

Revision Suggestion : Justify omission in context of load transfer during the fire.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 164
Paragraph : Paragraph 5/Sentence 2-4
Comment : It is of concern that only mechanical floor beams and core beams with moment connections were included in the main models. The justification given for this is that simple beams cannot transfer shear to columns at their connections.
Comment Reason : This is not strictly true and shear will be transferred if the beam is connected to a column. In reality moment can also be transferred because connections will have some moment capacity even if it has been ignored in design. By omitting beams in the core the gradient in the composite core slab thus the forces as a result of thermal expansion effects on the rest of the structure are not modelled. It is assumed the columns provided with some form lateral support where a beam is omitted else the slenderness of the column is too high in the models.

Revision Suggestion : Repeat analysis with all beams in the core at least in sub-model or flag as a research study for the future.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 164
Paragraph : Paragraph 4/Sentence 4-5
Comment : In reality the material properties of plates 1 and 2 versus plate 3 of a typical exterior column are different however in the models they were assumed to be the same. This has not been justified.
Comment Reason : It is not clear from the report if this assumption affects the outcome of the modelling process.

Revision Suggestion : Justify assumption.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 171
Paragraph : Paragraph 2-3
Comment : It is of concern that the outriggers of the hat truss were increased in size in the WTC1 model to account for the incorrect increase in compressive stresses when the construction sequence was not considered.
Comment Reason : This could make the models non conservative because the loads in the hat truss during the fire will be very different to the loads at ambient regardless of how stressed the hat truss was originally.

Revision Suggestion : Justify decision by looking at the response of the hat truss to the load redistribution during the fires in WTC1 with and without this increase in member size.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 7
Paragraph : Paragraph 1/Sentence 1-4
Comment : There is no mention of wind load applied to the 3D structural fire models of the towers. It is of concern if this has not been considered.
Comment Reason : Given the height and impact of wind on the frame a sensitivity study should have been carried out to quantify the impact of wind and omit if justified.

Revision Suggestion : Do sensitivity study or apply to global model and repeat analysis.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 7
Paragraph : Paragraph 1/Sentence 1-4
Comment : The report states that 25% of the design live load is applied to the models but there is no justification given as to why this value was chosen. Is this based on survey data of the actual building or an assumption if so how is it justified?
Comment Reason : Of interest to the reader why this value was chosen.

Revision Suggestion : Justify or explain the use of 25% of the live load.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 22
Paragraph : Paragraph 2/Sentence 6
Comment : The report states that gravity load was not applied to the floors but it is not clear if live load was applied or whether this was only to the columns. Was live load applied to the columns only?
Comment Reason : If live load was not applied to the floors then there is no load at all applied to the floors therefore no pull-in force applied to the columns as a result of this.

Revision Suggestion : Clarify and justify decision.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 165
Paragraph : Paragraph 1-2
Comment : It is of concern that the concrete floors with smeared model included to model the trusses are fully elastic with the same strength in compression and tension.
Comment Reason : This □elastic□ property approach allows the floors to carry significant tensile loads in membrane action. This approach was used 15 years ago in very early models of the Cardington tests in the UK when convergence problems were an issue. This was then justified because the building was not near impending failure. Later models used accurate damage plasticity models to represent the concrete. An elastic floor model is not a reliable method of modelling a slabs response to fire particularly near failure when tension forces should not be allowed to develop to unrealistic levels.

Revision Suggestion : Repeat analysis with full inelastic material properties or flag as a research study for the future.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 6
Paragraph : Paragraph 1/Sentence 4
Comment : It is clear that NIST have spent significant time and effort modelling creep. They have been able to extract creep strains separately from the mechanical strains calculated by the ANSYS models therefore it is assumed that the model includes creep explicitly.
Has the creep model and its effects been tested as part of a sensitivity study of load, temperature and section size on simple single beams or columns? How was it validated?

Comment Reason : Validation is important for new modelling techniques.

Revision Suggestion : Conduct simple sensitivity study to understand the effect oif creep on a single heated element.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 31
Paragraph : Paragraph 3/Sentence 4-6
Comment : The exact details of how the simplified temperature distribution was established are not clear and it would be useful if the simplified temperature data was explained in diagrammatic form for comparison with the real gradients and temperature distributions in the structure.
Comment Reason : For comparison so the reader can understand if it was reasonably accurate or overly simple.

Revision Suggestion : Show the simplified temperature data in diagrammatic form for comparison with the real gradients and temperature distributions in the structure.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 31
Paragraph : Paragraph 3/Sentence 4-6
Comment : It is not clear how the simplified temperature-time data at 10 minute intervals compares with the predicted temperature-time data at many points.
Comment Reason : The reader should be able to understand if the 10-minute interval plots were reasonably accurate or overly simple compared with the actual predicted temperatures.

Revision Suggestion : Generate graphs of the actual temperature-time data with the simplified model data at 10 minute intervals superimposed on top to clarify this concept for the reader.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 36/48
Paragraph : Paragraph 1-2/Paragraph 3
Comment : It is of concern that the amount of thermal bowing on the columns is highly dependent on the pull-in force applied which was arrived at by applying different forces in a trial and error approach until the bowing in the model matched the pull-in observed by the video footage.
Comment Reason : Clearly the impact of thermal expansion was considered important for the columns and in the floors/trusses in the sub-assembly models but due to convergence problems was omitted from the floor system (trusses and slab) in the main 3D models of WTC 1 and 2. Consequently, the pull-in forces on the columns from the floors were estimated by a trial and error approach to match bowing of the columns from visual evidence in videos and photographic footage. This force was not calculated by modelling. Moreover, by ignoring expansion in the floors of the 3D model the push force from the expanding floors on the columns in the earlier stages of the fire was also ignored. The time dependent change of □pull or push□ force on the columns has not been captured and this is critical to the structural response thus eventually the collapse mechanism proposed.

Revision Suggestion : Include thermal expansion in the floors and repeat analysis.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 36/48
Paragraph : Paragraph 2/Paragraph 3
Comment : No push-out forces are ever applied to the columns which would represent the floors expanding.
Comment Reason : This is critical to the structural response thus eventually the collapse mechanism proposed.

Revision Suggestion : Include thermal expansion in the floors and repeat analysis.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 57
Paragraph : Paragraph 1/Sentence 1
Comment : There is no justification for the extent of the wall model chosen.
Comment Reason : It is of interest to the public why 9 storeys was chosen and if this can be justified.

Revision Suggestion : Justify decision.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 304
Paragraph : Paragraph 2
Comment : The key responses described by NIST as the events which lead to collapse are all plausible when considered qualitatively i.e. sagging of floors, pull-in of columns, load transfer, weakening of the core. The validity of the collapse mechanism cannot be proven.
Comment Reason : The collapse mechanism proposed is one possible mechanism only but the reasoning and calculation of the pull-in forces which contribute to the collapse are not justified nor validated. The load transfer and column response are calculated in response to □made-up□ forces from the floors therefore the values of strain, stress etc calculated by the models are not useful as a quantitative assessment.

Revision Suggestion : Include thermal expansion in the floors, model trusses explicitly with thermal expansion also, use a full inelastic model for the concrete floor and repeat analysis.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 333
Paragraph : Paragraph 2
Comment : Of greatest concern is the removal of the strap anchors as this prevents the columns being loaded by the expanding and sagging floor therefore horizontal reaction forces experienced by the columns are not accurately distributed. The removal of the bridging trusses also changes the restraint to thermal expansion of the perpendicular trusses and the slab therefore also introducing errors to the calculation.
Comment Reason : The inadequacy of the single floor model to calculate pull-in forces further emphasises the need to calculate it in the global model.

Revision Suggestion : Include thermal expansion in the floors, model trusses explicitly with thermal expansion also, use a full inelastic model for the concrete floor and repeat analysis.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6D

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6D
Page Number : 349
Paragraph : Paragraph 1/Sentence 12-13
Comment : It is of concern that the single floor models showed push-out of the columns but that this was not modelled in the global models.
Comment Reason : A key force on the columns is not modelled in the global model.

Revision Suggestion : Include thermal expansion in the floors, model trusses explicitly with thermal expansion also, use a full inelastic model for the concrete floor and repeat analysis.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 272
Paragraph : Paragraph 4
Comment : Of concern is the fact that multiple floor fires have not been considered on an undamaged model without impact therefore the conclusions are not justified. Evidence from research being carried out by Arup suggests that multiple-floor fires could result in collapse of structures comprised of long span floor systems similar to WTC and other forms of construction. Moreover, burnout of the compartment in 20 minutes seems short and it is known that multiple floor fires can burn at relatively low temperatures for many hours, for example the Madrid Torre Windsor Fire, Spain, 2005, continuously heating protected steel and concrete reducing the effectiveness of thermal lag and weakening the structure.

Comment Reason : The most likely reason that the structure would survive a multiple floor fire is that in an undamaged building the core would not be heated therefore this alternative load path via the hat truss for load from the exterior columns would remain sufficiently strong for the duration of a fire and could have prevented collapse. This not modelled by a single floor model.

Revision Suggestion : Include thermal expansion in the floors, model trusses explicitly with thermal expansion also, use a full inelastic model for the concrete floor in the global models and repeat analysis without impact damage.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 286
Paragraph : Bullet Point 1
Comment : In Section 9.3, floor sagging is attributed to the steel temperatures as a result of loss of fire proofing, yet it is well documented that protected steel can be subject to sagging, in fire events.
Comment Reason : Protected steel can be subject to sagging also.

Revision Suggestion : Change text to explain that floor sagging can be a result of a number of factors and unprotected steel is only one.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 312
Paragraph : Bullet Point 6
Comment : Whilst we agree the Towers did not collapse solely due to impact, we do not agree with NIST□s conclusion that only impact induced fire proofing damage caused the collapse.
Comment Reason : In the event of a multiple floor fire, protected structure heats (as it does in a single floor fire), and this heating of columns over multiple floors causes thermally induced structural responses, which could lead to collapse. Loss of fire proofing may have reduced the time to collapse, but the analysis presented in Project 6 does not prove that it would have prevented collapse, particularly when so much emphasis is placed, in this regard, on the tests carried out.

Revision Suggestion : Alter report conclusions to reflect this.

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From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 311
Paragraph : Paragraph 3/Sentence 2-3
Comment : NIST correctly observe the loss of strength and stiffness attributed to temperatures in the region of 500-600°C> However they do not mention that thermal expansion effects occur in structures at temperatures as low as 100°C. Therefore even for their stated protected structural elements not exceeding 400°C, we would expect to see serious thermally induced structural response, particularly if such temperatures occurred over multiple floors.
Comment Reason : Thermal expansion effects occur in structures at temperatures as low as 100°C.

Revision Suggestion : Change text to explain that thermal expansion occurs at temperatures < 400C.

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From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 311
Paragraph : Paragraph 4/Sentence 3-4
Comment : We disagree that only without fire proofing does floor sagging occur to the extent possible to exert pull-in forces on the wall. In addition NIST do not mention the outward lateral expansion of the columns that could occur at temperatures in the region of 400°C, before inward bowing would occur. In addition we disagree that load distribution would be negligible had the fire proofing remained in place, and that the towers would remain stable.
Comment Reason : Floor sagging, push and pull-in of columns by the heated floors occurs even when steel protected.

Revision Suggestion : A global multi-floor model analysis with accurate time dependent material properties, thermal expansion and full representation of the trusses but without impact damage should be carried out before this current conclusion, of critical importance, that only loss of fire proofing due to impact resulted in the collapse of the Towers.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 311
Paragraph : Paragraph 6/Sentence 1-2
Comment : It is of concern that the standard test data has been used as proof that had the fireproofing remained in place no structural response would have occurred.
Comment Reason : We believe the single element test can not replicate the complex multiple element structural system in the Tower, the effects of restrained thermal expansion, and resulting fire-induced load bearing mechanisms, and this concept is well accepted in the structural fire community.

Revision Suggestion : State limitations of test and justify conclusion as a result of whole frame modelling not testing.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR 1
Page Number : 204
Paragraph : Paragraph 3/Bullet 4
Comment : We do not support the concept of preventing local failure in an unsprinkerled fire as this should have no impact on life safety in a building with an implemented evacuation plan for both occupants and emergency responders.
Comment Reason : Local failure can in fact relieve thermally induced forces and so may help prevent a progressive collapse mechanism. Such over - design in our view would not greatly enhance the overall building response to the fire.

Revision Suggestion : Reconsider the issue of design for local failure or define clearly what local failure is? Buckling of a beam is good for the structure therefore should not be designed against.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/3/2005.

Name : Barbara Lane
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Phone : +44 (0)207 755 3303
Report Number : NCSTAR 1
Page Number : 204
Paragraph : Paragraph 3/Bullet 5

Comment : We do not understand how a window assembly could ever be detailed to guarantee prevention of failure in a severe fire event.
Comment Reason : From a structural robustness perspective we would prefer to detail the structure to withstand such an event, rather than rely solely on prevention of glazing failure. This form of prevention we would consider to be a serious weakness in the design package.

Revision Suggestion : Omit or revise recommendation.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR 1
Page Number : 205
Paragraph : Paragraph 2/Sentence 2
Comment : Recommendation 5 is of concern.
NIST recommends that the technical basis for the century-old standard for fire resistance testing of components, assemblies, and systems should be improved through a national effort. Necessary guidance also should be developed for extrapolating the results of tested assemblies to prototypical building systems.
We support NIST□S call for improved evaluation of untested building elements; as well as the relationship between prescriptive ratings and performance of assembly□s in real fires.

Comment Reason : The standard fire resistance test provides an excellent comparative test to understand the relative performance of products in the construction industry. It does not attempt to quantify real structural response to fire, nor the factors NIST have identified as significant to now understand, particularly the role of long span systems in fire.
The lack of identification by NIST of the role of thermal expansion here is a concern.

Revision Suggestion : The knowledge NIST recommends as now being required, can only be gained from full-scale structural testing or thermo-mechanical analysis of structural systems and frames in fire.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

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Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR 1
Page Number : 207
Paragraph : Paragraph 2/Sentence 2
Comment : Recommendation 7 is of concern.
NIST recommends the nationwide adoption and use of the □structural frame□ approach to fire resistance ratings.

Comment Reason : We would recommend that full frame structural fire analysis provides the most robust form of determining weakness in structural designs for fire, particularly when multiple floor fires are a real concern. We recommend that a move towards specific structural detailing to prevent structural collapse mechanisms in fire be the future of tall building design, rather than increasing reliance on passive fire protection.

Revision Suggestion : Make changes to the recommendation where possible to reflect our concern.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR 1
Page Number : 207
Paragraph : Paragraph 4/Sentence 2
Comment : Recommendation 8 is of concern.
NIST recommends that the fire resistance of structures should be enhanced by requiring a performance objective that uncontrolled building fires result in burnout without local or global collapse.

Comment Reason : The concept of non-operation of sprinklers is significant should a risk based assessment deem it necessary to consider in a structural design only. We do not however support the concept of design to limit local collapse but do to prevent global collapse, as it is not clear why this level of over design would be merited, except for some very specific and rare events.

Revision Suggestion : Suggest that the concept of preventing local collapse is qualified with the following statement, □unless such collapse leads to an overall/progressive collapse, or compromises the integrity of required primary routes for egress and emergency services access□.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR 1
Page Number : 207
Paragraph : Paragraph 5/Sentence 2
Comment : Recommendation 9 is of concern. NIST recommends the development of: (1) performance-based standards and code provisions, as an alternative to current prescriptive design methods, to enable the design and retrofit of structures to resist real building fire conditions, including their ability to achieve the performance objective of burnout without structural or local floor collapse: and (2) the tools, guidelines, and test methods necessary to evaluate the fire performance of the structure as a whole system.
Comment Reason : We disagree with the concept of preventing local collapse. We would also point out that tools already exist to assess structural response to fire, and would benefit from increasing validation for the increasing number of structural systems available. It is not clear if NIST support retrofit of all structures, which seems an unrealistic concept.

Revision Suggestion : It is not clear what form of testing could ever standardise this approach as it is not possible to re-create fires as a standardised event in building and so we would suggest alternative means of validating performance based design for structures in fire.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR 1
Page Number : 80
Paragraph : Paragraph 1/Sentence 2-3
Comment : It is not clear where NIST have presented their formal statistical methods to identify those parameters that had the greatest effect on the model output (page 80).

Comment Reason : Methods used, assumptions and results of interest to researcher, consultants etc.

Revision Suggestion : Provide details of where this information is presented and access for review.

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR 1
Page Number : 87
Paragraph : Paragraph 2
Comment : NIST should present the values used in the structural fire models for specific heat, thermal conductivity and coefficient of thermal expansion.

Comment Reason : In order that researchers can repeat work if interested and reviewers can check validity of the models.

Revision Suggestion : Provide details of where this information is presented and access for review.

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From: Barbara Lane <barbara.lane@arup.com>
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR 1
Page Number : 101
Paragraph : Phase 3
Comment : We strongly disagree with NIST□s repeated statement that disconnection of the spandrels and use of equivalent thickness slabs (incorporating the concrete slab and truss in the same model plate finite elements) in tenant areas had little influence on the global collapse initiation □ this in our opinion is one of the key parameters contributing to the global failure.

Comment Reason : We disagree with NIST's statement.

Revision Suggestion : Revise statements if possible.

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR 1
Page Number : 117
Paragraph : Paragraph 4
Comment : On page 117 Section 6.9.3 NIST raise the interesting point that in areas not affected by debris the SFRM was dislodged from perimeter columns □ has it been investigated if this in fact means some columns were entirely unprotected in the as-built condition? Or is it the case that the bonding was so poor that the material fell off relatively easily on about 67% of the steelwork.

Comment Reason : Of interest.

Revision Suggestion : State in the report the reason for the exterior columns being unprotected or best guess at reason.

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR 1
Page Number : 139
Paragraph : Paragraph 2
Comment : It remains a serious concern that the fact even low temperatures can cause thermal expansion appears to be not considered as significant in the report and was therefore likewise not reflected in the global models. In Section 6.12.6 again the role insulation played in keeping temperatures low even in the vicinity of a fire is emphasised. However it is well documented that protected steel also undergoes thermal expansion and therefore affects the overall frame response. How was this incorporated therefore in the global models when determining the collapse behaviours?

Comment Reason : We believe the repeated statements about fire protection are a little mis-leading.

Revision Suggestion : Address the issue that protected steel expands and explain the importance of this throughout all reports.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR 1
Page Number : 144
Paragraph : 2nd last bullet point
Comment : Again, in Section 6.14.4 the role thermal expansion played in the early stages of the fire is identified here. It is very difficult to conclude therefore what exact role NIST believe thermal expansion effects had on the overall stability of the structural systems. In addition the loss of strength is repeatedly stated as the critical behaviour and the result of high temperatures, yet we would contend that thermal expansion is the governing behaviour.
Comment Reason : It is unclear the importance NIST place on thermal expansion.

Revision Suggestion : Confirm exact role that thermal expansion had if the behaviour of the towers and be consistent throughout report.

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR 1
Page Number : 145
Paragraph : Section 6.14.4 last 3 bullets in this section
Comment : Probably the most important conclusion in the NIST report is their belief that had the insulation not been removed by impact, collapse would not have occurred. In other words had their been as serious multiple floor fire collapse would not have occurred. It has not, in our view, been quantified in anyway through the structural fire models presented to date, how NIST have reached this conclusion. Particularly when the role of thermal expansion of the floor systems, which in multiple floor fires can trigger failure, has not been included in NIST□s models.

Comment Reason : We are concerned that this conclusion cannot be adequately justified

Revision Suggestion : Modify conclusion to take into account the shortcomings of the modelling approach

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 314
Paragraph : Section 10.3, Paragraph 1/Sentence 3
Comment : The average SFRM thickness based upon a limited set of measurements does not necessarily represent the entirety of these very large buildings. Therefore, it is not valid to consider the average value to be the as-applied thickness, especially since it does not represent the critical (minimum) thickness observed.
Comment Reason : Clarification needed.

Revision Suggestion : Replace "as applied" with "average"
Include discussion regarding the justification and impact of using the average SFRM thickness.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 318
Paragraph : Paragraph 3
Comment : We request clarification and quantification of how the lack of inward bowing of the west face contributed to the time to collapse, and probable collapse mechanism.
Comment Reason : We do not understand this aspect of finding 28.

Revision Suggestion : Clarify and quantify how the lack of inward bowing of the west face contributed to the time to collapse, and probable collapse mechanism.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 321
Paragraph : Paragraph 6
Comment : Finding 52: We agree with finding 52 but the floors also pushed the columns out and provided support to the columns in their weakened, deflected form. This was not captured by the models and is of concern.
Comment Reason : Structural behaviour for the duration of the design fire is not modelled properly as a result of shortcomings in the floor model.

Revision Suggestion : Model the concrete floors with inelastic properties, thermal expansion and include the trusses explicitly therefore calculate the true role of the floors on the behaviour.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 321
Paragraph : Paragraph 7
Comment : Finding 53: Noted. Arup models with thermal expansion and inelastic properties included have shown that very little lateral support is required by the columns from the floor therefore even when highly weakened and deflected the floors play an important role.
Comment Reason : This finding is difficult to justify because it still relies on the accuracy of the floor models which is flawed as a result of elastic properties, no thermal expansion and no trusses included.

Revision Suggestion : Model the concrete floors with inelastic properties, thermal expansion and include the trusses explicitly therefore calculate the true role of the floors on the behaviour.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 322
Paragraph : Paragraph 2
Comment : Finding 55: This statement is plausible and could be true but is not adequately justified by the models used.
Comment Reason : This finding is difficult to justify because it still relies on the accuracy of the floor models which is flawed as a result of elastic properties, no thermal expansion and no trusses included.

Revision Suggestion : We would suggest that a study of the quantity of outward and inward bowing columns in WTC 2 relative to WTC 1 could provide an interesting theme with respect to understanding time to collapse of each Tower. In addition creating a multiple floor model with full inelastic properties, thermal expansion of the floors fully included and allowed to change with time would also assist in understanding the time to collapse, and the various possible probable collapse mechanisms in a Tower of this structural form. Such a study would also greatly benefit future design guidance for tall buildings in severe fire events.

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From: Barbara Lane <barbara.lane@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 8/3/2005.

Name : Barbara Lane
Affiliation : Arup Fire
Email Address : barbara.lane@arup.com
Phone : +44 (0)207 755 3303
Report Number : NCSTAR1-6
Page Number : 317
Paragraph : Paragraph 3/ Sentences 1
Comment : It should be explained why it is conservative to ignore large part of fire protection being dislodged in determining the structural fire behaviour of the towers. It is unclear why damage to fire protection due to vibrations in the building is not investigated, since the presence of fire protection material is a critical factor in the global structural fire analysis.
Comment Reason : Fire behaviour is mainly driven by thermal expansion and material degradation at elevated temperatures and our main concern is more steel is cool than may have occurred and this is not conservative for a failure analysis.

Revision Suggestion : Explain how this estimation is conservative.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Andrew Allsop <andrew.allsop@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Andrew Allsop
Affiliation : Arup- London
Email Address : andrew.allsop@arup.com
Phone : 44 7919693554
Report Number : NCSTAR 1
Page Number : 203
Paragraph : 9.2.1. Recommendation 2
Comment : Arup are responsible for organising and quality review of a large number of wind tunnel studies on projects around the world and have observed and done our best to correct a number of problems with wind tunnel testing similar to those observed by NIST. These have involving variety of different laboratories, including those in N.America.

It is many years since the Aylesbury Experiment was carried out and revealed very significant differences in mean and peak cladding pressures caused by differences in choice of wind profile, turbulence intensity and static reference pressure. This was useful, enabling some laboratories at least to tighten their procedures. There are also secondary issues of effects of turbulence length scale, appropriate frequency response of instrumentation and methods of statistical estimation of peak factors.

Measurement of static and dynamic responses using techniques such as the "High-Frequency" Force Balance, flexible and semi-rigid aeroelastic modelling and "simultaneous-pressure" studies are also sensitive to all the above plus directional combinations and the influence of damping when calculating the dynamic responses.

The issues of when and how to use more advanced methods are technically complex and are subject to continuing research and development making it difficult to write down prescriptive rules. (eg see the ASTM "Manual on Wind Tunnel Testing".) Performance based rules are thus used in most international standards with minimal guidance on how to achieve them. This encourages research in these areas and makes it possible to differentiate between the more and less technically capable laboratories, even if it is a little anarchic. In special cases an independent 3rd party review of procedures could be introduced as in other cases where there may be unusual structural reliability issues.

We should also remember that current methods of wind tunnel testing are good for testing a limited range of structures, such as tall and other major buildings, but do less well with housing. Also we currently cannot model thunderstorm gust effects in any realistic way and these are potentially the governing case for smaller structures in many parts of USA.

There is however an urgent need to increase the reliability of procedures for estimating wind speeds. Most wind tunnel laboratories primary expertise is in the wind tunnel testing process rather than wind climate assessment. In Arup's experience the choice of appropriate design wind speeds is the most significant and worrying cause of the differences between laboratories.

It is an unfortunate fact of life that wind speeds, especially mean wind speeds, are very sensitive to exposure effects, especially near the ground. Taking data from limited numbers of 10m level anemometers in less than ideal exposures and extrapolating to several hundred metres in height is always going to be a difficult, subjective and hence highly unreliable process. It is very easy to end up with results which are significantly out of line with climatological expectations. The best method we have at present for increasing the consistency of results from wind tunnel studies using such data is to achieve a consensus of interested parties on the wind speeds to be used. This is problematic since there is no appropriately skilled forum where such a consensus may be built. The AAWE has members who could form a base for such a forum.

One of the problems here is that most are used to working with highly oversimplified models of how the wind behaves, which do not take account, for example, the effect of changes of ground roughness and topography. There are very different predictions of mean and gust speed variation with height between standards based on the Harris and Deaves non-equilibrium wind model (published by ESDU International and as used by NJ Cook in his analysis of a large number of anemometers in the UK) and those in most international standards including ASCE-7. (eg Gust wind speeds at 150m and above don't actually take much notice of the speed limit signs at the edge of town!)

Very little money has been spent to date on trying to improve this situation. In the case of major cities, it would seem appropriate that high level anemometers are established and maintained as a means of increasing knowledge of winds at high levels. New technologies of remote monitoring, using eg sodar, may be (or become) even more cost effective and robust against storm damage for this purpose.

It is interesting to note that, whereas meteorologists are finding that CFD technology is gradually becoming more capable of modelling meso-scale events such a thunderstorms and hurricanes, the treatment of the bottom km of so of the atmosphere is necessarily still rather messy. We should all be looking for opportunities here.

Recent measurements of damping on finished buildings also do not entirely support commonly assumed design values, especially on slender new concrete buildings where values less than 1% of critical are frequently measured compared with the commonly used 2% (or higher). It is much easier and cheaper to establish frequency and damping data from remote monitoring of ambient vibrations than it was in the past. It may be time to encourage more routine monitoring.

These are matters which concern many if not most in the wind engineering community. Commercial pressures do not always automatically produce the best

answers.
Comment Reason :

Revision Suggestion : Arup suggestion 1: Steps should be taken to create a better consensus of wind speeds at heights important for design of tall buildings, especially in major cities. This should involve as a minimum the ASCE, AAWE and the City Authorities to ensure that appropriate knowledge is used. Some publicly organised funding would be needed.

Arup suggestion 2: Third party detail review of wind tunnel testing procedures and analysis should be routinely undertaken in cases of special risk. In UK speak we would say category 2 (calculation checks by 3rd party) or category 3 (independent evaluation by 3rd party) checks should be undertaken as for structural design in appropriate cases.

Arup suggestion 3: Means of increasing the database of damping measurements of tall buildings should be explored.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Andrew Allsop <andrew.allsop@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : Andrew Allsop
Affiliation : Arup- London
Email Address : andrew.allsop@arup.com
Phone : 44 7919693554
Report Number : NCSTAR 1
Page Number : 203
Paragraph : Recommendation 3
Comment : Sway and deflection limits.

The ASCE has recently initiated a study to update guidance on the human acceptability of building motions. This should be encouraged to run its course. It is important that changes introduced as a result of such work are compared to experience with acceptability resulting from use of current methods.

It has been our experience that lateral stiffness rather than member strength has governed the choice and size of main structural elements of tall buildings. Reducing the deflection limits will thus have a significant effect on the quantity of material used in tall buildings. However deflections of themselves do no damage. Apart from the above, deflections are limited in tall building design for the following reasons:

1. To meet arbitrary code guidance.
2. To avoid secondary P-Delta effects which are now routinely included in structural calculations for strength and stiffness.
3. To minimise dynamic wind effects, which are now routinely calculated accurately (with some reservations above) using WT testing.
4. To limit motions which might cause damage to secondary elements, which is caused by inter-storey shear not overall deflection.
5. To avoid buildings striking each other - rarely a problem with tall buildings, but an obvious problem to avoid if it might occur.

One further problem with interpretation of code deflection limits is that they are frequently taken to apply only to serviceability limit states. Clearly it is pointless to design cladding to resist wind loads at the ultimate limit state when it is likely to fail at just above the serviceability limit state once the movement joints have closed up.
Comment Reason :

Revision Suggestion : Arup suggestion: It may be useful to provide better guidance on inter-storey shear limits for which normal cladding and partition units can installed without needing special detailing.

Subject: Response to NIST Recommendations
From: "Saville, Mary Ellen" <mesaville@asce.org>
To: <wtc@nist.gov>

The Structural Engineering Institute respectfully submits the attached comments in response to the NIST WTC Recommendations. If it's not too much trouble, I would appreciate notification of receipt of this attachment.

Thank you, and best regards,
Mary Ellen

Mary Ellen Saville
Administrator
Structural Engineering Institute of ASCE
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Reston VA 20191
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8.3.05.SEI Response to NIST Recommendations.doc

SEI's Comments on the National Institute of Standards and Technology's World Trade Center Investigation Recommendations

Submitted to NIST
August 3, 2005

The events at the World Trade Center in New York City on September 11, 2001, were the worst building disasters in the history of the United States. The National Institute of Standards and Technology conducted a building and fire safety investigation of the disaster under the authority of the National Construction Safety Team Act (15 USC 7301 et seq). As a result of its WTC Investigation, on June 23, 2005 NIST issued a draft report with recommendations, and invited public comments on June 23, 2005.

The Board of Governors of the Structural Engineering Institute of the American Society of Civil Engineers held a meeting on July 1, 2005, to discuss the NIST WTC report. The meeting was attended by SEI Board members Jeremy Isenberg, Gene Corley, Barry Goodno, Neil Hawkins, Joe Ales, Robert Ratay, James Rossberg, James Harris, and Rawn Nelson. The following are the group's comments on behalf of SEI/ASCE on the recommendations of NIST's WTC report.

SEI supports a thorough review and deliberation of all of the NIST Recommendations and looks forward to further discussions clarifying the situations to which the NIST Recommendations should apply.

SEI believes that engineers must avoid over-optimistic reassurances about building safety, and agrees that increased efforts should be focused on preventing terrorist attacks. That said, the 30 recommendations presented by NIST within eight categories address a range of issues that we at SEI think require serious discussion. Many of the recommendations were presented by NIST as "changes to codes and standards," which some may interpret to mean that the painstaking process of developing consensus code and standard provisions should be unreasonably accelerated. We believe that the consensus process, which is already underway at SEI for some of the concerns NIST has raised, is essential so that all aspects of an issue can be considered. All of the issues deserve further consideration in that community.

In the view of SEI, at least some of the NIST recommendations will require development of new technologies and close examination of their effects upon the practice. At the same time, the existing codes and standards processes that are already in place, both in and outside SEI, provide appropriate mechanisms for advancing several of these discussions. Ultimately, the implementation of these recommendations will require the development of appropriate thresholds and bounds for their application. SEI looks forward to taking an integral role in clarifying the application of these recommendations.

In fact, some of the NIST recommendations follow actions previously initiated by SEI. For example, with respect to Recommendation #2, SEI is close to issuing a Wind Tunnel

Testing standard and anticipates opening it for public comment in the fall of 2005. With respect to Recommendation #9, SEI has been working with the Society of Fire Protection Engineers, and has already prepared a draft to update ASCE/SEI/SFPE 29-99 (Standard Calculation Methods for Structural Fire Protection), by incorporating performance-based fire resistant design. With regard to Recommendation #27, we look forward to engaging ASCE's professional practices committee for comment and guidance, though our initial reaction is that it may not be necessary or beneficial to all parties for the Engineer of Record to retain all documents for all time; our preliminary view on document retention is that the owner should retain the drawings.

The Board of SEI favors the development of tools to assist engineers in addressing the issue of progressive collapse (Recommendation #1). The development of a consensus standard providing multiple approaches to mitigating progressive collapse would benefit the profession by providing concepts and techniques upon which to build. It is worth noting that GSA requirements have already advanced technology for evaluating progressive collapse. In general, the Board of SEI prefers a building-specific and/or owner-specific approach to mitigating progressive collapse rather than a code-mandated requirement.

However, also with respect to Recommendation #1, the SEI Board reserves judgment on whether and how to develop standardized software to evaluate the susceptibility of a particular structural system to progressive collapse. Not all buildings are at risk of being exposed to the type of events commonly associated with initiating progressive collapse. This NIST recommendation needs study of its application and its effect upon the profession because of the various design thresholds involved. When considering possible causation events, other, non-structural, solutions are sometimes effective. Having said that, we look forward to discussing who would develop and maintain the potential software, who would distribute it and who would take responsibility for training the profession in its use.

SEI agrees that designing for fire performance of structures (Recommendations #4-7) needs to be discussed within the broad engineering profession, and is interested in taking an active role in supporting studies examining these recommendations. A draft has been prepared and we would welcome NIST's input in furthering the development of this standard. The concept embedded in Recommendation #8 of treating fire as a load case for structural design will necessitate assumption concerning fire protection systems. Their historical performance will need to be included in the discussions along with the technical and economic impact.

SEI feels that some of the NIST recommendations need further clarification and discussion. SEI would like a clearer description of the rationale and motivation for developing limit state criteria in Recommendation #3. It is possible that serviceability, perception of motion issues, and existing seismic criteria on drift may satisfy this recommendation. While much of Recommendation #25 appears to SEI to be reasonable, the concept of certification of "as-designed or as-built" safety needs additional discussion and understanding. Without further understanding of the envisioned intent of this recommendation, its implementation may face numerous technical, economic, and authoritative hurdles. Improving safety in existing buildings, as directed in Recommendation #26, is certainly a laudable goal and one that SEI supports. While the existence of as-built drawings would assist in the rehabilitation of existing structures as specified in Recommendation #26, a requirement for the retention of a broad range of documents would not improve the safety or performance of structures. Lastly, the roles of various professionals within a project will change and vary from project to project. The assignment of roles and responsibilities is an issue best handled by the contract documents rather than codes and standards, as proposed in Recommendation #28.

We are particularly encouraged by the recommendations pertaining to education and we enthusiastically support continuing education of the profession. However, specific issues, such as cross-training of fire and structural engineering professionals, need to be clarified in further discussions.

Our profession is responsible for protecting the public to the best of our abilities and to seek new technologies to help us meet that charge. In order to do that, we feel it is important to draw a distinction between advancing the technology through the development of various tools, such as consensus documents on progressive collapse and fire-structure interaction, and potentially adversely affecting the profession by imposing regulations and restricting the engineers' freedom to develop the best solution for each individual building and the embedding of mandatory provisions in building codes.

While not every NIST recommendation may be ready for enactment as is, SEI is moving forward with discussion of the issues and their implications for structural engineering practice, and looks forward to working closely with NIST to clarify the application of these recommendations.

NIST Recommendations Referenced:

1 – Progressive collapse
2 – Wind Tunnel Testing Standard
3 – Sway requirement
4 – Construction classification and fire rating requirements
5 – Fire resistance testing
6 – Spray-applied fire resistive materials standards
7 – Uniform fire protection
8 – Fire as a load case
9 – Performance based fire resistant design
25 – Third party review
26 – Egress and sprinkler requirements in existing buildings
27 – Document retention
28 – SE/FPE responsibilities and liabilities

Subject: Comments from ASTM International on WTC Investigation Draft Final Reports
From: "Bardi, Janice" <jbardi@astm.org>
To: <wtc@nist.gov>
Cc: "O'Toole, Thomas" <totoole ...snip... James" <jthomas@astm.org>

Dear Mr. Cauffman:

Please see attached letter with comments from Jim Thomas, ASTM International President on the NIST NCSTAR 1 Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Towers (Draft).

If you have any questions, please feel free to contact Mr. Thomas at 610-832-9598 or jthomas@astm.org.

Janice Bardi
ASTM International
Phone: 610-832-9595
E-mail: jbardi@astm.org

wtc.doc

INTERNATIONAL
Standards Worldwide

Office of the President

Address 100 Barr Harbor Drive
PO Box C700
W. Conshohocken, PA
19428-2959 | USA

Phone 610.832.9500
Fax 610.832.9555
e-mail jthomas@astm.org
Web www.astm.org

August 1, 2005

WTC Technical Information Repository
Attention: Mr. Stephen Cauffman
National Institute of Standards and Technology
Stop 8610
Gaithersburg, MD 20899-8610

Subject: Public Comments on World Trade Center Investigation Draft Final Reports

Dear Mr.Cauffman:

On behalf of the members and Board of ASTM International, I wish to take this opportunity to congratulate the National Construction Safety Team of the National Institute of Standards and Technology for their comprehensive efforts to reconstruct the collapses of the World Trade Center (WTC) towers and to produce a final report and recommendations.

For over 100 years, ASTM International Committee E05 on Fire Standards has provided valuable evaluation tools to advance the cause of fire safety. Today, ASTM E05 has over 500 dedicated volunteers and jurisdiction of 55 standards to meet the needs of fire safety. We share the goal of fostering a deeper understanding of fire safety issues amongst the construction, building, and public safety communities and look forward to working with NIST to achieve such an important goal.

ASTM International standards are widely used by the building construction industry around the world. In addition, thousands of ASTM standards are referenced in building codes. In response the recommendations from the NIST Report of the National Construction Safety Team on the Collapse of the World Trade Center Towers ASTM has commissioned an analysis of the NIST report as it relates to ASTM's standards.

It is expected that this analysis of the NIST recommendations and the resulting report will provide timely recommendations for standards development initiatives for ASTM Committee E05 and other ASTM technical committees. By commissioning this analysis, ASTM will be able to continue its tradition of quickly addressing the needs of standards users in a timely fashion by providing state-of-the-art standards. Specifically, the review will identify items in the NIST report that bear upon the following areas of application:

- The development or revision of ASTM standards intended for analysis & assessment of structural fire protection & fire resistance of building assemblies.
- The development or revision of ASTM standards which deal with buildings, structures, building materials, building assemblies, interior finish, furnishings & contents.
- The development or revision of ASTM standards intended to measure & describe the response of building materials, products & assemblies to sources of heat &/or flame under controlled conditions, including fire growth rate & products of combustion, e.g. smoke & toxic gas.
- Evaluation of E05 standards related to computer fire modeling and determine whether new standards or revisions to existing standards are needed.

- The development or revision of fire test methods for measuring fire responses and properties of materials, products and assemblies when exposed to laboratory sources of heat, or flame, or both, especially input data from computer fire modeling.

- Fire-related research relevant to E05 activities.

- Any additional analysis of ASTM standards.

It is anticipated that a formal report will be presented at the next Committee E05 meeting in December 2005, in Dallas, Texas. Like all ASTM International technical committee meetings, these Committee E05 meetings are open to the public. Interested parties are welcome to attend and contribute to the enhancement of existing standards or the development of new methods, guides, and practices.

Again, I thank NIST for its leadership in this important area of fire safety. Please feel free to contact me directly at (610) 832-9598 should you need additional information or if ASTM International can be of assistance to your efforts. For specific information concerning the work of ASTM Committee E05 on Fire Standards, please contact Mr. Thomas O'Toole at (610) 832-9739.

Sincerely,

Jim Thomas

James A. Thomas
President, ASTM International

WTC PUBLIC COMMENTS

PART # 2

X-Sieve: CMU Sieve 2.2
Date: Fri, 05 Aug 2005 18:40:34 -0500
From: dz <news@911blogger.com>
User-Agent: Mozilla Thunderbird 1.0.2 (Windows/20050317)
X-Accept-Language: en-us, en
To: wtc@nist.gov
Subject: Comments and Questions Related to WTC Draft Reports
X-NIST-MailScanner-Information: Please contact the ISP for more information
X-MailScanner:
X-MailScanner-From: news@911blogger.com

To whomever it may concern,

I am a concerned citizen who has actively followed the investigation performed by the NIST into the collapses of WTC1, WTC2, and WTC7 on 9/11. Over time I have developed several questions which stick out in the collapses of these buildings. Unfortunately I have not been able to find any place in which your most recent release of documents addresses my questions.

It seems almost as if the issues and concerns I have are omitted as non-issues, perhaps because I am coming from the direction of questioning how the buildings actually collapsed instead of simply explaining the commonly accepted reasons behind the collapses.

In any event, one particular issue in your documents stuck out to me, and it leads to my most prominent concern with your report, namely the use of the term 'global collapse' without a detailed definition, and the avoidance of studying the intact structures which resided below the point of 'global collapse'.

These quotes from your document illustrate my point:

From 'http://wtc.nist.gov/pubs/NISTNCSTAR1-6DDraft.pdf', page 5:
Simpson Gumpertz & Heger Inc (SGH) developed global models of the World Trade Center (WTC)
towers using finite elements to gain an understanding of the roles of the aircraft impact damage and the
subsequent fires in the WTC towers with respect to structural stability and sequential failures of components and subsystems and to determine the probable sequence of structural responses that let to
initiation of ***global collapse****. The study was conducted as part of the investigation on the WTC disaster by*
the National Institute of Standards and Technology (NIST).

From 'http://wtc.nist.gov/pubs/NISTNCSTAR1-6DDraft.pdf', page 169:
The parts of structures below the impact zones (Floor 89 to Floor 91 in WTC 1 and Floor 73 to Floor 77
in WTC 2) ***contributed little to the overall behavior of the buildings****. Previous analyses of subsystem*
models and preliminary global models showed that the elements below the impact zone did not experience plastic deformations or buckling. Therefore, they were eliminated to further reduce the size of
the models. With this modification, the global model for WTC 2 was truncated at Floor 77 just

above the
mechanical floors and at Floor 91 for WTC 1.

Perhaps I am misreading the above, but it sounds as if aside from studying the initial reasons for collapse, the rest of the building was not considered. This is particularly of concern to me because while I find your research into the initiation of 'global collapse' somewhat convincing, I can find no relevant definition of the term 'global collapse', and no explanation as to how the remaining structure below this point was demolished so quickly and thoroughly. Were the term 'global collapse' a commonly understood term regarding steel buildings I would not find this omission so notable, but in my research I have yet to find any historical examples of such a 'global collapse' in regards to a steel superstructure.

I would like to know specifically what sections, if any, of your report explain the 'global collapse', and its mechanics.

Here are my specific concerns:
1) How could 77 floors of intact superstructure in WTC2 and 91 floors of intact superstructure in WTC1 be considered as 'contributing little to the overall behavior of the buildings'?
2) What resistance should the remaining intact superstructure have provided in this 'global collapse'?
3) What energy from the 'collapse' would have been spent in destroying the remaining super structure?
4) Is the incredible speed of 'global collapse' (approximately 10 floors per second) within reason given the massive superstructure which laid directly underneath the 'collapsing' floors?
5) How does the time it took for the 'global collapse' relate to the speed of a free fall with no resistance at all?
6) Is it reasonable to suggest that 77 floors in WTC2 and 91 floors in WTC1 were destroyed at near free fall speeds with the remaining superstrucutre providing virtually no resistance to the speed of the collapse?

I had hoped that the NIST might take the same amount of time spent in explaining the 'global collapse' as it spent in how that 'global collapse' started, unfortunately that appears not to be the case. Given the incredible speed of the virtually symmetrical 'collapses', and the lack of historical context for such 'global collapses' with steel superstructures, I would think it would have deserved even more time than postulating on what might cause such a 'global collapse' across only a very small segment of floors in these massive superstructures.

I look forward to your upcoming report on WTC7, and I hope that you might consider addressing the energy necessary, and the time it should have taken, to completely obliterate 77+ floors of intact superstructure in both towers only from fires on a set number of floors.

Thank you for your consideration,

Roger Peters
8008 Bluebonnet Blvd. Apt 12-15
Baton Rouge, LA 70810
www.911blogger.com

X-Sieve: CMU Sieve 2.2
Date: Fri, 05 Aug 2005 18:40:34 -0500
From: dz <news@911blogger.com>
User-Agent: Mozilla Thunderbird 1.0.2 (Windows/20050317)
X-Accept-Language: en-us, en
To: wtc@nist.gov
Subject: Comments and Questions Related to WTC Draft Reports
X-NIST-MailScanner-Information: Please contact the ISP for more information
X-MailScanner:
X-MailScanner-From: news@911blogger.com

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Thank you for your consideration,

Roger Peters
8008 Bluebonnet Blvd. Apt 12-15
Baton Rouge, LA 70810
www.911blogger.com

ATTN: Mr. Stephen Cauffman

July 15, 2005

WTC Technical Information Repository
National Institutes of Standards and Technology (NIST), Stop 8610
Gaithersburg, Maryland 20899-8610

Dear Mr. Stephen Cauffman :

It is widely **known** (not "perceived", since people now have the Internet) that the initial NIST hearings and determinations were transparently **fraudulent** attempts at **cover-up** of an act that constituted **high treason** and **mass murder** which occurred on 11 September, 2001 in downtown Manhattan, New York City. It was similar, in this regard of **cover-up**, to the infamous "**Warren Commission**" which covered-up a **coup d'etat** (unlawful change in government), whereas the NIST hearings and determinations covered up **high treason** and **mass murder**, which cover-ups have been contributing factors to our (USA's) getting involved in two wars based on **lies** and **false pretexts** and which could potentially escalate into what, some day, could be called **World War 3**.

My question for you is, will **you**, as the official NIST investigative authority into the WTC **building fires** and **collapses**, initiate:

1)A **full**, **open**, **public**, **televised**, **truthful**, and **independent** **inquiry** into what **really** happened on that day, with **full**, **open** participation by **independent** **general public**, **law enforcement**, **NYC firemen**, **military**, **demolitions experts**, **architects and structural engineers**, **retired military**, **newsmedia**, **alternate/independent non-mainstream newsmedia**?

2)Furthermore, will you permit **video and audio recording** of the proceedings by **independent** sources so that the actual events of such inquiry will not be subject to **editing** of the type that occurred with the **Zapruder film**, which **temporarily** made the **truth** into a **lie**, but which altered video has subsequently become on of the most widely **studied**, **circulated**, and **viewed** videos in **history**, with particular **emphasis** on **how** it was **altered** to make the truth into a **temporary** lie that is now well known and widely exposed, **worldwide**?

3)Furthermore, will you kindly have your reply to this question address **these specific questions and details** and have the **signature** of the responsible/accountable **authority** at NIST, who is able to **authorize** this, and put his/her **signature** on the **letterhead of NIST** by **30 July, 2005**, and returned to me at the address below?

I'd also like to add that it is **inevitable**, and an **absolute certainty**, that the **full truth will** be coming out about this matter, and those who are guilty of these crimes of high treason and mass murder, as well as those who have participated in any sort of **cover-up** or **suppression of truth** with regard to any truth seeking investigation into this matter, will be **paying** the price for these crimes. I say this because there is a God Who has **guaranteed** that the full truth eventually would come out about **everything**, and that the appropriate penalties would be applied either in this life or the next. The "long arm of the law" is infinitesimally short when compared to God's ability, and promise, that He **will** bring out the full truth and have the appropriate penalties applied. For those who might participate in a lie and cover-up that could potentially lead to **World War 3**, history will **not** view those individuals kindly. Furthermore, it is most likely that neither will God. I'd imagine that His penalty will be along the lines of "**eternity in Hell/eternal**

damnation" for those involved, wherein they can spend the rest of eternity with individuals such as **Adolph Hitler**, **Josef Stalin**, **Vlad the Impaler**, etc.

Please, always remember the greatest statement of truth that was ever made, "You **shall know** the **truth**, and the **truth shall** set you **free**", and that **you** have been **given** the **authority** and the **responsibility** to do what is **right** in this **circumstance**. Furthermore, you can **expect** the strongest public support imaginable, **worldwide**, for doing the **right** thing, and history will view you most favorably for having done so.

Sincerely,

Robert B. Thorne

Robert B. Thorne, M.D.
P.O. Box 590
Bloomfield, New Jersey 07003-0590

Subject: BOMA International Comments on
From: "Dave Johnston" <djohnston@boma.org>
To: <wtc@nist.gov>

August 4, 2005

WTC Technical Information Repository
Attention: Mr. Stephen Cauffman
National Institute of Standards and Technology
Stop 8610
Gaithersburg, Maryland 20899-8610

Dear Members of the NIST World Trade Center Investigation Team:

BOMA was founded in 1907 and is a dynamic international federation of over 100 local associations. BOMA's 19,000-plus members own or manage more than 9 billion square feet of downtown and suburban commercial properties and facilities in North America and abroad. The mission of BOMA is to advance the performance of commercial real estate through advocacy, professional competency, standards and research.

BOMA International appreciates the National Construction Safety Team making its draft reports on the World Trade Center Disaster available for public comment. The tragic event of September 11, 2001 is a day that will always be remembered.

BOMA International will comment on most of the 30 recommendations that the Team has made. BOMA also wants to urge the Team to consider the fact that safety in the built environment has made tremendous strides over the past several decades. Improvements in structures, fire protection systems, building components and materials have made for a safer place for building occupants that ever before. Through the consensus code development process, further improvements will be made. These improvements, like past improvements, will be incremental, carefully considered, fair to occupants and owners, and cost-effective.

Building safety is an issue that BOMA International and its membership take very seriously. BOMA International will work with any organization that has the improvement of building safety in mind. BOMA reminds NIST that improvement in building safety is a gradual process built upon past experience and the advances of new technology.

Again, we express our appreciation for the opportunity to submit comments on the recommendations.

Sincerely,

David A. Johnston
Director of Codes and Standards
BOMA International
Suite 300
1201 New York Avenue, NW
Washington, DC 20005
(202) 326-6357

BOMA Comments to NIST on WTC Recs.doc

BOMA Comments on
NIST Recommendations Contained in the
Report on the WTC Disaster

Recommendation 1:

Progressive Collapse: The big issue here would be to what extent it would be required to 'prevent' progressive collapse. How many column failures (specific number, a percentage of a floor; etc) would need to be able to be withstood? "Progressive collapse should be prevented" is a pretty vague 'goal', without better explanation of what factors must be considered.

Recommendation 2:

No Comment.

Recommendation 3:

No Comment.

Recommendation 4:

BOMA believes that any code change recommended by NIST must be considered by national bodies and not on a community-by-community basis.

The record of sprinklered building performance is outstanding, no matter what their size. There is no need to increase redundancy with enhanced passive fire protection systems or passive fire protection systems in general. (This should be one of our major, recurring, points. Where is the basis to claim that sprinklers need to be assumed to fail completely? Especially while not noting that 'passive' solutions (or redundancies) also include active components (doors, dampers) that may fail, and that if not adequately maintained, the passive solutions may not work as advertised. In sum, BOMA points to the inspection, maintenance, and testing requirements for sprinkler systems and their excellent performance record. Re: the 12,000 compartment limitation: it would have significant impact, and again, cannot be justified in a sprinklered building.

How many situations could compromise any fire protection system? The number of specific perils needs to be assessed by the national building code community.

Recommendation 5:

No comment.

Recommendation 6:

No comment.

Recommendation 7:

No comment

Recommendation 8:

This recommendation is a bit unrealistic and unwarranted. NIST assumes the complete loss of the sprinkler system, and no intervention by fire department. This has two parts: how much compartmentation would be required (to keep the uncontrolled fire from spreading), and how the burnout could occur and not lead to collapse (progressive collapse issue).

Recommendation 9:

The effort to 'retrofit' on a large building-wide scale is an enormous task. This recommendation should, at least initially, be focused on new buildings.

Recommendation 10:

BOMA International concurs, but to achieve it is going to take some time.

Recommendation 11:

BOMA International concurs. However, it must be noted that this is a state-of-the-art type of recommendation. Certainly the buildings being designed now are better than the buildings designed10 years ago, and the building 10 years from now will be even better.

Recommendation 12:

Greater risks associated with greater heights? BOMA International will question what criteria and facts NIST is using to justify 'gold-plated' over-engineered fire protection requirements. Some questions that BOMA poses to NIST: How can building population be determined at any given time? What is 'higher threat profile'? NIST again says we must enhance the systems/design of what we now have. Where is data that shows that sprinklers fail? There is a lack of history to prove NIST's claim of 'increased risk' in taller buildings.

Recommendation 13:

This is more a communications issue. As long as this stays a general "more communication is better", the recommendation is hard to argue against. A modern zoned voice-alarm system would provide most, if not all, of what NIST is asking for here. Also, the NIST recommendation is against hardwired fire-department communication systems, which seems to be the direction building design is going. Communications providers are producing better and more reliable radio systems (sometimes requiring repeaters or antennas in buildings).

Recommendation 14:

Early detection is a big part of minimizing a fire. Many buildings just don't require this type of fire command center. Incremental improvements in the information provided will continue as the industry evolves, and major mandated advances are not warranted....a 'modern' system provides a good deal of information already (water flow location, fire alarm zones, etc.) Security and other building management systems controls also already can provide extensive info....video, doors open/closed, temperature, etc.

Recommendation 15:

This recommendation is just too costly to implement. BOMA International asks NIST exactly how many building collapses have there been.....ever? Again, this may be an incremental change that will occur as building management systems continue to evolve. Mandating off-site transmission doesn't appear warranted, and raises many questions......off-site to whom? (fire department? property management company?)

Recommendation 16:

Drills are good. BOMA International encourages the inclusion of fire drills in any building emergency management plan. A large amount of assistance is going to be required from the United States Fire Administration to advance this awareness.

Recommendation 17:

Certainly, fire protection system that extend building performance and that extend the time for building evacuation should be taken into account. Trade offs between the various systems are going to be important as the building community goes forward in making buildings safer.

BOMA International is concerned about paragraph (b) in the recommendations, which focuses on persons with disabilities, specifically about the 'provide them means of self-evacuation' recommendation. BOMA International believes that it's more appropriate to stay with current Americans with Disabilities Act provisions......evacuation planning is just another policy/procedure...and it should include provisions for how to accommodate persons with disabilities.

Recommendation 18:

Although this recommendation is more common sense than anything else, NIST needs to look at why it is making this recommendation. BOMA International recommends that buildings should be designed to provide safety to building occupants until the occupants can evacuate them.

If NIST starts to tie elevator locations to 'travel distance', which is a big leap towards starting to treat elevators as 'means of egress' components, this is a huge leap. Opening the door toward considering elevators as a way to move people in some situations is satisfactory; however the initiation of considering them parts of the means of egress, or as exits, is another matter entirely that BOMA questions.

Recommendation 19:

BOMA agrees with this recommendation and has publications to accommodate it. BOMA International currently works with the Department of Homeland Security on real estate alerts that notify building owners and managers of specific threats that are considered such by DHS.

BOMA International as well makes available emergency planning information to buildings owner and managers. This is accomplished through standard publications that BOMA makes available through it publications catalogue and through the offering of courses, seminars, and committee meetings.

Recommendation 20:

This is a pretty vague recommendation. I would assume that NIST would hope that the model codes would consider ALL the recommendations, not just these.

Recommendation 21:

Yes, building elevator protocols should be reviewed by code groups. This recommendation proposes separate, dedicated, hardened elevators for fire department use. It isn't clear how NIST justifies adding elevators that will ONLY be used in major emergencies. Why isn't use of general building elevators (which are used all the time, and therefore possibly more likely to be maintained), with whatever 'enhancements' might be found to be needed, acceptable?

Recommendation 22:

This recommendation is really not a matter for building owners. However, it may come into play for building owners if building owners need to provide signal repeaters or antenna. BOMA will comment on a specific proposal if it is advanced.

Recommendation 23:

BOMA International sees this recommendation as very expensive to implement. BOMA encourages NIST to accomplish a cost-benefit study prior to urging the adoption of this recommendation.

Recommendation 24:

This recommendation is directed more at the emergency response teams than for building owners and managers.

Recommendation 25:

BOMA International questions whether state and local governments would be receptive to this recommendation. A mandate to always have a third party review done, both of the design and the as-built condition, may be an intrusion on local government authority.

Recommendation 26:

BOMA International is unsure whether NIST is encouraging the sprinklering of existing buildings to the extent required in the codes for existing building (retroactive requirements), or to the extent required for new buildings. Even if only sprinklering buildings to meet retroactive code requirements, this picks up most high-rise buildings under NFPA 101 (unless an approved 'life safety plan' is done). Typically, retroactive sprinkler regulations have been a local/state issue.

Recommendation 27:

In an ideal world the idea of document retention is a good one. However, in reality, many buildings are older and, in some, if not many, their records are missing, inaccurate, or unusable for any number of reasons. Information for buildings of a certain size, if available, should be provided to emergency responders. If this recommendation does advance, it MUST focus on new buildings and maybe alteration work. An entire industry could otherwise be created to document existing buildings for which the original and/or as-built information is not available.

Recommendation 28:

BOMA International does not have an issue with this recommendation.

Recommendation 29:

The design professions are already stretched close to the maximum with so many knowledge requirements placed on them. There is very little, if any, room in curriculums currently for additional coursework on any topic. Possibly, there could be one designated profession to assume responsibility for complete knowledge on this topic. Architects, as the team leader, can collaborate with structural engineers, fire protection engineers, and as a team, they all can pull the project together. A solution to this maybe the institution of a certificate stating that "we, as a team, have looked at the risks related to fire damage and agree that we have employed the greatest technology presently available to mitigate those risks."

Recommendation 30:

BOMA International asks NIST the specific audience this recommendation is directed toward.

From: Harold Sprague <spragueho@bv.com>
To: wtc@NIST.GOV
Cc: dlowe@NIST.GOV
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/25/2005.

Name : Harold Sprague
Affiliation : Black & Veatch Special Projects Corp.
Email Address : spragueho@bv.com
Phone : 913-458-6691
Report Number : NCSTAR 1
Page Number : NA
Paragraph : NA
Comment : Intumescent Coatings:
Consider adding some verbiage and studies on what the expected scenario would have been had intumescent coatings been used in lieu of the Blazeshield SFRM.
Comment Reason : The reports are comprehensive and very informative. The focus on the SFRM in the studies was on its performance. Critical to the performance of the structure was how the SFRM Blazeshield performed. Another aspect of the entire study was to determine how the Codes could be changed to mitigate what happened. Intumescents may have been effective in mitigating the collapse. It should be stated so that designers know something could be done for mitigation with OTC existing technologies.

Revision Suggestion : Add studies of the performance of intumescent coatings including impact resistance and adhesion as well as fire exposure performance.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wally Parker <localgroup@earthlink.net>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/22/2005.

Name : Wally Parker
Affiliation : Citizen
Email Address : localgroup@earthlink.net
Phone : 541-342-4063
Report Number : NCSTAR 1
Page Number : N/A
Paragraph : N/A
Comment : Gentlepersons:

Every great investigator knows that he or she carries into every inquiry a narrative, not only the narrative of the past, but also the narrative of the apparent present. Indeed, the narrative is necessary for accomplishing the opening moves. One must begin somewhere.

Every great investigator knows too, that this narrative can sometimes warp his or her view of the subject at hand. Interpretation (even observation, sine qua non) of evidence consonant with the narrative is more assertive than interpretation of evidence that denies or even confutes the narrative. Often, evidence of the latter kind is not even sought (since it is very rarely found).

Every great investigator knows, finally, that the object of his or her enterprise is yet another narrative, which encompasses all the known facts, which comports with reason on the broadest human basis, and which can withstand peer review, legal adversity, or some similar stringent testing.

Therefore, it seems to me the investigation of the September 11, 2001 events ought to err on the side of going beyond mere duty and accepting the challenge of various imaginative witnesses (albeit at some remove, or in metaphor) who believe, or at least seriously suspect, that the narrative of 9/11 is not yet fully understood.

In particular, I would direct your attention to widely popularized claims that the WTCs were □helped□ to the ground by internal explosives. I think this is an easily testable proposition because the dust from the collapse of the buildings must still be driven deep into every nook and cranny for blocks around, and clever lads and lassies will be able to figure out where to look and how to do the archaeology. If the examination fails to turn up any suspicious explosive residue in the dust, fine; this notion will become a narrative stub. The present apparent narrative will be strengthened.

Addressing this question will redound to your credit and to the health of the nation. I beg to suggest you undertake it.

Thank you very much,

Wally Parker
Comment Reason : N/A

Revision Suggestion : N/A

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

To: wtc@nist.gov
Subject: Comments on the NIST report into the collapse of the World Trade Centre Towers
From: John.Dowling@corusgroup.com

Dear Sir/Madam

I have the following comments to make on the above report:

The recommendation for a move towards design against progressive collapse is laudable.
The emphasis on moving away from dependence on the standard fire test towards analysis based on building burnout is also to be applauded.
The report also places emphasis on the need to move towards performance based approaches for the design of tall buildings in fire. It gives the strong impression that such approaches are in their infancy and that a great deal of research must be carried out before performance based methods can be widely used. I do not believe this to be universally true. A great deal of the necessary research and development has already been carried our, particularly in the United Kingdom where large scale fire testing in buildings has been going on for over ten years. Advanced analysis tools exist to assess whole frame behaviour in fire and these are being widely used in prestigious projects. I urge you in the strongest possible terms to look at the experiences in the UK and to learn from these. I am concerned that, otherwise, a great deal of work may be duplicated.
Your recommendations (6 & 10) for development of standards and methods for testing of fire protection for extreme events is welcome. However, this has also been addressed in the UK and two of our major fire protection manufacturers (Leighs paints & Cafco) have carried out explosion tests on their products. I urge you to contact both organisations and I am happy to supply contact details if requested.
I feel that there may be little value in following the detail of Recommendation 11 (the use of high performance materials in fire). Previous research has shown that these materials are effective only in low intensity or low duration fires, not the type of high intensity, burnout fires which we sat at the World Trade Centre.

Yours sincerely

John Dowling
Construction Development Manager
Corus Construction & Industrial
Scunthorpe
United Kingdom

From: "Lisa Kelly" <lkelly@crsi.org>
To: <wtc@nist.gov>
Subject: NIST NCSTAR 1 WTC REPORT COMMENTS

WTC Technical Information Repository
National Institute of Standards and Technology
Attention: Mr. Stephen Cauffman

Dear Mr. Cauffman:

Enclosed, from David P. Gustafson of CRSI, are comments on NIST NCSTAR 1 WTC Report. If you should have any questions, please feel free to contact me.

Best regards,

Lisa M. Kelly
Administrative Assistant
Concrete Reinforcing Steel Institute
Phn:847.517.1200 ext.14
Email: lkelly@crsi.org

NIST WTC Comments 080405.PDF

Comments on NIST NCSTAR 1
By
Concrete Reinforcing Steel Institute

General Comments

CRSI commends NIST for their extensive investigation of the WTC disaster. And for their "breadth-and-depth" reporting on the collapses of the WTC buildings. CRSI strongly supports the majority of NIST's recommendations. We would like, however, to call attention to several of the recommendations regarding exit enclosures (exit stairway shaft), uncontrolled burnout, and fire resistance for the structural frame.

Specific Comments

It is time to re-think and re-work the requirements for exit enclosures (stairways). As NIST reported, where the building occupants had access to an intact exit, the survivability of this terrorist act was nearly 100 percent, and on floors where the exit(s) were not intact the causality rate was nearly 100 percent. It should be clear that providing independent and remote exits is critical to the life and safety of the occupants. However current practice, consistent with the code provisions, often place exit enclosures (shaft) in the center of a building core, not necessarily remote from one another. The assembly forming the exit enclosure is commonly constructed of materials that only provide fire resistance and nothing structural. See exception 1 of Section 1014.2 and Section 1019.1 of the 2003 edition of the 2003 edition of the *International Building Code.*

We would like to call attention to the idea that certain structures need to be capable of resisting an uncontrolled burnout. From this incident, it can be seen that unforeseen circumstances do occur and automatic sprinkler systems may not be capable of providing fire suppression. Analogous to structural integrity and resistance to progressive collapse, building structures, in particular high-rise buildings, should have the necessary fire resistance to resist collapse in the event that the automatic sprinkler system fails.

We believe additional work is warranted in the area of "structural frames". This experience has drawn attention to the fact that fire resistance ratings are determined and assigned to idealized beams, columns, and wall/floor assemblies, and not to the actual construction itself. Some of the areas that should be investigated include connections, continuity of structural systems, durability of fireproofing, as well as the impact of the various connections through the fireproofing for the installation of mechanical systems.

CRSI agrees with the need to advance the technical base, as outlined by Recommendation 4, for improving the overall fire-safety of buildings. Achievement of these meaningful goals will require realistic fire resistance testing and modeling, as itemized in

Recommendation 5, and then followed by the adoption of appropriate provisions in codes and standards. Intuition says the conducting of realistic testing and implementation of the proper "fixes" in codes will require considerable time before they become a reality.

Tools and criteria now exist for implementing some level of rational design for the structural fire resistance of buildings. However, incentives are lacking in the current building codes to design a cast-in-place reinforced concrete building for structural fire resistance. Under the current building codes, considering floor slabs for example, the heat transmission criteria usually dictate the slab thickness required for a particular fire rating.

In the past, the State of Wisconsin maintained their building code, viz., the *Wisconsin Administrative Code*. The *Wisconsin Administrative Code* modified the heat transmission criteria in Section Ind. 51.042 — General Requirements:

> "(5) The heat transmission requirements of ASTM E119 (25b), with the exception of high hazard areas, penal and health care facilities and warehouses for combustible materials, may be reduced to one-half (½) of the hourly rating required by this code, but not less than one hour.
>
> > (a) The fire-resistive rating for structural integrity required by this code shall be maintained where the heat transmission criteria has been reduced."

If current building codes had similar provisions as the former *Wisconsin Administrative Code,* that might encourage an Architect/Engineer to structurally design reinforced concrete floor slabs for fire resistance in certain occupancies. A detailed example of a continuous one-way floor slab in the CRSI book, *Reinforced Concrete Fire Resistance, is* quite revealing. The one-way slab system is designed to have a 3-hour structural fire endurance, assuming the heat transmission requirements may be waived or set at a lower rating. The 4.5-inch thick slab spans 15 feet c.-c. of supports; the service live load is 60 psf and the superimposed service dead load is 10 psf.

Two detailed structural analyses of the end span of the slab system are presented. The end span is the most critical for thickness. In the first analysis, the structural fire endurance is determined based on continuity only. The second analysis includes the beneficial effects of restraint to thermal expansion. The two analyses confirm the floor slab has a 3-hour structural fire endurance.

An evaluation of the reinforcement details is also included in the example — the required length of the top bars to resist negative moment at the first interior support is determined for the two analyses. The extension of the top bars at the first interior support for gravity loads is compared to the extensions required by the two analyses for structural fire endurance. For gravity loads, the top bars, #13 (#4) spaced at 9 inches on center, required at the first interior support are extended 4'–9" into the end span. Based on the continuity-only analysis for structural fire endurance, the top bars would have to be extended 6'–11" into the end span. When the beneficial effects of restraint to thermal expansion are included, the second analysis for structural fire endurance, the top bars would have to be extended 5'–2" into the end span — about the same extension as that required for gravity loads.

Regarding materials, carbonate aggregate concrete is used in the slab. Concrete cover to the reinforcement is 0.75 inches. From Table 720.2.2.1 in the 2003 *International Building Code*, the 4.5-in. thick slab would have a 2-hour fire rating based on heat transmission. To achieve a 3-hour fire rating, using the empirical approach of the *IBC*, a 5.75 or 6-in. thick slab would be required (Table 720.2.2.1).

The analyses for structural fire endurance demonstrate that a 3-hour fire rating can be achieved with the 4.5-in. thick slab, which is the same thickness as that required for the gravity loads (strength and serviceability requirements).

Thus, CRSI urges NIST to consider including a recommendation in the report regarding short-term or near-term goals — to address the lack of incentives in current building codes for the rational design of structural fire resistance, and to encourage revising the current building codes so that the existing tools can be used effectively.

Contact
David P. Gustafson, Ph.D., S.E., P.E.
Vice President of Engineering
Concrete Reinforcing Steel Institute
933 N. Plum Grove Road
Schaumburg, IL 60173
Tel: 847-517-1200
Email: dgustafson@crsi.org

The Concrete Reinforcing Steel Institute was founded in 1924 as a cooperative, non-profit organization of fabricators and producers of steel reinforcing bars and accessories. CRSI's main objective is to increase the use of steel reinforced concrete in construction. To meet this objective, CRSI conducts technical and marketing promotion efforts, as well as supporting research and engineering for the safe and proper use of materials in reinforced concrete construction.

From: "Dr. Jonathan Shimshoni" <yoni@escaperescue.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/27/2005.

Name : Dr. Jonathan Shimshoni
Affiliation : Escape Rescue Systems Ltd.
Email Address : yoni@escaperescue.com
Phone : +972-9-8992219
Report Number : NCSTAR 1
Page Number : 211
Paragraph : paragraph 4, sentence 3
recommendation 17, last sentence: "Stairwell and exit capacity should be adequate to accommodate counterflow due to emergency access by responders. "
Comment : In addition to □stairwell and exit□ use the broaden term □means of evacuation and access□
Comment Reason : Stairwells are no longer the only means of evacuation and access. New technologies and solutions for emergency evacuation and access exist today; codes and standards are already in development, which would enable the use of these solutions. These technologies may provide additional capacity for evacuation, timely access for emergency responders, and equitable evacuation for mobility-impaired and all occupants. These technologies may well retrofit to existing building.
The language of the recommendations should be broad enough to include all present and future means of evacuation and access.

Revision Suggestion : The capacity of stairwells and exits, together with other means of evacuation and access should be adequate to accommodate counterflow due to emergency access by responders.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: "Dr. Jonathan Shimshoni" <yoni@escaperescue.com>
To: wtc@NIST.GOV
Cc: dlowe@NIST.GOV
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/27/2005.

Name : Dr. Jonathan Shimshoni
Affiliation : Escape Rescue Systems Ltd.
Email Address : yoni@escaperescue.com
Phone : +972-9-8992219
Report Number : NCSTAR 1
Page Number : 211
Paragraph : paregreph 7 (recommendation 7, section C) , sentence 1-2

Comment : 1. Use the term □means of evacuation and access□ instead of the word □stairwell.□
2. Add the option to use external evacuation and access technologies to provide sufficient evacuation capacity.
Comment Reason : Stairwells are no longer the only possible means of evacuation and access. New technologies and solutions for emergency evacuation and access exist today; codes and standards are already in development, which would enable the use of these solutions. These technologies can provide additional capacity for evacuation, timely access for emergency responders, and equitable evacuation for mobility-impaired and all occupants. These technologies may well retrofit to existing building.
The language of the recommendations should be broad enough to include all present and future means of evacuation and access.

Revision Suggestion : If protected/hardened elevators are provided for emergency responders but become unusable during emergency, due to a malfunction or a conventional treat whose magnitude exceeds the magnitude considered in design, sufficient means of evacuation and access capacity should be provided to ensure timely emergency responders access to buildings that are undergoing full evacuation. Such capacity could be provided either via dedicated stairways for fire services use or by building sufficient stairway capacity (i.e., number and width of stairways and/or use of scissor stairs credited as a single stair) or by external evacuation and access technologies to accommodate the evacuation of building occupants while allowing access to emergency responders with minimal hindrance from occupant counterflow.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: "Dr. Jonathan Shimshoni" <yoni@escaperescue.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/27/2005.

Name : Dr. Jonathan Shimshoni
Affiliation : Escape Rescue Systems Ltd.
Email Address : yoni@escaperescue.com
Phone : +972-9-8992219
Report Number : NCSTAR 1
Page Number : 212
Paragraph : paragraph 4 (Recommendation 18) sentences 1-2
Comment : Include evacuation and access systems as a possible egress component.
Comment Reason : Stairs and elevators are no longer the only means of evacuation and access. New technologies and solutions for emergency evacuation and access exist today; codes and regulations are in process to enable the use of these solutions. These technologies may provide additional capacity for evacuation, timely access for emergency responders, and equitable evacuation for mobility-impaired and all occupants. These technologies may well retrofit to existing buildings.
The language of the recommendations should be broad enough to include all present and future means of evacuation and access.

Revision Suggestion : NIST recommends that egress systems should be designed: (1) to maximize remoteness of egress components (i.e., stairs, elevators, evacuation and access systems, exits) without negatively impacting the average travel distance;

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: "Dr. Jonathan Shimshoni" <yoni@escaperescue.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/27/2005.

Name : Dr. Jonathan Shimshoni
Affiliation : Escape Rescue Systems Ltd.
Email Address : yoni@escaperescue.com
Phone : +972-9-8992219
Report Number : NCSTAR 1
Page Number : 214
Paragraph : paragraph 3 (recommendation 20), 1st sentence
Comment : Change the term □exterior escape devices□ to □exterior escape and access devices.□ Add □additional evacuation capacity□ to the attributes of these technologies.
Comment Reason : Some of the existing technologies of exterior escape enable emergency personnel access up and into elevated floors of the building and additional evacuation capacity.

Revision Suggestion : NIST recommends that the full range of current and next generation evacuation technologies should be evaluated for future use, including protected/hardened elevators, exterior escape and access devices, and stairwell navigation devices, which may allow all occupants an equal opportunity for evacuation, additional evacuation capacity and facilitate emergency response access.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: "Dr. Jonathan Shimshoni" <yoni@escaperescue.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/27/2005.

Name : Dr. Jonathan Shimshoni
Affiliation : Escape Rescue Systems Ltd.
Email Address : yoni@escaperescue.com
Phone : +972-9-8992219
Report Number : NCSTAR 1
Page Number : 214
Paragraph : paragraph 5 (recommndation 21), sentences 1-2
Comment : Use the broaden term "evacuation and access systems", describes variety of solutions that provide timely access to responders and evacuation of mobility-impaired persons. Use □external evacuation and access systems□ as additional type of system.
Comment Reason : Fire-protected and structurally hardened elevators are only one type of solution that may provide timely access to responders and evacuation of mobility-impaired persons. The language of the recommendations should be broad enough to include all present and future means of evacuation and access that provide these benefits.

Revision Suggestion : NIST recommends the installation of evacuation and access systems (i.e. fire-protected and structurally hardened elevators or external evacuation and access systems) to provide timely emergency access to responders and allowing evacuation of mobility-impaired building occupants. In tall buildings, consideration also should be given to installing such systems for use by all occupants.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

WTC PUBLIC COMMENTS

PART # 2

X-Sieve: CMU Sieve 2.2
From: Acaj1@aol.com
Date: Fri, 5 Aug 2005 17:26:19 EDT
Subject: Reoprt by Prof. Quintiere WTC Collapse
To: info@nistreview.org
CC: ncstac@nist.gov, sallyr@skyscrapersafety.org, wtc@nist.gov
X-Mailer: 9.0 Security Edition for Windows sub 5200
X-Spam-Flag: NO
X-NIST-MailScanner-Information: Please contact the ISP for more information
X-MailScanner:
X-MailScanner-From: acaj1@aol.com

Eric,

Attached for posting is a report by Professor James Quientiere with some suggestions by myself.

Thanks.

Arthur Scheuerman,
Ret. B.C. FDNY

NIST WTC 7-05 Suggestions.pdf

X-Sieve: CMU Sieve 2.2
From: Acaj1@aol.com
Date: Fri, 5 Aug 2005 17:26:19 EDT
Subject: Reoprt by Prof. Quintiere WTC Collapse
To: info@nistreview.org
CC: ncstac@nist.gov, sallyr@skyscrapersafety.org, wtc@nist.gov
X-Mailer: 9.0 Security Edition for Windows sub 5200
X-Spam-Flag: NO
X-NIST-MailScanner-Information: Please contact the ISP for more information
X-MailScanner:
X-MailScanner-From: acaj1@aol.com

Eric,

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Thanks.

Arthur Scheuerman,
Ret. B.C. FDNY

NIST WTC 7-05 Suggestions.pdf

X-Sieve: CMU Sieve 2.2
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Date: Fri, 5 Aug 2005 17:26:19 EDT
Subject: Reoprt by Prof. Quintiere WTC Collapse
To: info@nistreview.org
CC: ncstac@nist.gov, sallyr@skyscrapersafety.org, wtc@nist.gov
X-Mailer: 9.0 Security Edition for Windows sub 5200
X-Spam-Flag: NO
X-NIST-MailScanner-Information: Please contact the ISP for more information
X-MailScanner:
X-MailScanner-From: acaj1@aol.com

Eric,

Attached for posting is a report by Professor James Quientiere with some suggestions by myself.

Thanks.

Arthur Scheuerman,
Ret. B.C. FDNY

NIST WTC 7-05 Suggestions.pdf

Comments on NIST NCSTAR 1 Draft

July 27, 2005

James Quintiere, Prof
Fire Protection Engineering
University of Maryland
College Park, MD 20742
jimq@umd.edu
With suggested changes in red to NIST report by Arthur Scheuerman

General Comments

These comments pertain to the NIST summary chapter of the NCSTAR 1 Draft report, and are based on statements also from the June 2005 progress report. My comments will be annotated (Appendix A) to indicate their source and to provide additional information.

My comments address the fire analysis, the heating of the steel and issues pertaining to such. In summary, I list the issues and concerns that I have with the NIST presentation and findings:

1. I do not believe that NIST has presented a convincing argument for their collapse hypotheses for WTC 1 and 2. NIST had repeatedly stated that they would list all likely collapse scenarios in terms of their probabilities based on uncertainties in the analyses. That seems to have been abandoned in the final report. Their collapse hypothesis is based on damage done by the aircraft impacts, particularly in removing insulation from the core columns is key, together with brief local fire heating of above 1000 oC for about 15 minutes. NIST has not made a sufficient case for the removal of the steel insulation, and the fire analysis is based on a light fuel

load that is shown to be in error. I suggest an alternative hypothesis based on longer fire duration, and on the insulation staying primarily in place.

2. NIST claims that if the insulation had stayed in place, the computed fire was not able to cause building collapse. Therefore, they conclude that the insulation applied in design was adequate: "The WTC towers would likely not have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact." [p172] I have not seen sufficient evidence to indicate that the insulation was removed, nor that the insulation applied, had it remained in place, was adequate.

3. NIST was not able to document the WTC design process with respect to the selection of the steel insulation or its basis: "NIST was not able to find any evidence that there was a technical basis to relate SFRM thickness to a fire resistance rating, nor was there sufficient prior experience to establish such thickness requirements by analogy." [p 55] the lack of findings is a tragedy of this investigation as it goes to the core of fire protection design and its dependence on regulations. If we do not know how the process worked for these buildings, how do we know it is being done satisfactorily now.

4. The report represents more of a scientific analysis rather than an investigation to find all of the relevant facts. NIST held no hearings to ascertain testimony, used no subpoenas, and enlisted no investigative team to gather information. NIST was very late in acquiring witness accounts due to the federal government bureaucracy requirements on public surveys. Steel remnants were collected as they were available, and reports from the PA or others involved were taken as fact without corroboration. An example is the acceptance of insulation applied to the trusses in renovation to the north tower, WTC1, impact area as 2.5 inches compared to the

specification of 1.5 inches over the original 0.5 inches. This is an incredible difference, realizing that they reported up to 4 inches applied to a 1- inch diameter rod. ("The Port Authority provided NIST with the records of measurements of SFRM thickness on upgraded floors in both towers. The average thickness and standard deviation on the main trusses was 2.5 in. ± 0.6 in. NIST analysis of several Port Authority photographs from the 1990s of the upgraded 31 st floor of WTC 1 indicated an average thickness and standard deviation on the main trusses of 1.7 in. ± 0.4 in.") [p 70] Had more steel been examined from the fire floors, NIST may have been able to establish proof for its hypothesis that key core columns were denuded of insulation and therefore significantly heated to cause their reduction in strength. NIST found no evidence to corroborate that finding. "None of the recovered steel samples showed evidence of exposure to temperatures above 600 C for as long as 15 min. This was based on NIST annealing studies that established the set of time and temperature conditions necessary to alter the steel microstructure. These results provide some confirmation of the thermal modeling of the structures, since none of the samples were from zones where such heating was predicted." [p 176] Had NIST recovered steel from the areas where steel was predicted to have been heated, could have given them key evidence to support their claim. As the steel was expeditiously sold to Asia, before the fire floor steel could be identified from its markings and saved, was a significantly blunder in the investigation. Since NIST has jurisdiction over future investigations, a protocol for protecting evidence and securing the site must be established. Moreover, the rationale for the speedy elimination of the steel in this incident, NIST fails to document. Spoliation of fire scene evidence can border on a crime.

5. The NIST report is difficult to read due to its length and tedious style. It does not clearly show cause and effect. Standard analyses of fires attempt to give a time line. While the actual

timeline is clearly known in this case, the predicted timeline and its cause and effect listing is not presented. There are vague references that the predicted fire looked right. Dr. Sunder indicated that a timeline was not predicted, as difficulties exist with the nonlinear creep structural model. Only a mechanistic analysis was presented [NFPA meeting at NIST, July 12, 2005]. The report needs to clearly indicate the scientific reasons for the NIST description of the collapse scenarios and tie them to the results of their computations and assumptions. This needs to be done with footnoted annotations so a reader can find the details. This 10,000- page report will only serve as a smoke screen unless it is fully documented for easy reference.

6. NIST has never acknowledged of answered comments in the past, so it is doubtful that these comments will have any impact. I urge them to be more responsive. I am attaching my unanswered November 22, 2004 comments for background. (Appendix B)

Specific comments:

1. Collapse Hypothesis

Structural Failure

NIST contends that the collapse is due the floors pulling in the external columns that in turn lose stability [p 171,2]. This occurs on the south of WTC 1 and the east of WTC 2. They say WTC 2 collapses earlier because it received more damage from the aircraft.

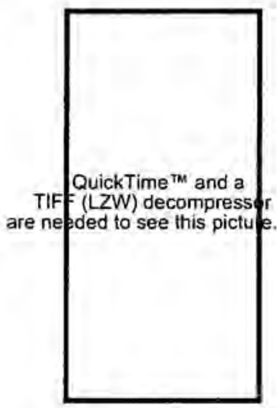
I find an alternative hypothesis that can be supported by relatively simple computations on the heating of the steel trusses with their specified insulations in place [Quintiere et al, Fire Safety J. 2002, and Quintiere, Interflam 2004]. This analysis does not include the heating of the core columns, as they would never get hot enough to fail if their insulation remained intact. Table 1 summarizes the results, and shows computations for a fire of 800 °C, and indicates the time for the steel to reach 600 °C where it falls to 20 % of its original strength. The truss at this temperature would fail due to the deflection pulling in the external columns as indicated by Usmani [FSJ 2003], and by NIST [June 2004 Progress report, Vol 1, p 81, 120] by either this column buckling or by failure of the connections. Buckling can occur at steel temperatures as low as 400 °C while the seat failure occurs at 650 °C.

It is noted that the predicted times to reach the critical failure temperature of the truss steel of 55 -73 minutes for WTC 2 and 111 minutes for WTC 1 in Table 1 is consistent with the building collapse times of 56 and 102 minutes, respectively. These predicted heating times are also consistent with the NIST measured heating times (to 66 to 86 minutes, although the reduced scale 17 ft span tests compromised heat transfer) in the UL furnace tests at fire temperatures comparable to 800 °C shown in Table 2 taken from NIST. Indeed, the UL time to reach 1100 °F (593 °C) for the 35 ft span ranges from 66 to t6 minutes which is consistent with 73 minutes in Table 1 and an extrapolated time of 50 minutes for the UL temperature conditions. (See Figure 1.)

Table 1. Time for steel elements to reach 600 °C in an 800 °C fire (Interflam 2004).

Element	Insulation Thickness mm	Time to Reach 600 °C with insulation, min.	Time to Reach 600 °C with no insulation, min	E119 Rating Requirement min.
27.7 mm rod, 54 kg/m^2 WTC 2	12.7	55	8	120
N WTC 2	19.1	73	8	120
N WTC 1	38.1	111	8	120
14WF43, 43 kg/m^2 core	44.5	213	6	180
55.8 cm box column, 7.6 cm thick, 513 kg/m ^{2} core	28.6	1640	75	180

Table 2. UL test results form NIST



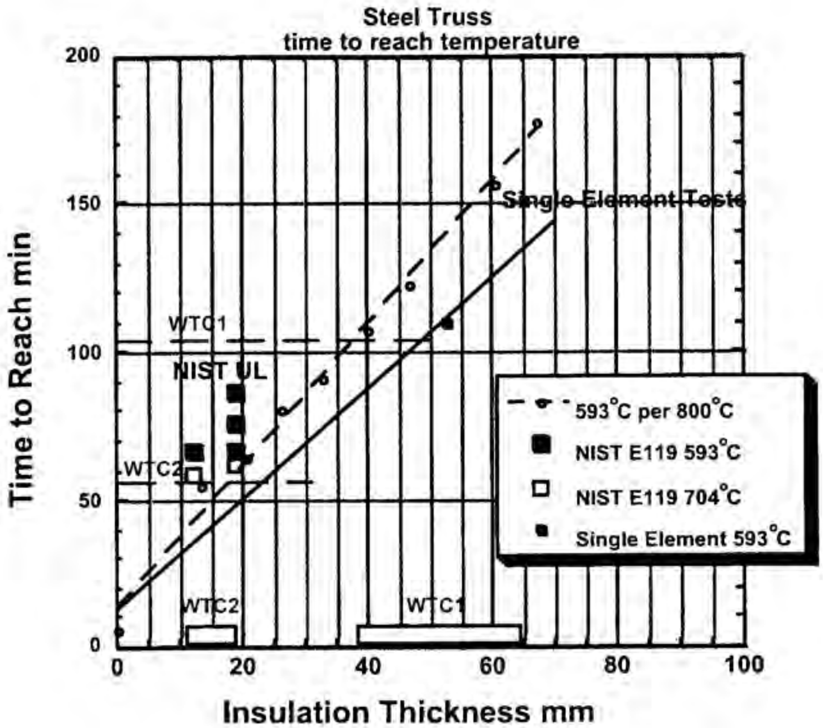


Figure 1. UL and Isolatek results.

Consequently, if the truss elements with specified insulation levels of ½- ¾ in. for WTC 2 and 1 ½ in. for WTC 1 can be heated to about 600 °C in an 800 °C fire at computed times of 55-73 minutes and 111 minutes, respectively, and NIST and others determined that the truss would cause either column buckling or connection failure at 600 °C or below, then this mode of collapse cannot be discounted. This is especially compelling since the collapse times are consistent at 56 and 102 minutes. Moreover, it is commonly known that floor sections were collapsing up to 20 minutes before the full collapse of each of the buildings. NIST has not addressed those early failures.

Fire Simulation

The results of the NIST fire predictions are based on a fuel loading of 4-5 psf. These levels are based on data from the impacted floors of Marsh & McLennan in WTC 1. NIST says this has "high" accuracy [p 119]. They find for WTC 1 that a given floor did not have uniform temperatures. "At any given location, the duration of temperatures near 1,000 °C was about 15 min to 20 min." [p 127] Upper layer temperatures are shown in Figure 2 for WTC 1 97th floor [NIST]. Temperatures generally exceeded 600°C for about 30 minutes, and for about 60 minutes in the core. In contrast, a scale model test conducted at the University of Maryland, representative of the 96th floor with a simulated fuel load of 11.5 psf, shown in Figure 3 indicates temperatures are generally over 6000C(typo?, 600C) for 100 minutes, by(typo?) are much cooler in the core. These results are distinctly different from the NIST simulation. One may be dubious of scale modeling, but it is a tried and true technique.

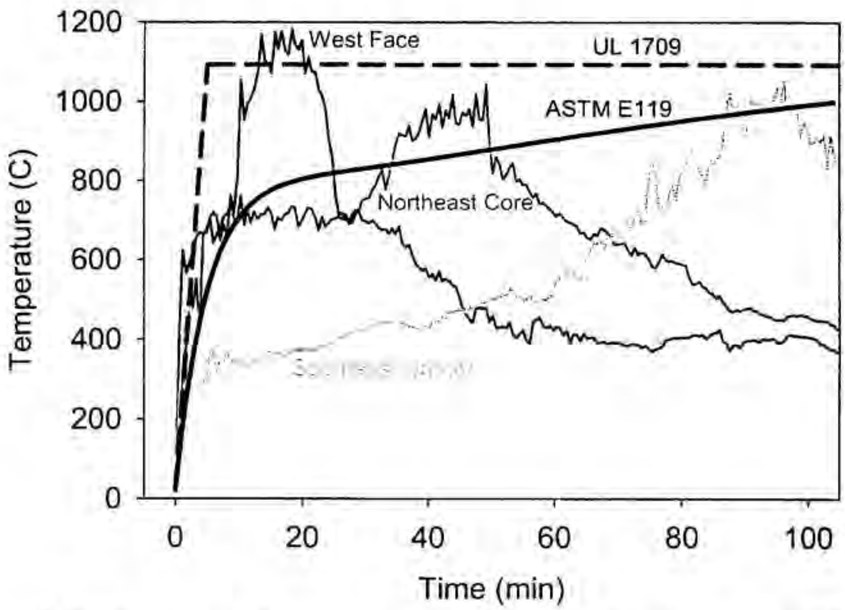


Figure 2. Predicted upper layer temperatures at various locations on the 97th Floor.

8

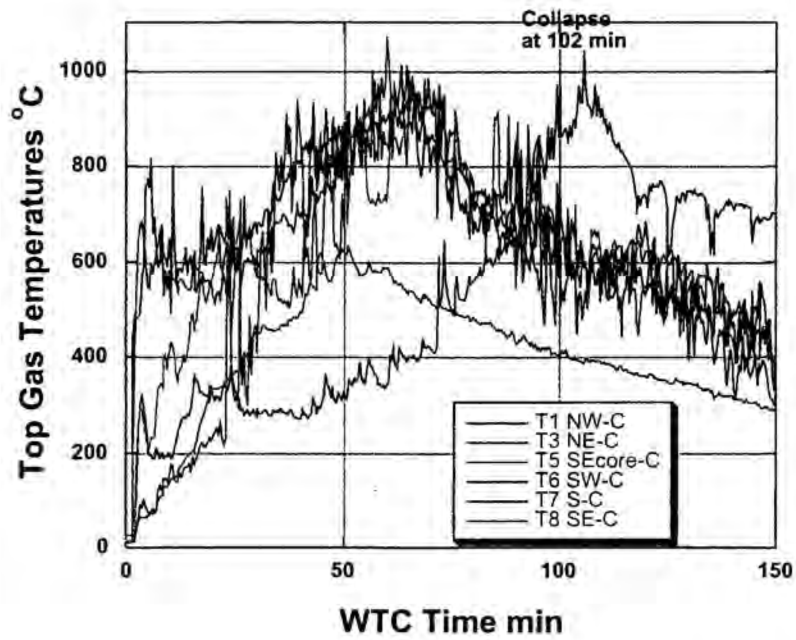


Figure 3. Temperatures in a scale model of WTC 1 96th floor

The heavier fuel load in the scale model was based on traditional office loadings and on anecdotal interviews of people familiar with the floors. Subsequently, we conducted a fuel load survey of the 96th floor based on architectural plans obtained from the furniture installer. This led to a conclusion that a loading of 10 psf or greater was the case. Appendix C contains the details in a report. Figure 4 shows a section of the architectural plans used for the 96th floor. A handwritten notation indicates a section of common files that ringed the core of the office space. There were 170 of these 4-drawer lateral files. NIST completely ignored this fuel load (and others) in their assessment. We assigned 100 lbs of paper per draw (a sub-capacity level) giving 68,000 lbs for this contribution. In addition, there were other common files and a storage room that gave a grand total of 95,400 lbs not included by NIST. In the survey conducted by Kate Stewart, estimates of paper and personal items were included in the workstation loads based on typical office conditions. Our total floor combustible loading was estimated at 302,062 lbs compared to 134,640 lbs determined by NIST. Taken over the office floor space area (31,013 ft^2), this computes to 9.7 psf and 4.3 psf for NIST. Our paper extimat per file draw is well below

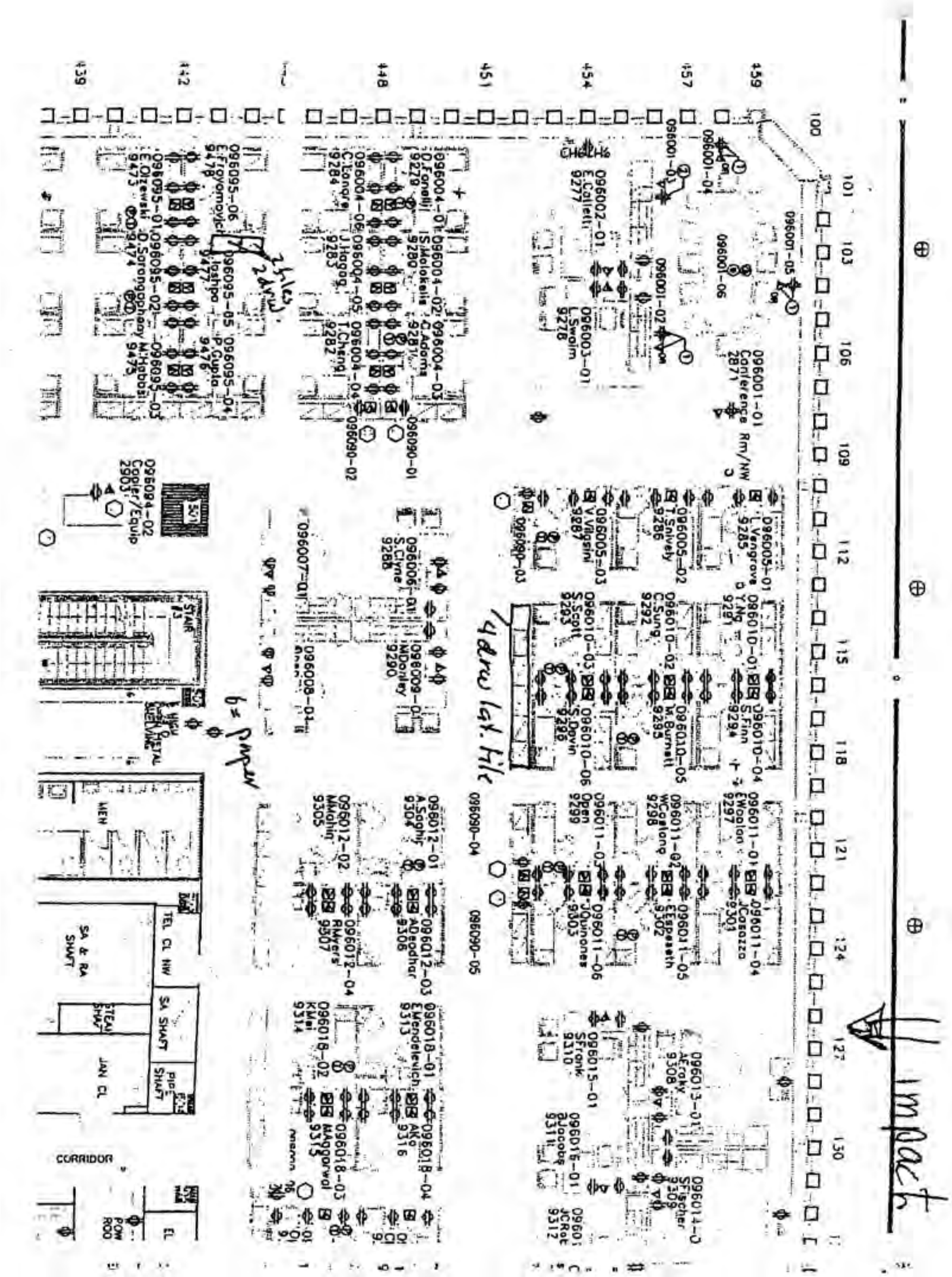


Figure 4. Section of furniture layout WTC 1 96th floor

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capacity, so the loading we determine is likely too low. Indeed, it was told to us that Marsh was a "paper hog" and "kept everything". Paper fuel in closed files is de-rated in fire design considerations, but the aircraft impact could have opened the file draws.

It is generally expected that fully developed fires achieve nearly uniform temperature of over 800ºC, and are expect to persist for hours. Hence, we have the standard rating of structures at 2 to 3 hours of endurance. Had NIST used higher fuel loadings, they would have had longer hot fire conditions and this would impact their input into the structural modeling. The discrepancy in the fuel load raises some questions. Moreover, the large differences in the fuel loading found by us and NIST on the Marsh floors raises more questions. Incidently, our independent check of the workstations exclusively counted by NIST gave us a combustible load of 133,694 lbs compared to their count of 134,640 lbs. In addition, while NIST claims high accuracy for the loading in WTC 1, they do not for WTC 2. Moreover, it appears that the fire simulation in WTC 2 is only about half the size of WTC 1. More needs to clarified here.

2. *Insulation Lost on Impact*

NIST has not presented clear and sufficient evidence that the aircraft impacts caused the elimination of insulation, especially from the core columns. According to NIST [Sunder, July 12, 2005 NFPA committee meeting], the planes disintegrated on impacting the exterior columns. This debris and its momentum is alleged to have removed the insulation. Heavy item, such as an engine or landing gear, could cause structural damage to a column in the core: "If the engine missed the floor slab, the majority of the engine core remained intact and had enough residual momentum to sever a core column upon direct impact. " [p 105] This suggest that hitting a floor slab, which is very likely due to the diameter of the engine, then less damage would be done. Moreover, the accuracy of the impact calculation is not high as other compute different damage results. Specifically on the insulation loss, NIST says it could be shook off due to vibrations, or eroded off due to pulverized debris impact. On the former NIST concludes: "The analyses were not sufficient to establish justifiable, general criteria for a coherent pattern of vibration-induced dislodging." [p 117] ON the erosion, NIST did static tests on the insulation adhesive strenth, but never coupled these results to a computational model. Instead, "NIST assumed that the debris impact dislodged insulation if the debris force was strong enough to break a gypsum board

partition immediately in front of the structural component. Experiments at NIST confirmed that an array of 0.3 in. diameter pellets traveling at 350 mph stripped the insulation from steel bars like those used in the WTC trusses." [p 117] These pellet tests need more amplification, as they are the only test simulation of the erosion effect. Moreover, the test speed of 350 mph is not consistent with the average speed of debris traversing the buildings. The debris took about 0.7 s [sunder, July 12, 2005] to exit, giving an average speed of 205 ft/0.7s or 200 mph. As momentum depends on the square of the velocity, NIST has overestimated the momentum in these pellet tests by a factor of 3.

It is crucial to the NIST collapse hypothesis that the insulation is removed on impact. It begs more support.

3. WTC Fire Resistance Design

From the outset of its construction, fire safety was a concern for the WTC. From the records, clearly cost, time and safety were involved. For NIST not to have probed these facets, and to assess, in the least, the disparate range of insulation thickness assigned to the floor assembly truss system a dereliction of the intent of this investigation. NIST cites historical facts [p 69 +], but not the underlying rationale for decisions. Although an extensive civil suit on the insulation deficiencies occurred in the 1990's, NIST appears to have not examined those records.

How can on justify a specification of ½ in., a change to 1 ½ in. in the 90's, an ICBØ recommendation of 2 in. [p 192], and an actual upgrade to 2.5 +/- 0.6 in. on the impact floors of the WTC 1? The extensive over-application up to 3 in. on a round 1 in. diameter bar-joist is difficult to accept based solely on a report from the PA when photographic evidence for other upgraded floors shows only 1.7 +/- 0.4 in. according to NIST [p 71].

Whether this insulation on the truss was key as I believe, or not, is not the issue here. The process of fire resistance regulations and their interpretation is the issue. This needs to be scrutinized. It should have been at the heart of the investigation, and that is why NIST has proceeded as a scientific body rather than an investigative agent. Civil lawyers would have

pushed this, whereas the Commerce lawyers seemed more concerned to restrict the scientists, and block information from the public.

4. Lack of In Depth Investigation

The NIST report reads like a scientific enterprise using computer simulations that have never been used (or validated) in this way before. [119] Other government agencies that have investigative authority operate differently. The NTSB has time scene presence, press briefings, and formal hearings with testimony. The ATF has a National Response Team that is on the scene within hours of the event. They secure the scene, question witnesses, and gather evidence. NIST has operated in near secrecy, has had a low public profile, and has gathered facts as in a library search. Although they have held public forums, these have been very controlled, under publicized, and dominated by NIST. They have not appeared to have aggressively, or with corroboration in mind, pursued evidence. The Commerce lawyers could have helped here. With the amount of funding that they received they could have conducted a full-scale test of a floor. They could have given more support to their purely mathematically modeling results. As scientists are sometime stereotyped as being out of touch with reality, NIST cannot afford that stigma as an investigative body as NCSTAR.

5. On the Recommendations

Thirty recommendations are listed. They all are general and imply more research is needed. One cannot fault NIST fro trying to expand its research base, as they have not been properly funded in the fire and building areas since the 1970's. The fire funding with NSF and industry support ran as high as $ 10 million in the mid- 70's. Its comparable level in today's dollars is much lower. But the funding issues should not cloud the work of the NCSTAR. Yet the NCSTAR is only authorized to proceed and funding for its continuation is doubtful. So perhaps funding is the real issue.

The recommendation areas cover:

1. Increased structural integrity, including methods for preventing conditions that could result in progressive collapse (when a building or a significant portion of a building collapses due to disproportionate spread of an initial local failure), standardizing the estimation of wind loads that frequently govern the design of tall buildings, and enhancing the stability of tall buildings.

2. Enhanced fire resistance of structures, including the technical basis for determining construction classification and fire resistance ratings, improvements to the technical basis for standard fire resistance testing methods, adoption of the "structural frame" approach to fire resistance ratings, and in-service performance requirements and conformance assessment criteria for spray-applied fire resistive materials.

3. New methods for designing structures to resist fires, including the objective of burnout without collapse, the development of performance-based methods as an alternative to current prescriptive design methods, the development and evaluation of new fire resistive coating materials and technologies, evaluation of the fire performance of conventional and high performance structural materials, and elimination of technical and standards barriers to the introduction of new materials and technologies.

4. Improved active fire protection, including the design, performance, reliability, and redundancy of sprinklers, standpipes/hoses, fire alarms, and smoke management systems.

5. Improved building evacuation, including system designs that facilitate safe and rapid egress, methods for ensuring clear and timely emergency communications to occupants, better occupant preparedness for evacuation during emergencies, and incorporation of appropriate egress technologies.

6. Improved emergency response, including better access to the buildings and better operations, emergency communications, and command and control in large-scale emergencies.

7. Improved procedures and practices, including encouraging (legislating?) code compliance by nongovernmental and quasi-governmental entities, adoption and application of egress requirements in available code provisions for existing buildings, and retention and availability of building documents over the life of a building.

8. Education and training programs for fire protection engineers, structural engineers, and architects.

I generally support NIST in all of these areas, as they are important areas to pursue for research. Recommendation that can lead to immediate code changes need to go more slowly, as they require consensus and checks and balances. NIST as part of its name suggests can play an important role in "Standards" for fire safety, but they must be enabled to do that successfully. The fire and building programs at NIST have atrophied, and must be brought back to full competence. These and other programs at NIST must rely on outside funding to support their staffs. That effort, in particular, takes away form the fire program, as industry does not wish to fund safety regulations. For other programs in NIST where standards benefit industry and grease the market place, those programs find fertile support in industry. Fire safety is different, and the congress needs to appreciate that, and direct its funding accordingly.

I would like to offer some more specific comments to the NIST recommendations # 29 and 30 that pertain to education. They advocate "continuing education curricula" for structural and fire engineers and architects on modern principles and on the use of computational methods. While this is good, it is not enough; and it could produce people who think they have expertise, but do not. The education in fire protection engineering is sorely lacking in the US. Only about 50 engineers are produced a year at institutions granting a recognized engineering degree (U of MD, WPI) and technology degrees (OSU, U of Akron, etc.). The US likely needs 500 engineers a year. While a careful study of the need has not been done, the training received in continuing education courses currently indicates the lack of fire protection engineer in the field of fire investigation and in the protection of nuclear plants as stark examples. In addition, the population that makes up the regulators and participate in the code and standards making process generally lack degrees. The estimate I cite comes from the fact the University of Lund program in Sweden place all of their graduates at a rate of 2 in million of population per year in the private sector and 2 more in the fire service profession. This gives a benchmark of 2 to 4 per million of population. If the fire service in the US began to hire fire protection engineers, the estimate for the US would be 1000 per year.

The Congress needs to bring the education level of fire protection engineering up to a level that fill the infrastructure needs for the country. This can be fulfilled with NSF providing funds to this field. The Congress needs to further recognize that NIST is under funded in these areas, and

the country needs a better way of getting the proper technical input into the regulatory process for fire safety. It cannot be dependent on voluntary efforts and special interest actions. After the tragedy of 9/11, a better process of fire safety needs to be created. Unfortunately, the NIST NCSTAR draft report does not dramatically demonstrate the deficiencies in the fire process for the design and collapse of the WTC buildings.

Appendix A: NIST NCSTAR 1 Draft Source Material

Collapse Cause

Why the collapse, p171,2

Objective 1: Determine why and how WTC 1 and WTC 2 collapsed following the initial impacts of the aircraft. • The two aircraft hit the towers at high speed and did considerable damage to principal structural components: core columns, perimeter columns, and floors. However, the towers withstood the impacts and would have remained standing were it not for the dislodged insulation and the subsequent multifloor fires. The robustness of the perimeter frame-tube system and the large size of the buildings helped the towers withstand the impact. The structural system redistributed loads without collapsing in places of aircraft impact, avoiding larger scale damage upon impact. The hat truss, which was intended to support a television antenna atop each tower, prevented earlier collapse of the building core. In each tower, a different combination of impact damage and heat-weakened structural components contributed to the abrupt structural collapse. • In WTC 1, the fires weakened the core columns and caused the floors on the south side of the building to sag. (this sentence should read "The fires caused the floors on the South side of the building to sag and weakened the core columns.") The floors pulled the heated south perimeter columns inward, reducing their capacity to support the building above. Their neighboring columns quickly became overloaded as the south wall buckled. The top section of the building tilted to the south and began its descent. The time from aircraft impact to collapse initiation was largely determined by how long it took for the fires to weaken the building core and to reach the south side of the building and weaken the perimeter columns and floors. (This sentence should read; "The time from aircraft impact to collapse initiation was largely determined by haw long it took for the fires to weaken the long span floors on the south side of the building. In WTC 1 the perimeter wall and the core were heavily damaged on the North side and if it were not for the South side floors sagging and failing, destabilizing the South perimeter wall and possibly the core, the building would have tilted to the North before collapsing.") • In WTC 2, the core was damaged severely at the southeast corner and was restrained by the east and south walls via the hat truss and the floors. The steady burning fires on

the east side of the building caused the floors there to sag. The floors pulled the heated east perimeter columns inward, reducing their capacity to support the building above. Their neighboring columns quickly became overloaded as the east wall buckled. The top section of the building tilted to the east and to the south and began its descent. The time from aircraft impact to collapse initiation was largely determined by the time for the fires to weaken the perimeter columns and floor assemblies (change to; "to waken the floor assemblies and possibly the perimeter columns") on the east and south (eliminate "east and") side of the building. WTC 2 collapsed more quickly than WTC 1 because there were early and persistent fires on the east side of the building, where the fireproofing was thinner and had not been upgraded and aircraft may have extensively dislodged insulation from the structural steel. Since the core columns on the lower floors in Tower 2 were much more robust than in Tower 1, it was unlikely there was more aircraft damage to the building core. • It is unknown whether the WTC towers would likely have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact. A full scale test of the 60 foot long span flooring assembly is needed to clarify thermal stability problems.

On WTC 1: p xliii-xliv

The two aircraft hit the towers at high speed and did considerable damage to principal structural components: core columns, floors, and perimeter columns. However, the towers withstood the impacts and would have remained standing were it not for the (add "deficient", "inadequate" or) dislodged insulation (fireproofing) and the subsequent multifloor fires.

The time from aircraft impact to collapse initiation was largely determined by how long it took for the fires to weaken the building core and to reach the south side of the building and weaken the perimeter columns and floors. (change to "... largely determined by how long it took to weaken the floors which sagged and possibly detached destabilizing the heat weakened perimeter columns and building core."

On WTC 2

n WTC 2, the core was damaged severely at the southeast corner and was restrained by the east and south walls via the hat truss and the floors. The steady burning fires on the east side of the building caused the floors there to sag. The floors pulled the heated east perimeter columns inward, reducing their capacity to support the building above. Their neighboring columns quickly became overloaded as columns on the east wall buckled. The top section of the building tilted to the east and to the south and began its descent. The time from aircraft impact to collapse initiation was largely determined by the time for the fires to weaken the floor assemblies and perimeter columns and on the east and the south sides of the building. WTC 2 collapsed more quickly than WTC 1 because there were early and persistent fires on the east side of the building, where there was less insulation on the structural steel. Whether there was more aircraft damage to the building core and aircraft had extensively dislodged the insulation is still questionable.

Also an analysis of the stability of the towers, assuming no damage to the core, gives the number of floors that need to be removed to cause global failure (June 2004, Vol. 1, p.81):

> The following presents some preliminary findings obtained from the preliminary stability analyses under service live loads and subject to the assumptions and the limitations of these models (see Appendix D): Linear stability analysis was used to examine the stability of the undamaged WTC 1 under service loads through increased un-braced column lengths (floor removal). The tower was stable when two complete floors including the core floors were removed. Two core columns buckled when three floors were removed, but the tower maintained its overall stability. The tower also maintained its stability when four columns buckled with four floors removed. The analysis suggested that global instability of the tower occurred when five floors were removed from the model. Assuming that all columns at the region of the removed floors reached a temperature of 600 °C (reduced modulus of elasticity), the analysis indicates that removal of four floors would induce global instability.

1. <u>Single truss analysis</u>: A model of a single truss and its connection shows that the truss fails at the interior column seat connection, and 'walks off' the seat. This occurs at 650 C. The web diagonals begin to buckle at 340 C, and the exterior columns bow inward at 560 C as the truss to acted as a catenary. (June 2004, Vol. 1 p. 120).

On steel inspected p 88,89

Examination of photographs showed that 16 of the exterior panels recovered from WTC 1 were exposed to fire prior to the building collapse. None of the nine recovered panels from within the fire floors of WTC 2 were directly exposed to fire. NIST used two methods to estimate the maximum temperatures that the steel members had reached: • Observations of paint cracking due to thermal expansion. Of the more than 170 areas examined on 16 perimeter column panels, only three columns had evidence that the steel reached temperatures above 250 °C: east face, floor 98, inner web; east face, floor 92, inner web; and north face, floor 98, floor truss connector. Only two core column specimens had sufficient paint remaining to make such an analysis, and their temperatures did not reach 250 °C. NIST did not generalize these results, since the examined columns represented only 3 percent of the perimeter columns and 1 percent of the core columns from the fire floors. • Observations of the microstructure of the steel. High temperature excursions, such as due to a fire, can alter the basic structure of the steel and its mechanical properties. Using metallographic analysis, NIST determined that there was no evidence that any of the samples had reached temperatures above 600 oC. These results were for a very small fraction of the steel in the impact and fire zones. Nonetheless, these analyses indicated some zones within WTC 1 where the computer simulations should not, and did not, predict highly elevated steel temperatures. 6.5

On the steel p 176

None of the recovered steel samples showed evidence of exposure to temperatures above 600 oC for as long as 15 min. This was based on NIST annealing studies that established the set of time and temperature conditions necessary to alter the steel microstructure. These results provide some confirmation of the thermal modeling of the structures, since none of the samples were from zones where such heating was predicted.

On single truss analysis p 96

Single composite truss and concrete slab section. A floor section was modeled to investigate failure modes and sequences of failures under combined gravity and thermal loads. The floor section was heated to 700 °C (300 °C at the top surface of the slab) over a period of 30 min. Initially the thermal expansion of the floor pushed the columns outward, but with increased temperatures, the floor sagged and the columns were pulled inward. Knuckle failure was found to occur mainly at the ends of the trusses and had little effect on the deflection of the floor system. Figure 6–11 shows that the diagonals at the core (right) end of the truss buckled and caused an increase in the floor system deflection, ultimately reaching approximately 42 in. Two possible failure modes were identified for the floor-truss section: sagging of the floor and loss of truss seat support.

Impact Damage

On damage to WTC1 pp20- 21

The 94 th floor was more severely damaged. The midsection of the left wing, laden with jet fuel, and the left engine cut through the building façade, severing 17 of the perimeter columns and heavily damaging four more. The pieces of the aircraft continued inward, severing and heavily damaging core columns. The insulation applied to the floor trusses above and the columns was scraped off by shrapnel-like aircraft debris and building wall fragments over a wedge almost 100 ft wide at the north face of the tower and 50 ft wide at the south end of the building core.

A 40 ft width of the 96 floor slab was broken 80 ft into the building. The insulation was knocked off nearly all the core columns and over a 40 ft width of floor trusses from the south end of the core to the south face of the tower.

On WTC1 p34

Dislodging of SFRM from structural members due to the aircraft impact, that enabled rapid heating of the unprotected structural steel;

On WTC2 78 flr p 40

Dislodging of SFRM from structural members due to the aircraft impact, that enabled rapid heating of the unprotected structural steel;

On WTC2 81 flr p 41

On the 81 st floor, the fuselage pulverized a section of the floor 40 ft wide that extended into the southeast corner of the core. The SFRM and gypsum fire protection on the full depth of the east side of the core and in the entire east side of the tenant space was stripped.

On impact p 105

The Investigation Team gained valuable knowledge from these component impact analyses, for example: • Moving at 500 mph, an engine broke any exterior column it hit. If the engine missed the floor slab, the majority of the engine core remained intact and had enough residual momentum to sever a core column upon direct impact. • The impact of the inner half of an empty wing significantly damaged exterior columns but did not result in their complete failure. Impact of the same wing section, but filled with fuel, did result in failure of the exterior columns.

On the accuracy of the impact model p 114

Two pieces of landing gear penetrated WTC 1 and landed to the south of the tower. The Case B prediction showed landing gear penetrating the building core, but stopping before reaching the south exterior wall. For WTC 2, a landing gear fragment and the starboard engine penetrated the building and landed to the south. The Case D prediction correctly showed the main landing gear emerging from the northeast corner of WTC 2. However, Case D showed that engine not quite penetrating the building. Minor modifications to the model (all within the uncertainty of the input data) would have resulted in the engine passing through the north exterior wall of the tower.

On damage to insulation, p 117

An intact ceiling tile system could have provided the floor trusses with approximately 10 min to 15 min of thermal protection 6.9.3 Damage to Thermal Insulation The dislodgement of thermal insulation from structural members could have occurred as a result of direct impact by debris and could have occurred by inertial forces due to vibration of structural members as a result of the aircraft impact. In interpreting the output of the aircraft impact simulations, NIST assumed that the debris impact dislodged insulation if the debris force was strong enough to break a gypsum board partition immediately in front of the structural component. Experiments at NIST confirmed that an array of 0.3 in. diameter pellets traveling at 350 mph stripped the insulation from steel bars like those used in the WTC trusses. Determining the adherence of SFRM outside the debris zones was more difficult. There was photographic evidence that some fraction of the SFRM was dislodged from perimeter columns not directly impacted by debris. NIST developed a simple model to estimate the range of accelerations that might dislodge the SFRM from the structural steel components. As the SFRM in the towers was being upgraded with BLAZESHIELD II (CAFCO II) in the 1990s, The Port Authority had measured the force required to pull the insulation from the steel. The model used these data as input to some basic physics equations. The resulting ranges of accelerations depended on the geometry of the coated steel component and the SFRM thickness, density and bond strength. For a flat surface (as on the surface of a column), the range was from 20g to 530g, where g is the gravitational acceleration. For an encased bar (such as used in the WTC trusses), the range was from 40g to 730g. NIST estimated accelerations from the aircraft impacts of approximately 100g. The analyses were not sufficient to establish justifiable, general criteria for a coherent pattern of vibration-induced dislodging. Thus, NIST made the conservative assumption that all other insulation remained adhered to the structural components.

Fire Modeling

Active Fire Protection: Active fire protection systems (i.e., sprinklers, standpipes/ hoses, fire alarms, and smoke management systems) should be enhanced through improvements to design, performance, reliability, and redundancy of such systems.

On Fireballs WTC1 p 24

Less than 15 percent of the jet fuel burned in the spray cloud inside the building. A roughly comparable amount was consumed in the fireballs outside the building. Thus, well over half of the jet fuel remained in the building, unburned in the initial fires.

On loading p 76

NIST estimated the fuel loading on these floors to have been about 4 lb/ft 2 (20 kg/m2), or about 60 tons per floor. This was somewhat lower than found in prior surveys of office spaces. The small number of interior walls, and thus the minimal amount of combustible interior finish, and the limited bookshelf space account for much of the differences.

On WTC fire in 1975 p 89

INFORMATION GAINED FROM OTHER WTC FIRES There had been numerous fires in the towers prior to September 11, 2001. From these, the Investigation Team learned what size fire WTC 1 and WTC 2 had withstood and how the tower occupants and the responders functioned in emergencies. While The Port Authority's records of prior fires were lost in the collapses, FDNY provided reports on 342 fires that had occurred between 1970 and 2001. Most of these fires were small, and occupants extinguished many of them before FDNY arrival. Fortyseven of these fires activated one to three sprinklers and/or required a standpipe hose for suppression. Only two of the fires required the evacuation of hundreds of people. There were no injuries or loss of life in any of these fires, and the interruptions to operations within the towers were local. A major fire occurred in WTC 1 on February 13, 1975, before the installation of the sprinkler system. A furniture fire started in an executive office in the north end of an 11 th floor office suite in the southeast corner of the building. The fire spread south and west along corridors and entered a file room. The fire flashed over, broke seven windows, and spread to adjacent offices north and south. The air conditioning system turned on, pulling smoke into the return air ducts. Telephone cables in the vertical shafts were ignited, destroying the fire-retarded wood paneling on the closet doors. The fire emerged on the 12 th and 13 th floors, but there was little nearby that was combustible. The fire also extended vertically from the 9th to the 19 th floors within the

telephone closet. Eventually the fire was confined to 9,000 ft2 of one floor, about one-fourth of the total floor area. The trusses and columns in this area had been sprayed with CAFCO D insulation to a specified 1/2 in. thickness. Four trusses were slightly distorted, but the structure was not threatened.

On modeling floor fires, p 119

6.10.2 Modeling Approach The time frame of the Investigation and the above requirements led to the use of the Fire Dynamics Simulator (FDS). Under development at NIST since 1978, FDS was first publicly released in February 2000 and had been used worldwide on a wide variety of applications, ranging from sprinkler activation to residential and industrial fire reconstructions. However, it had never before been applied to spreading fires in a building with such large floor areas. Figure 6–30 shows how FDS represented the eight modeled floors (92 through 99) of the undamaged WTC 1. A similar rendition was prepared for floors 78 through 83 of WTC 2. The layout of each floor was developed from architectural drawings and from the information described in Section 5.8. There was a wide range of confidence in the accuracy of these floor plans, varying from high (for the floors occupied by Marsh & McLennan in WTC 1, for which recent and detailed plans were obtained) to low (for most of the space in WTC 2 occupied by Fuji Bank, for which floor plans were not available).

On the fuel load effect p 124

6.10.3 The Four Cases Four fire scenarios (Case A and Case B for WTC 1 and Case C and Case D for WTC 2) were superimposed on the four cases of aircraft-driven damage of the same names (Section 6.9). A number of preliminary simulations had been performed to gain insight into the factors having the most influence on the severity of the fires. The most influential was the mass of combustibles per unit of floor area (fuel load); second was the extent of core wall damage, which affected the air supply for the fires. The aforementioned workstation fire tests had also indicated that the damage condition of the furnishings also played a key role. The scenario variables and their values are shown in Table 6–6. Table 6–6. Values of WTC fire simulation variables. WTC 1 WTC 2 Variable Case A Case B Case C Case D Tenant fuel

load a 20 kg/m2 (4 lb/ft2) 25 kg/m2 (5 lb/ft2) 20 kg/m2 (4 lb/ft2) 20 kg/m2 (5 lb/ft2) Distribution of disturbed combustibles Even Weighted toward the core Heavily concentrated in the northeast corner Moderately concentrated in the northeast corner Condition of combustibles Undamaged except in impact zone Displaced furniture rubblized All rubblized Undamaged except in impact zone Representation of impacted core walls b Fully removed Soffit remained Fully removed Soffit remained a. In addition, approximately 12,000 kg (27,000 lb) of solid combustibles from the aircraft were distributed along the debris path. b. In Cases A and C, the walls impacted by the debris field were fully removed. This enabled rapid venting of the upper layer into the core shafts and reduced the burning rate of combustibles in the tenant spaces. In Cases B and D, a more severe representation of the damage was to leave a 1.2 m soffit that would maintain a hot upper layer on each fire floor. This produced a fire of longer duration near the core columns and the attached floor membranes. FDS contained no algorithm for breaking windows from the heat of the fires. Thus, during each simulation, windows were removed at times when photographs indicated they were first missing. Damage to the ventilation shafts was derived from the aircraft impact simulations. For undamaged floors, all the openings to the core area were assumed to total 5 m 2 in area. 6.10.4 Characterization of the Fires

On the accuracy of spread p 126

The fire simulation results for Case A and Case B were similar, indicating only a modest sensitivity to the fuel load and the degree of aircraft-generated damage. This was because, in general, the size and movement of the fires in WTC 1 were limited by the supply of air from the exterior windows. Since the window breakage pattern was not changed in Case B, the additional and re-distributed combustibles within the building did not contribute to a larger fire. The added fuel did slow the spread slightly because the fires were sustained longer in any given location. Although there was generally reasonable agreement between the simulated and observed fire spread rates, there were instances where the fires burned too quickly and too near the windows. This resulted from an artifact of the model: the combustible vapors burned immediately upon mixing with the incoming oxygen. Simulations performed with doubled fuel loads slowed the

fire spread well below the observed rates. Combined with the above results, this suggested that the estimated overall combustible load of 4 lb/ft 2 was reasonable.

On the predicted fires in WTC1, p 127

The predictions of maximum temperatures (e.g., red zones in Figure 6–37) were consistent with those in the three-workstation fire tests. The use of an "average" gas temperature was not a satisfactory means of assessing the thermal environment on floors this large and would also have led to large errors in the subsequent thermal and structural analyses. The heat transferred to the structural components was largely by means of thermal radiation, whose intensity is proportional to the fourth power of the gas temperature. At any given location, the duration of temperatures near 1,000 °C was about 15 min to 20 min. The rest of the time, the calculated temperatures were near 500 °C or below. To put this in perspective, the radiative intensity onto a truss surrounded by smoke-laden gases at 1,000 °C was approximately 7 times the value for gases at 500 °C.

On the modeling of WTC2, p 127

WTC 2 Simulating the fires in WTC 2 posed challenges in addition to those encountered in simulating the fires in WTC 1. The aircraft, hitting the tower to the east of center, splintered much of the furnishings on the east side of the building and plowed them toward the northeast corner. Neither the impact study nor the validation experiments performed at NIST could be completely relied upon to predict the final distribution, condition, and burning behavior of the demolished furnishings. In addition, only the layouts of the 78th and 80th floors were available to the Investigation; the other floors were only roughly described by former occupants. As a result of these unknowns, the uncertainty in these calculations was distinctly greater than in those for WTC 1. To help mitigate gross differences between the simulations and the observables, NIST made floor-specific adjustments, based on the results of preliminary computations. In particular, the fuel load and volatility on the 80 th floor were reduced, and the fuel load on the 81st and 82 nd floors was increased. In contrast with WTC 1, in WTC 2 there was less movement of the fires. The major burning occurred along the east side, with some spread to the north. There was no significant burning on the west side of the tower. Also unlike WTC 1,

changing the combustible load in WTC 2 had a noticeable effect on the outcome of the simulations. Because so many windows on the impact floors in WTC 2 were broken out by the aircraft debris and the ensuing fireballs, there was an adequate supply of air for the fires. Thus, the burning rate of the fires was determined by the fuel supply. In the Case D simulation, the office furnishings and aircraft debris were spread out over a wider area, and the furnishings away from the impact area were undamaged. Both of these factors enabled a higher burning rate for the combustibles.

ON the heating of the structure by the FDS fire, p 139

Tables 6–8 and 6–9 summarize the regions of the floors in which the structural steel reached temperatures at which their yield strengths would have been significantly diminished. Instances of brief heating of one or two columns early in the fires were not included. Even in the vicinity of the fires, the columns and trusses for which the insulation was intact did not heat to temperatures where significant loss of strength occurred. Unlike the simulations of the aircraft impact and the fires, there was no evidence, photographic or other, for direct comparison with the FSI results. Table 6–8. **Regions in WTC 1 in which temperatures of structural steel exceeded 600 °C.** Trusses Perimeter Columns Core Columns Floor Number Case A Case B Case A Case B Case A Case B 93 – – – – – – 94 – – – – N, S NE, S 95 N N, S – – S NW, S 96 N N, S – S S W, S 97 N, S N, S – S N W, S 98 N N, S – – – – 99 – – – – – – Key: N, north; S, south; W, west; NE, northeast; NW, northwest. Table 6–9. **Regions in WTC 2 in which temperatures of structural steel exceeded 600 °C.** Trusses Perimeter Columns Core Columns Floor Number Case C Case D Case C Case D Case C Case D 79 – – – – – – 80 – – – – – – 81 NE NE NE NE – NE 82 E E E E E E 83 E E – E – E

On the fire duration predicted, p 144

Both the results of the multiple workstation experiments and the simulations of the WTC fires showed that the combustibles in a given location, if undisturbed by the aircraft impact, would have been almost fully burned out in about 20 min.

Insulation Saga

On insulation: p xlvi

NIST found no technical basis or test data on which the thermal protection of the steel was based. On September 11, 2001, the minimum specified thickness of the insulation was adequate to delay heating of the trusses; the amount of insulation dislodged by the aircraft impact, however, was sufficient to cause the structural steel to be heated to critical levels. • Based on four standard fire resistance tests that were conducted under a range of insulation and test conditions, NIST found the fire rating of the floor system to vary between 3/4 hour and 2 hours; in all cases, the floors continued to support the full design load without collapse for over 2 hours.
P55 on insulation

NIST was not able to find any evidence that there was a technical basis to relate SFRM thickness to a fire resistance rating, nor was there sufficient prior experience to establish such thickness requirements by analogy.

On insulation p 69

Floor Systems- At the time the WTC was designed, the ASTM E 119 test method had been used for nearly 50 years to determine the fire resistance of structural members and assemblies. However, The Port Authority confirmed to the Investigation Team that there was no record of fire endurance testing of the innovative assemblies representing the thermally protected floor system used in the towers. The floor assembly was not tested despite the fact that the Architect of Record and the Structural Engineer of Record stated that the fire rating of this novel floor system could not be determined without testing. Prior to construction, the Architect of Record had used information from (unidentified) manufacturers to recommend a 1 in. thickness of SFRM around the top and bottom chords of the trusses and a 2 in. thickness for the web members of the trusses. This was to achieve the fire endurance requirements for Class 1A construction (Section 5.3.3). In 1969, The Port Authority directed that a 1/2 in. thick coating of

CAFCO BLAZE-SHIELD Type D (CAFCO D), a mixture of cement and asbestos fibers, be used to insulate the floor trusses. This was to achieve a Class 1A rating, even though the preponderance of evidence suggests that the towers were chosen to be Class 1B, the minimum required by the NYC Building Code. NIST found no evidence of a technical basis for selection of the 1/2 in. thickness. This coating had been installed as high as the 38 th floor of WTC 1 when its use was discontinued due to recognition of adverse health effects from inhalation of asbestos fibers. The spraying then proceeded with CAFCO DC/F, a similar product in which the asbestos was replaced by a glassy mineral fiber and whose insulating value was reported by Underwriters Laboratories, Inc., to be slightly better than that of CAFCO D. On the lower floors, the CAFCO D was encapsulated with a sprayed material that provided a hard coat to mitigate the dispersion of asbestos fibers into the air. In 1994, The Port Authority measured the SFRM thickness on trusses on floors 23 and 24 of WTC 1. In all, average thicknesses were reported for 32 locations, and the overall average thickness was found to be 0.74 in. NIST performed a further evaluation of the SFRM thickness using photographs taken in the 1990s of floor trusses on (non-upgraded) floors 22, 23, and 27 of WTC 1 (Figure 5–5). By measuring dimensions on the photographs, NIST estimated the insulation thicknesses on the diagonal web members of trusses. (The thickness of chord member insulation could not be measured.) The average thickness and standard deviation of web members was 0.6 in. ± 0.3 in. on the main trusses, 0.4 in. ± 0.25 in. on the bridging trusses, and 0.4 in. ± 0.2 in. on the diagonal struts. These numbers indicated that there were areas where the coating thickness was less than the specified 0.5 in.

P 70

Chapter 5 Draft for Public Comment 70 NIST NCSTAR 1, WTC Investigation Note: Enhancement by NIST. Figure 5–5. Irregularity of coating thickness and gaps in coverage on SFRM–coated bridging trusses. In 1995, The Port Authority performed a study to establish requirements for retrofit of sprayed insulation to the floor trusses during major alterations when tenants vacated spaces in the towers. Based on design information for fire ratings of a similar, but not identical, composite floor truss system contained in the Fire Resistance Directory published by Underwriters Laboratories, Inc., the study concluded that a 1 1/2 in. thickness of sprayed mineral fiber material would provide a 2 hour fire rating, consistent with the Class 1B requirements. In 1999, the removal of existing SFRM and the application of new material to this

thickness became Port Authority policy for full floors undergoing new construction and renovation. For tenant spaces in which only part of a floor was being modified, the SFRM needed only to be patched to 3⁄4 in. thickness or to match the 1 1⁄2 in. thickness, if it had previously been upgraded. In the years between 1995 and 2001, thermal protection was upgraded on 18 floors of WTC 1, including those on which the major fires occurred on September 11, 2001, and 13 floors of WTC 2 that did not include the fire floors. The Port Authority reported that the insulation used in the renovations was CAFCO BLAZE-SHIELD II. In July 2000, an engineering consultant to The Port Authority issued a report on the requirements of the fire resistance of the floor system of the towers. Based on calculations and risk assessment, the consultant concluded that the structural design had sufficient inherent fire performance to ensure that the fire condition was never the critical condition with respect to loading allowances. The report recommended that a 1.3 in. thickness be used for the floor trusses. In December 2000, another condition assessment concluded that the structural insulation in the towers had an adequate 1 hour rating, considering that all floors were now fitted with sprinklers. The report also noted the ongoing Port Authority program to upgrade the fire resistive material thickness to 1 1⁄2 in. in order to achieve a 2 hour fire rating. The Port Authority provided NIST with the records of measurements of SFRM thickness on upgraded floors in both towers. The average thickness and standard deviation on the main trusses was 2.5 in. ± 0.6 in. NIST analysis of several Port Authority photographs from the 1990s of the upgraded 31 st floor of WTC 1 indicated an average thickness and standard deviation on the main trusses of 1.7 in. ± 0.4 in. NIST found no statistically significant difference in the average thickness of the upgraded insulation in the two towers.

Perimeter Columns In 1966, the contractor responsible for insulating the perimeter columns proposed applying a 1 3/16 in. thick coating of CAFCO D to the three external faces (Figure 5-6) to achieve a 4 hour rating, which is a Class 1A rating requirement (1 hour more than Class 1B). NIST found evidence of a technical basis for this decision. In the construction drawings prepared by the exterior cladding contractor, the following SFRM thicknesses were specified: • 7/8 in. of vermiculite plaster on the interior face and 1 3/16 in. of CAFCO D on the other three faces. • 1⁄2 in. of vermiculite plaster on the interior surfaces of the spandrels and 1⁄2 in. of CAFCO D on the exterior surfaces. Figure 5-6. **Thermal insulation for perimeter columns.**

Vermiculite plaster had a higher thermal conductivity and thereby increased heat migration from the room air to the column steel and, thus, could keep the steel temperature at 70 °F when the temperature was 0 °F outside. In October 1969, The Port Authority provided the following instructions to the contractor applying the sprayed fire protection, in order to maintain the Class 1-A Fire Rating of the NYC Building Code: • 2 3/16 in. of CAFCO D for columns smaller than 14WF228 11 and 1 3/16 in. for columns equal to or greater than 14WF228. • 1⁄2 in. covering of CAFCO D for beams, spandrels and bar joists. NIST's review of available documents has not uncovered the reasons for selecting CAFCO fire resistive material or the technical basis for specifying 1⁄2 in. thickness of SFRM for the floor trusses. As with the trusses, CAFCO DC/F was applied to the perimeter columns above the 38 th floor of WTC 1 and all the perimeter columns in WTC 2. Core Columns and Beams Multiple approaches were used to insulate structural elements in the core: • Those core columns located in rentable and public spaces, closets, and mechanical shafts were enclosed in boxes of gypsum wallboard (and thus were inaccessible for inspection). The amount of the gypsum enclosure in contact with the column varied depending on the location of the column within the core. SFRM (CAFCO D and DC/F) was applied on those faces that were not protected by the gypsum enclosure. The thicknesses specified in the construction documents were 1 3/16 in. for the heavier columns and 2 3/16 in. for the lighter columns. • Columns located at the elevator shafts were protected using the same SFRM thicknesses. They were not enclosed and thus were accessible for routine inspections. Inspection of the columns within the elevator shaft spaces in 1993 indicated some loss of SFRM coverage. As a result, new insulation was applied to selected columns within the elevator shaft space. Information provided to NIST indicated that a different SFRM, Monokote Type 2-106, was used. Thickness measurements for columns and beams below the 45 th floor indicated average thicknesses of 0.82 in. and 0.97 in., respectively. Information from The Port Authority indicated that the minimum required thickness of the re-applied SFRM was 1⁄2 in. for the columns and 3⁄4 in. for the beams. NIST was unable to locate information from which to characterize the insulation of the core columns and beams that were not accessible. Except as noted above, once completed, the core was generally not inspected. NIST was not able to locate any post-collapse core beams or columns with sufficient insulation still attached to make pre-collapse thickness measurements.

On the selection of insulation, p 192

No technical basis was found for selecting the spray-applied fire resistive material (SFRM) used or its thickness for the large-span open-web floor trusses of the WTC towers. The assessment of the insulation thickness needed to meet the 2 hour fire rating requirement for the untested WTC floor system evolved over time: – In October 1969, The Port Authority directed the insulation contractor to apply 1/2 in. of insulation to the floor trusses. – In 1999, The Port Authority issued guidelines requiring that insulation be upgraded to 1 1/2 in. for full floors undergoing alterations. – Unrelated to the WTC buildings, an International Conference of Building Officials (ICBO) Evaluation Service report (ER-1244), re-issued June 1, 2001, using the same SFRM recommends a minimum thickness of 2 in. for "unrestrained steel joists" with "lightweight concrete" slab.

Recommendations

On major rec's p xlvii

The eight major groups of recommendations are: • Increased Structural Integrity: The standards for estimating the load effects of potential hazards (e.g., progressive collapse, wind) and the design of structural systems to mitigate the effects of those hazards should be improved to enhance structural integrity. • Enhanced Fire Resistance of Structures: The procedures and practices used to ensure the fire resistance of structures should be enhanced by improving the technical basis for construction classifications and fire resistance ratings, improving the technical basis for standard fire resistance testing methods, use of the "structural frame" approach to fire resistance ratings, and developing in-service performance requirements and conformance criteria for spray-applied fire resistive materials. • New Methods for Fire Resistance Design of Structures: The procedures and practices used in the fire resistance design of structures should be enhanced by requiring an objective that uncontrolled fires result in burnout without local or global collapse. Performance-based methods are an alternative to prescriptive design methods. This effort should include the development and evaluation of new fire resistive coating materials and technologies and evaluation of the fire performance of

conventional and high-performance structural materials. ethecal and standards barriers to the introduction of new materials and technologies should be eliminated. • Improved ?????

Appendix B: November 2004 Comments

November 22, 2004

To: The National Construction Safety Team Advisory Committee
NCST Advisory Committee
100 Bureau Drive, Stop 8610
Gaithersburg, MD 20899-8610
NCSTAC@nist.gov

From: James G. Quintiere

RE: NIST conclusions on the WTC collapse mechanism reported on October 19, 2004

The October surprise in the NIST investigation was the assertion that all of the core column insulation was knocked off by the airplane impacts. To a lesser extent, reliance on NYNJPA audit insulation data solidified the NIST assertion that the failure of the core columns, and not the trusses, were to blame for the collapses of the South and North towers. That audit information was reported by NIST to have the fire floors of the north tower with truss insulation thicknesses as an average of 2.5 inches up to 4 inches instead of the prescribed 1.5 inches.
NIST needs to produce demonstrable and clear substantive information to support this rationale for its conclusions. The core-damage theory was put forth by the Weidlinger group in the Silverstein civil suit, and I heard it expressed at a local ASME meeting over a year ago by a NIST staffer. Therefore, I think it is incumbent on NIST to explain when and how they came to this conclusion. This collapse mechanism conclusion has profound influence on the recommendations brought from this investigation. The airplane-caused column collapse theory yields significantly, and almost diametrically, opposed recommendations than the fire induced truss collapse mechanism.

NIST needs to validate its conclusion by addressing the following:

1. The NYNJPA North tower insulation data needs to be authenticated. There is a long saga on the insulation coverage of the truss assemblies, and it should not end with an audit report that contains data that are extraordinary. The claim that up to 4 inches of insulation was sprayed onto 1-inch diameter truss elements needs testimony, photographic corroboration, or other tangible evidence to establish the accuracy of this information.
2. It needs to be clearly demonstrated how the core column insulation was removed. This cannot simply be based on an assumption or an extrapolation from impact calculations. It is too important to the conclusions to have modeling as the sole basis. Sandia has been experimenting with airplane crashes into buildings. Have they been consulted for supporting information or assistance? NIST needs to live up to the Daubert-rulling in civil case law, and demonstrate a clear methodology for their conclusion that the insulation was removed.

Finally, NIST needs to clarify inconsistencies that appear in their public information to date. These inconsistencies and apparent weakness lead me to question their collapse theory, and place the collapse cause more on the lack of sufficient truss insulation.

1. NIST metallurgical analyses show no core columns from the fire floors reached temperatures above 250 C. It is claimed that this information is consistent with computer modeling. Moreover, I was pleased to see that after many inquiries for microscopic analysis of the steel debris, it was done and reported in the October briefing. The importance of forensic evidence to document the temperatures reached of the steel cannot be overlooked. First, its consistency with the modeling has little significance since the modeling cannot have that level of detailed accuracy precise fire effects around the core columns. Secondly, the core column theory requires that the columns got sufficiently hot, say 500 C, and tangible evidence from metallurgical analysis is crucial in supporting the NIST conclusion. Unfortunately, that evidence has not been found by NIST. Thirdly, as a consequence, this crucial lack of evidence must indict the selling of the WTC steel debris before an investigation could be launched. Will NIST speak to this as they now have future investigative authority?

2. NIST computations show that floor truss assemblies can fail at temperature measured in the UL tests. UL fire tests showed for ½ and ¾-inch insulation that steel truss temperatures exceeded 1300 F (704 C) in roughly 58 minutes and 62-76 minutes, respectively. They reached average temperatures of 1110 F (593 C) in 66 and 66-86 minutes, respectively. My own data with Isolatek indicate that individual web elements can reach 593 C in about 35 to 50 minutes, respectively for ½ and ¾ inches. NIST's model for a single WTC truss (which is more accurate than the impact computations), predicts a truss would fail at the column connections at these temperatures. The NIST model for a single truss and its connection shows that the truss fails at the interior column seat connection, and 'walks off' the seat. This occurs at 650 C. The web diagonals begin to buckle at 340 C, and the exterior columns bow inward at 560 C because the truss acts as a catenary. Other independent work done by Usmani et al, and Burgess et al., show similar results. If one floor falls on the floor below while both are heated by fire, can the impacted floor carry the load? Is this a plausible global collapse mechanism? To me, this means that truss failure is likely, at least in the South tower; and in the North if the PA audit data are wrong. Collapses of the floors were seen in both of the towers well up to 20 minutes before the buildings collapsed. This indicates the presence of the floor collapse mechanism.

   Incidently, the NIST scaling criterion used for the ½-scaling in the UL tests should be examined, as it is thermally not to scale. The shorter truss members will cause lower temperatures as the web transfers heat into the concrete floor.

3. NIST has relied on state-of-the-art computer models that are at the forefront of their technologies. However, these models have not been proven comprehensively for less complex incidents than the WTC. Will NIST continue to invest in these modeling technologies, or are they proven and ready for general use? If they are ready, will NIST advocate their use in design, or will NIST continue to perform research to improve them? If the latter is true, will NIST articulate the uncertain aspects of the modeling, and comment on how they bear on the investigation's conclusions?

4. NIST has used workstations fire experiments as a basis for their modeling. The stated fuel load is 4 lbs/ft^2 and this loading has been questioned, as it appears very low in the spectrum of office loadings. Because our students are conducting a scale model experiment of the 96th floor of the North tower, it forced us to examine this loading. While we could not pursue our information in depth, I can relate some major concerns. NIST experimental photographs of the office modules show little paper, and NIST has told me that the paper load was reported as light. I was told by a WTC inspector that the load was heavy, storage areas were overloaded and floors were continually cited for having paper stacked on the window sills; a furniture installer of the Marsh floors gave me information that showed extensive file cabinets surrounding the cubicles and these were not included in the NIST fire experiments – he, too, said that the Marsh office spaces were heavy in paper; an anonymous Marsh employee said that the Marsh company were paper "hogs", and a family member said it was heavy as well. The fuel loading is crucial to the duration and the temperatures of the fires. A light fuel load in the modeling will lead to low temperatures and this would affect the overall results.

It is imperative that NIST get the cause of the WTC tower collapses correct. The legacy of its victims bears on future fire safety. The protection of buildings in fire and terrorists attacks will be impacted by these conclusions, so they need to be right. The Advisory Panel plays a clear role to sign off on these conclusions. I know of others that feel the NIST conclusions need, in the least, clarity, and in the main, more support. However, we are few in number, and it falls on you to insure the public that they got it right.

<u>Recommendations</u> that should come from this study are submitted in no priority order as suggestions for your consideration:

1. Experimental studies to establish temperatures and fire duration characteristic of modern facilities including office large plan spaces, places assembly, and underground structures should be undertaken to validate models and establish design methods. The current correlations are incomplete in terms of fuel type and building type.

2. The standard time-temperature structural fire tests should be examined in light of computational methods. Data for the tests yielding temperature and deflection should be integrated with computations to extrapolate to actual assemblies used in practice.
3. Sensor technologies integrated with alarm monitoring for building performance should be integrated into the emergency response network for assessing the nature of the hazard.
4. Forensic techniques and standards should be established to assess failure information from structural debris. The elimination of the steel structure from the WTC site should be fully addressed, and its consequences fully stated.
5. Fire and disaster planning should include full and proper analyses for safe egress and effective response. Responders and building planners need to have the benefit of analyses that quantitatively address these facets. Real time modeling of the fire effects based on sensor information are possible and should be integrated into special building designs and response actions.
6. Novel techniques need to be investigated to rescue people and to fight high-rise fires.
7. Current codes weaknesses, in light the WTC collapses, need to be fully addressed. Issues of lightweight construction designs that are vulnerable to catastrophic collapse of a structure need particular attention.
8. A nationally supported infrastructure is needed to insure that objective scientific input is placed into the code consensus process to bring fire safety to a proper level of engineering analyses. The current code process is lacking in scientific underpinning, and the WTC disaster should stand for change in this direction, especially if the scientific community cannot render a clear and decisive verdict.

October Review:

Review of NIST WTC Investigation
Addressing Tasks 3, 5 and 6.

J. G. Quintiere
September 11, 2004

Modified October 17, 2004

The following constitutes the NIST projects designed to reach the objective of the investigation.

NIST Projects: Federal building and fire safety investigation of the WTC disaster

Project No./Technical Area /Project Purpose

1. Analysis of Building and Fire Codes and Practices
    a. Document and analyze the code provisions, procedures, and practices used in the design, construction, operation, and maintenance of the structural, passive fire protection, and emergency access and evacuation systems of the WTC 1, 2, and 7.
2. Baseline Structural Performance and Aircraft Impact Damage Analysis
    a. Analyze the baseline performance of WTC 1 and 2 under design, service, and abnormal loads, and aircraft impact damage on the structural, fire protection, and egress systems.
3. Mechanical and Metallurgical Analysis of Structural Steel
    a. Determine and analyze the mechanical and metallurgical properties
4. Investigation of Active Fire-Protection Systems
    a. Investigate the performance of the active fire protection systems in WTC 1, 2, and 7 and their role in fire control, emergency response, and fate of occupants and responders.
5. Reconstruction of Thermal and Tenability Environment
    a. Reconstruct the time-evolving temperature, thermal environment, and smoke movement in WTC 1, 2, and 7 for use in evaluating the structural performance of the buildings and behavior and fate of occupants and responders.
6. Structural Fire Response and Collapse Analysis
    a. Analyze the response of the WTC towers to fires with and without aircraft damage, the response of WTC 7 in fires, the performance of open-web steel joists,

and determine the most probable structural collapse sequence for WTC 1, 2, and 7.

7. Occupant Behavior, Egress, and Emergency Communications
   a. Analyze the behavior and fate of occupants and responders, both those who survived and those who did not, and the performance of the evacuation system.
8. Fire Service Technologies and Guidelines
   a. Building on work done by the Fire Department of New York and McKinsey & Company, document what happened during the response by the fire services to the WTC attacks until the collapse of WTC 7;
   b. identify issues that need to be addressed in changes to practice, standards, and codes;
   c. identify alternative practices and/or technologies that may address these issues; and
   d. identify research and development needs that advance the safety of the fire service in responding to massive fires in tall buildings.

The NIST investigation objectives are:

1. To determine (a) why and how the WTC 1 and WTC 2 collapsed following the initial impact of the aircraft, and (b) why and how the 47-story WTC 7 collapsed.

2. To determine why the loss of life and injuries were so low or so high depending on location, including technical aspects of fire protection, occupant behavior, evacuation, and emergency response.

3. To determine the procedures and practices which were used in the design, construction, operation, and maintenance of the WTC buildings.

4. To identify, as specifically as possible, areas in national building and fire codes, standards, and practices that warrant revision.

Among the **specific questions that NIST is investigating** within the above four objectives are the following:

- How and why did WTC 1 stand nearly twice as long as WTC 2 before collapsing (103 min versus 56 min), though they were hit by virtually identical aircraft?
- What factors related to normal building and fire safety considerations not unique to the terrorist attacks of September 11, 2001, if any, could have delayed or prevented the collapse of the WTC towers?
- Would the undamaged WTC towers have remained standing in a normal major building fire?
- What factors related to normal building and fire safety considerations, if any, could have saved additional WTC occupant lives or could have minimized the loss of life among the ranks of first responders on September 11, 2001?
- How well did the procedures and practices used in the design, construction, operation, and maintenance of the WTC buildings conform to accepted national practices, standards, and codes?

I will address Tasks 3, 5 and 6 in the format indicated below:

Issue for the project
Approach taken by NIST
Questions on the Approach
Comments on ability to address objectives

3. Mechanical and Metallurgical Analysis of Structural Steel

Objective: Determine and analyze the mechanical and metallurgical properties

Issue

NIST has established the mechanical and thermal properties of the steel used in the WTC, and generally has found no remarkable departures from the literature for steel. However, an important aspect of this fire and large fires in general is the temperature reached by the fire, and that achieved by the steel.

NIST approach

In the December 2003 Public Update it states that part of this task objective is "estimating the maximum temperature reached by available steel" (p.8). In the May 2003 (p. 33) and June 2004 Vol. 1, p. 87), it appears that this objective is being done by examining paint degradation at 250 and 750 C.

Questions

A common forensic technique for determining the temperature reached by steel in a fire is to microscopically examine the grain size. It has been said that very precise determinations can be made if compared to an unheated similar steel sample. Why has NIST not used this method?

Comments

The importance of knowing the temperature achieved by the steel on the fire floors is crucial to establishing the cause of the buildings collapse. This is like a thermometer in the building, so its significance cannot be overlooked. The temperature of the fire and the steel are important in determining the time and the nature of the collapse of the buildings. NIST is using computational methods to predict these temperatures. It is incumbent on NIST to use all methods for ascertaining the steel temperatures to achieve confirmation of its predictions.

Also, NIST has steel samples salvaged from the dumpsite, and has said those samples were adequate. NYC made a unilateral decision to remove and sell the steel before the NIST investigation began. What is the NIST recommendation on how to preserve evidence in future investigations in order to render complete structural and thermal analysis to the debris samples? Was the steel prematurely discarded in the WTC before adequate analysis could occur?

5. Reconstruction of Thermal and Tenability Environment

Objective: Reconstruct the time-evolving temperature, thermal environment, and smoke movement in WTC 1, 2, and 7 for use in evaluating the structural performance of the buildings and behavior and fate of occupants and responders.

Issue

The accuracy of the computer modeling predictions for the fire environment need to be assessed, and their consistency with literature data for fully developed fires and with the factual evidence of the WTC fires needs addressing. A computation of this magnitude is beyond the state of the art for fire modeling, and although NIST and the investigators should be commended for their efforts at pushing the state of the art, they must not solely rely on computer-driven computations for estimating the fire temperatures. They have other sources from which to also draw information on the state of the fire: They include: conducted fire tests, correlations for fully developed fires in the literature, data on window breakage and the fire progress, and people reaction to the fire heat and smoke from potential interviews. Consistency must be assessed between the various sources of information and from alternative, albeit, simpler computational methods.

NIST Approach

Information about the fire can come from several sources. NIST has extensively examined and compiled the fire behavior and its effect on the building through the correlation of various photographic evidence. This task has been done with excellence it appears, and should offer valuable information. Another source of fire could come from the collection of data from people. This appears to have lagged and it is not clear that anything of value in a timely manner will be reported on the fire and damage effects observed directly by people and ascertained through interviews. In all of the fire predictions NIST has chosen to use its Fire Dynamics Simulator (FDS) as the sole computational tool. In order to evaluate its accuracy, experiments have been conducted on small features of the WTC office occupancies in order to calibrate and

assess the accuracy of the fire predictions. Hence, both the modeling and the experimental data offer information on the WTC fires. As with other aspects of the investigation, NIST appears to be weighting the computational approach as their primary result, especially since that result must be supplied to the structural modelers in order to make their prediction of the building's ability to carry its load.

NIST has approached the validation effort by conducting two series of tests. The first series consisted of a spray fuel fire in a compartment containing structural members. The second involved a larger compartment containing three workstations that NIST decided were representative of the WTC offices. That fuel load is roughly 4 lb/ft^2 (psf) (or about 20 kg/m^2 and 50 MJ/m^2), June 2004 Vol. 1, p xxxvii, Vol. 5, J-37.

Series 1 consisted of the following (June 2004 Vol. 5, J-2):

> The test compartment consisted of a steel stud frame lined with calcium silicate board. The internal dimensions of the compartment were 3 m high, 7 m deep, and 4 m wide. There were four openings in the west wall through which air entered the room; they totaled 1.75 m 2 (10.8 ft^2) in area and were located 1 m (3.3 ft) above the floor. There were four openings in the east wall through which heat and combustion products were emitted; they also totaled 1.75 m^2 (10.8 ft^2) in area and were located 2 m above the floor. In each of the six tests, the four test subjects were a bar, two trusses, and a thin-walled tubular column. Depending on the test, these specimens were either left unprotected or were coated with spray-applied fire protective insulation material, Blaze Shield DC/F. The fibrous insulation was applied by an experienced applicator who took considerable care to apply an even coating of the specified thickness. As such, the insulated test subjects represent a best case in terms of thickness and uniformity. The fires consisted of liquid hydrocarbon fuels sprayed by a two-nozzle spray burner onto a 1 m × 2 m (3.3 ft × 6.6 ft) pan. The fuels were (a) heptanes and (b) a mixture of nominally 60 percent (by mass) heptanes with 40 percent toluene. The latter fuel produced a significantly sootier flame.

Six tests were done. The instrumentation for the tests comprised up to 352 channels of data.

Series 2 consisted of 3 workstations in a large room (June 2004, Vol. 5, J-27):

Six experiments were designed to assess the accuracy with which FDS predicts the fire spread, heat release rate, and thermal environment in a compartment burning multiple workstations in a configuration characteristic of that found in the WTC buildings. In each of these experiments, sets of three workstations were burned in a large compartment (about 11 m x 7 m x 3.4 m high). The challenges to the model included varying the location of the ignition burner (and thus the fire ventilation), adding jet fuel and/or noncombustible material occluding a fraction of the workstations' surfaces, and "rubblizing" the workstations.

It should be noted that the workstation fuel load was "suggested by personnel from a company that supplied office furnishings to the occupants of WTC 1. Information on the distribution of papers and other office items was provided by a frequent visitor to these offices". (p J-12)

NIST performed some additional computations based on FDS. They have early on reported on the smoke dynamics from the building (Rehm et al., IAFSS 2002), and recently on the fireball dynamics (Baum, Comb. Inst., 2004). These are considered somewhat ancillary to the prediction of the fire conditions on the floors that bear directly on the heating of the structure and the effect of the fire on the ultimate collapse. However, the work by Prasad and Baum (Comb. Inst. 2004) on linking the predictions of FDS for the fire with the heating of core columns under different core damage scenarios is very significant. It is the closure of the fire and the structure modeling that is critical to answering the issues pertaining to collapse. McGrattan has simulated the fires on a floor based on the workstation fuel load. That loading was indicated at about 4 pounds per square ft of office space (psf). McGrattan indicates the fire at this low fuel loading burn in an under-ventilated state as "oxygen consumed drives fires to the windows" (p. J-44). In addition, these full-scale WTC computer simulations are reported to for about 20 minutes in a region and then move on with an entire floor burning out in about 1 hour (Fact Sheet June 2004 pp. 2, 3).

Also it was indicated that these simulated fire burn at an average temperature over the floor at about 600 C.

Questions

It is well known that FDS results depend on the grid size and its scaling to the fire conditions. The experiments done by NIST may well serve the credibility and accuracy of using FDS with a grid size of 40 cm, but enough comparison has not been shown between the computations and the experiments. Only about 4 or 5 plots have been presented for comparison in the reports, and they show very good prediction for the fire gas temperatures and heat release rate. Some of NIST's own funded work (Ierardi and Barnett, 2003) have shown that the accuracy of predicting a single fire plume from a 30 cm burner give drastic variations in temperatures with the fire plume for grids of 1.5 to 15 cm. Temperatures within 20 per cent of the experiment results required grids of 1.5 to 5 cm. So it is incumbent on NIST to address this accuracy question completely. They have done 13 experiments with over 300 measuring stations in each test. In the least, NIST needs to demonstrate the ability of FDS to compute all aspects that FDS has in common with these measurements.

The issue of accuracy for computer models is a serious matter when they are to be used as general engineering tools. The literature is filled with data and correlations for fully develop fires. NIST should at least demonstrate how its approach using FDS compares to these other empirical approaches in the literature. Japan uses one of these empirical approaches as a design method in regulations, and the SFPE has just completed a guide on the prediction of fire conditions for structural considerations. It has been said that the full WTC floor simulation agree with the phenomenon observed by (I. Thomas et al.) in which the fire moves about the compartment seeking air. Can FDS predict the data of Thomas? These questions are broader that the effort that has gone into the WTC simulation, and therefore it would be important for NIST to examine FDS in light of its validation needs. Moreover, FDS is using a charring model to compute the burning rate and flame spread on the workstations, and NIST should state the accuracy of using FDS for the prediction of flame spread on charring materials. Boeing would not take the use of CFD models in its aircraft design lightly, and neither should those assessing fire behavior, especially from NIST.

The fuel load selected in the representative experiments and the modeling raises some questions. NIST is using roughly 4 psf, and a floor burns for an average of about 1 hour (Key Findings of NIST's June 2004 Progress Report...). This selection of loading is critical to establishing the burning time, crucial to predicting the impact of fire on the structure. The literature (Robertson and Gross, ASTM STP 464, 1970) suggests an average office load of 18.4 psf, ranging from 7 to 43 psf according to surveys. Why is the WTC representative office so low? This needs examining and supportive data.

The FDS simulations indicate a one-hour burning period for a floor at 600 C. This may be due to the light fuel, but appears inconsistent with the under-ventilated burning achieved in the simulation. Also the actual fires appear to have burned longer with WTC burning until collapse at 103 minutes. Finally, the average temperature of 600 C is about coincident with critical failure temperature associated with steel structures, and would never allow the steel to reach this temperature.

In an investigation where information comes in different forms, the final analysis must show that the information pieces are consistent. NIST has observational information, hopefully people information, experimental test information, and the FDS simulations. These must be shown to be consistent.

Ultimately FDS results must be linked to a structural model. Prasad and Baum (C.I. 2004) have attempted this for the heating of the core columns. They show that simplifications need to be made in representing the FDS temperature spatial distributions in order to better interface with the structural heating model. Their approach has demonstrated the needed closure of the fire and structural heating. However, they have not considered the vulnerable floor assembly in their calculations. This will need to be added to fully assess the role of the fire on the complete structure. NIST has not made clear how the fire and structural computations will come together, particularly since the structural modeling is being done under contract. We would like to see NIST speak to the accuracy and issues related to the modeling of the fire and structure together.

Since NIST has test data on the heating of insulated structural members in their fire tests, some comparisons, at least, need to be presented for these simpler fire scenarios.

Can NIST successfully modeling the 1975 WTC fire (June 2004, Vol. 4, G-1) that did extensive damage to a floor? This fire prompted the use of sprinklers, and local structural damage occurred. Since the damage and extent of the fire was known, it could be a useful benchmark for NIST to compare their simulations.

Comments

The fire computations are perhaps the most important determination since its heating impact and its duration determine the ultimate temperature of the protected steel. The heat transfer by conduction into the insulation and the steel is trivial by comparison. Also when it realized that failure in furnace testing of structures is often based on steel temperature, and temperature strongly affects the strength of steel, e.g. the modulus of elasticity is reduced by 50 % when steel attains about 600 C. Since the modulus is directly related to the critical load to cause buckling, the buckling of elements in compression can occur more easily at elevated temperatures. The ability of the fire modeling to relate to the structural heating model is very import step in this investigation. NIST should make this step as transparent as possible in order to judge its conclusions. FDS will yield a spatial and time varying temperature throughout a floor. Its accuracy needs to be supported at this level of sophistication. Alternative estimates on the level of temperature and its duration might need to be couched in simpler forms for the best structural analysis to be produced. It might serve just as well to specify uniform temperature in a range. The duration will depend on the fuel load, and it has been pointed out that the NIST selected load is very low compared to office load surveys. Some variation of uncertainty must be considered here.

Finally, it appears almost foolish to have received $16 million for the investigation and to not have conducted a test more representative of a WTC floor. A quarter of a floor could have been tested for fire and the heating of the structure. It would only involve a plan space at 100 x 100 feet. This could have settled many issues. Especially when it is realized that no experimental results exist for compartments with small ratios of height to their lateral dimension as 1/20 in the

WTC. The smallest has been ¼ in the well known CIB studies, and those results should be examined by NIST for their applicability. However, the interaction of air from the perimeter and fuel within the compartment need to be examined under these conditions by an experiment, to at least see if FDS is qualitatively correct. Moreover, it is known that in large fire plumes that smoke can trap radiation and drive the core fire temperatures to 1300 C and more. This can happen at fires of 30 ft in diameter, so the question must be raised if this might apply to the WTC with lateral floor dimensions of 200 ft.

6. Structural Fire Response and Collapse Analysis

Objective: Analyze the response of the WTC towers to fires with and without aircraft damage, the response of WTC 7 in fires, the performance of open-web steel joists, and determine the most probable structural collapse sequence for WTC 1, 2, and 7.

Issue

The principal issue here is to examine the NIST working hypothesis in conjunction with its collection of findings and to assess their consistency. The working hypothesis is found in June 2004 Vol. 6, Q-3.

> The working hypothesis addresses the following chronological sequence of major events; specific load redistribution paths and damage scenarios are currently under analysis:
>
> 1. Aircraft impact damage to perimeter columns with redistribution of column loads to adjacent perimeter columns and to the core columns via the hat truss;
> 2. After breaching the building's exterior, the aircraft continued to penetrate into the buildings, damaging core columns with redistribution of column loads to other intact core and perimeter columns via the hat truss and floor systems;
> 3. The subsequent fires, influenced by post-impact condition of the fireproofing, further weakened columns and floor systems (including those that had been damaged by aircraft impact), triggering additional local failures that ultimately led to column instability;

4. Initiation and horizontal progression of column instability ensued when redistributing loads could not be accommodated any further. The collapses then ensued.

NIST Approach

NIST and its contractors are using computational analyses to compute the impact damage by the aircrafts, the performance of a single floor truss under temperature elevation, the evaluation of a portion of the floor assembly in the ASTM E 119 test, and the history of the insulation applied in the WTC, especially to the floor assembly.

2. Impact computations: These computations are portrayed in figures on pp 78-79 of June 2004, Vol. 1, and they show an engine impacting and shredding a floor and then buckling a core column.

NIST reports further (June 2004, Vol. 1, p 81):

• A 500 mph engine impact against an exterior wall panel results in a penetration of the exterior wall and failure of impacted exterior columns. If the engine does not impact a floor slab, the majority of the engine core will remain intact through the exterior wall penetration with a reduction in velocity of about 10 percent and 20 percent. The residual

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

> velocity and mass of the engine after penetration of the exterior wall is sufficient to fail a core column in a direct impact condition. Interaction with additional interior building contents prior to impact or a misaligned impact against the core column could change this result.

Also an analysis of the stability of the towers, assuming no damage to the core, gives the number of floors that need to be removed to cause global failure (June 2004, Vol. 1, p.81):

The following presents some preliminary findings obtained from the preliminary stability analyses under service live loads and subject to the assumptions and the limitations of these models (see Appendix D): Linear stability analysis was used to examine the stability of the undamaged WTC 1 under service loads through increased un-braced column lengths (floor removal). The tower was stable when two floors were removed. Two core columns buckled when three floors were removed, but the tower maintained its overall stability. The tower also maintained its stability when four columns buckled with four floors removed. The analysis suggested that global instability of the tower occurred when five floors were removed from the model. Assuming that all columns at the region of the removed floors reached a temperature of 600 °C (reduced modulus of elasticity), the analysis indicates that removal of four floors would induce global instability.

3. <u>Single truss analysis</u>: A model of a single truss and its connection shows that the truss fails at the interior column seat connection, and 'walks off' the seat. This occurs at 650 C. The web diagonals begin to buckle at 340 C, and the exterior columns bow inward at 560 C because the truss begins to act as a catenary. (June 2004, Vol. 1 p. 120).

4. <u>E 119 tests</u>: Standard fire tests were conducted at UL. Two were done at a 35 ft span representing the short span in the WTC towers. These had ¾ in. thickness of insulation applied. A third test was conducted with public viewing with ½ in. insulation, and at a span of 17 ft. In that test the truss was scaled –down so that it was half its depth. The failure criterion used was primarily structural integrity for the most part. The third test was conducted *restrained* and obtained a 2 hour restrained rating meaning it did not structurally collapse, and it obtained a 1 hour unrestrained rating which results from exceeding a critical temperature of the steel.

5. <u>Insulations history:</u> NIST has traced documents and recommendations related to the thickness of insulation, particularly on the floor joist assembly. They have found and stated the following:
   a. The truss specified thickness was 0.5 in., but as applied was 0.6 +/- 0.3 inch.

b. The upgraded truss insulation was 1.5 inches (based on UL G805, May 2003, p. 78), but was later measured in application as 1.7 +/- 0.4 inches based on photographic analysis, but was reported in audit documents over 1997 to 1999 as 2.5 +/0.6 inches, with thickness as high as 4 inches (June 2004, Vol. 4, I 15-18).
c. A model code recommended 2 inches for 2 hours in a 2001 assessment of a similar truss (June 2004).
d. A report by Burro-Happold recommended in 2001 that the upgraded insulation could be dropped to 0.5 inches based on an ambient value of the conductivity used in a calculation, but settled on a recommendation of 1.3 inches. (May 2003, p. 82)

Questions

Column impact: It is very important to determine an accurate estimate of the core column damage. In view of the variability of the impact computer codes, what does NIST consider is their accuracy? It was reported by the NY Times that the Weidlinger computations indicated that the South tower would fall solely upon impact of the aircraft. It is know that calculations were made in 1966 that indicated only local damage would occur. Why is there so much variability in these computations? In addition, the NIST reported results indicate that an engine needs to directly strike a core without loss of momentum for the column to fail. This would suggest very limited core column damage is possible as might be inferred from the NIST computational graphic shown above. Can an engine possibly hit a core column without hitting anything on the floor occupancy and structure? That does not seem possible, so how can an engine damage a core column? Perhaps I am missing something. Why is NIST then considering in its "working hypothesis" that considerable core damage is likely? Moreover, it is known that landing gear and at least one engine was found in the surrounding streets suggesting a flight path through the building. Can NIST use information on the location of the engines to assess the likelihood of core column damage?

Temperature importance for floor failure: The single truss analysis done by NIST and the work done both Usmani et al, and Burgess et al., indicate that the truss deflections occur at temperatures ranging from roughly 400 to 600 C. During these deflections, the truss can cause failure to its connections, or to column instability. It would seem that temperature is a key feature

in causing failure. How does NIST relate its work to those cited above in the literature? If one floor falls on the floor below while both are heated by fire, can the impacted floor carry the load? Will this be a mode of global collapse? NIST considers the number of floors to be removed before the columns would become unstable, but would not the loss of 2 or 3-floors cause the failure before this instability? Is a critical temperature a good measure of structural failure as it might appear from the element computations, and the implication of the loss in strength at elevated temperatures?

Role of E119: Ratings have been achieved at UL for the E-119 test. Will NIST be analyzing these results to see how they would apply to the WTC? If the temperatures reached by the steel in these tests is sufficient to cause failures in the WTC computations, but the structure did not fall in the E 119 test, how will NIST reconcile these differences? NIST scaled the depth of the truss to ½ full-scale in its 17 ft E 119 test. This was done for stress purposes, but the heat transfer along the web into the concrete deck is now changed. Since temperature is a criterion for failure of the test in some modes of testing, the temperature of particularly the full-scale 35 ft. truss should be examined. Moreover, as UL G805 was used for justifying the 1.5-inch insulation thickness, why would the recent tests give such different results? Also UL N 826 might have been more appropriate, and gives 2 1/16 inches. So what is the meaning of the E 119 test and how should it be used in this WTC analysis?

Reconciliation of insulation thicknesses: As seen by the various E 119 results for the Cafco insulation, and the varied specifications and recommendations on the WTC truss insulation, it is incumbent on NIST give some rationality to these variations. Since the amount of insulation is so crucial to the outcome of finding the cause, NIST needs to be very sure about how much insulation was actually in place. The latest information from PANYNJ indicates that the upgrade in WTC 1 could have been as much as 4 inches over the 1.5 specification, when field workers were having difficulties in application, and that was the main reason for the Burro-Happold report. A 4-inch radius on a 1 inch steel rod would give a 9-inch diameter cylinder – a very big result. How much confidence does NIST have on these large amounts? Do they have photographic evidence as in the previous smaller amounts? Would not a hearing on the insulation thickness issues serve NIST well in documenting the facts and rationality of these

variations? If so much variation occurred for the WTC, how does this relate to the protection in other buildings?

Comments

It appears that NIST has to answer some very focused questions with clarity and accuracy.

1. How many core columns were removed and why?
2. How much insulation was in place during the fire?
3. What are the critical temperatures needed for failure?
4. Could the fire cause these temperatures?

The global collapse mechanism of the buildings must be made as clear as possible. A vague answer expressed by the current NIST working hypothesis is not sufficient. NIST has expended a lot of good individual effort, and it has done some very good fact finding and analyses. Now all of that has to be put together, and it seems contractors (who we have not heard from) play a significant role. NIST needs to harness those individual efforts and expertise in a balanced evaluation. Reliance solely on complex computer models should not be the sole basis of the answers. If the core of the answers are really revealed and understood, NIST should be able to explain them in simple fundamental physics, and not shroud them in computer graphics. This was the purpose of the investigation, and this project task is critical.

Appendix C:

Analysis of the Fuel Load Calculations for the 96th Floor of the WTC North Tower

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April 2005
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Abstract

An impartial examination into the combustible fuel load for the 96th floor of the North World Trade tower is described in this paper.

Introduction

The dimensions used for analysis of the WTC North tower are as follows, the overall building dimensions are 207.2' x 207.2' = 42,932 ft^2 (3988.5 m^2), building core dimensions are 87' x 137' =11,919 ft^2 (1107.3 m^2), and the area that office equipment sits on is therefore 31,013 ft^2 (2881.2 m^2), while FEMA reports that area for office furniture is 30,930 ft^2 (2,873.5 m^2) [1].

Typical structural live loads used in design or analysis for offices are 50 psf (pounds per square foot) (244.35 kg/m^2), and for lobbies, 100 psf (488.7 kg/m^2).

The paperweight found in the Marsh & Mc Lennan office is significant because it directly impacts the fire size/duration, which in turn, affects results obtained for performance of structural members.

UMCP considerations and examination:

- The cabinets used by NIST contained two reams of packed paper, which is not consistent with the files that I weighed. The significance is that the tighter the packed paper is, the less air can get in to feed the fire whereas, typical files are not uniform in size or spacing and leave room for air to supply the fire.
- The following are graphical representations of the difference between the paper weight not included (NIST) and the total weight inclusion (UMCP):

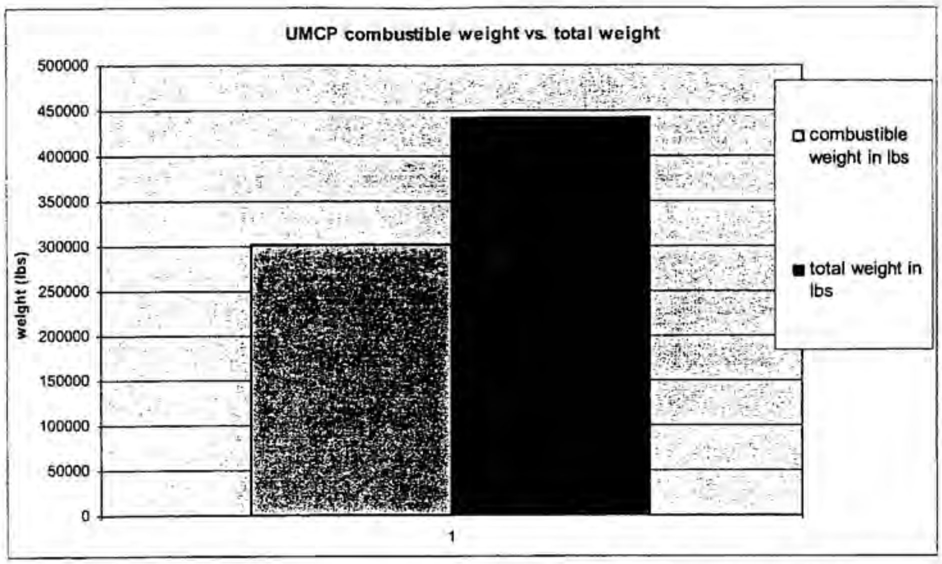

Figure 1. UMCP estimate of how the total workstation weight is distributed.

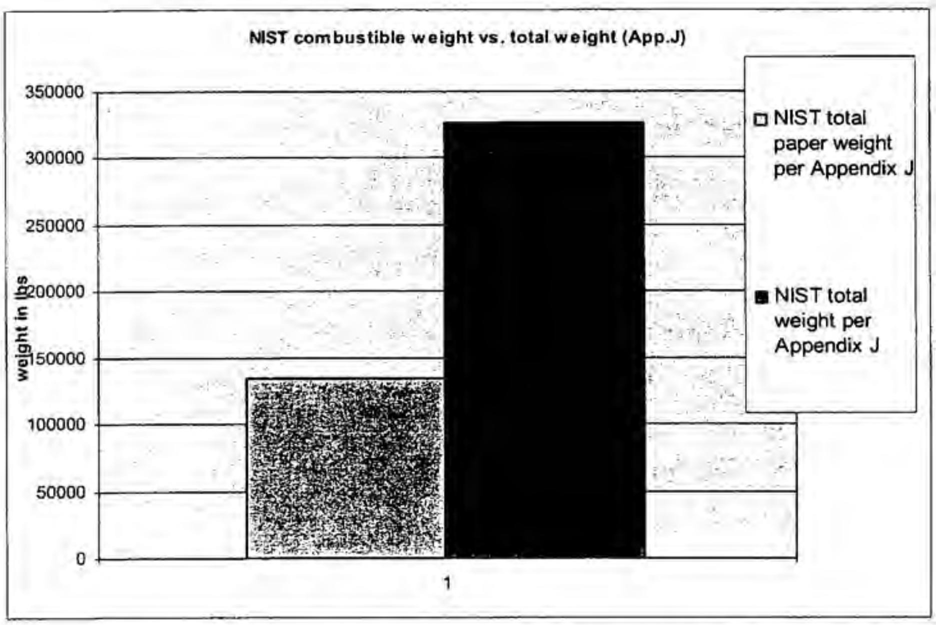

Figure 2. NIST estimate of how the total workstation weight is distributed.

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Summary of results from NIST

- The book case, which was 48" high (1.22m), was stuffed with 10 boxes containing 13 reams of copier paper (260 lb ~ 118 kg).
- Total workstation weight considered to be 1600 pounds (726 kg) and the amount of combustible material contained in that workstation was estimated as 660 pounds (300 kg) by NIST. Based on the information obtained in these simulations, McGrattan then passed the FDS results onto others who analyzed the temperature of the steel and concrete [2].
- NIST used a per desk weight rather than obtaining combustibles for the entire floor and attributing that to their experiments. However, in the impact zone, there are two conference rooms (~1,590 lbs (721 kg) of combustible materials), 8 sets of four drawer lateral files (48 cabinets=192 drawers~13,824 lbs (6270.5 kg) (of paper that was likely dislodged by the impact) and the paper storage area (~28,000 lbs (12,701 kg) of paper & paper/office products) that directly contribute to the initial fire started by the jet fuel.

Information obtained from FEMA

- Estimated combustible fuel load as 8 psf.
- Additionally, the report acknowledges that typical office loading is 50 psf, per Load Resistance Factored Design published by American Society of Civil Engineers. (50*31013=1,550,650 lbs (7,577,988 kg) live load- i.e. combustible and non-combustible materials)

Methodology used for this examination

- The assumptions made for this project are as follows:
  1. That the symbols had not changed for the Knoll furniture between those used in 1997 and those used today.
  2. Veneer panels close in weight to panels used by NIST.
  3. Used FEMA building and core dimensions and assumed NIST did the same.
  4. Based on NIST drawing, I counted 204 workstations but according to plans from Dr. Quintiere, there were 210 workstations. I used 210 workstations.

5. Estimated that there were 20 units of five shelf storage files by the stairwell area. Each unit was determined to have dimensions 63" high x 36" wide (1.6 m x 0.9 m) and it was assumed that items were stored on top of the shelving units.
6. One Calibre cabinet held 15 lbs ~ 6.8 kg (of contents and one 3-drawer pedestal contained one paper file with 17" (0.4 m) of file storage (24 lbs ~ 10.9 kg of paper weight).
7. Southeast corner of building plan did not photocopy well therefore assumptions were made consistent with other corners of the 96th floor layout.

- The approximations made are as follows:
  1. The weights for chair models that were not found in the symbol library (perhaps not manufactured by Knoll), like "CH6", were estimated based on other known chair weights.
  2. Wall panels and workstation layout based on information provided by NIST [3]: (5) 4'panels-36"wide, (1) 5' panel-36"wide and (5) 4' panels-24"wide. In SI units: (5) 1.2 m panels- 0.91 m wide, (1) 1.5 m panel- 0.91 m wide, and (5) 1.2 m panels-0.61 m. The two foot panel weights were estimated using 10.55 lbs (4.8 kg) per foot of height.
  3. Based on files weighed in the ENFP office, an average file weight was obtained of 2 lbs/inch using standard paper size, type 20 wt.
  4. Only desks that could be positively identified as having a computer were given 'credit' for one (i.e. 165 computers for 210 workstations)
  5. Trapezoidal conference room table weight was estimated based on locating it once in AutoCAD, noting that there were several sizes, and then not being able to locate the table again.
  6. Knoll representative did not want to be quoted on specific amounts of combustible material in furniture.
  7. A request of the Manufacturer must be made in order for the privacy panels to be chemically treated to meet ASTM E-84 class "A" flame spread rating.

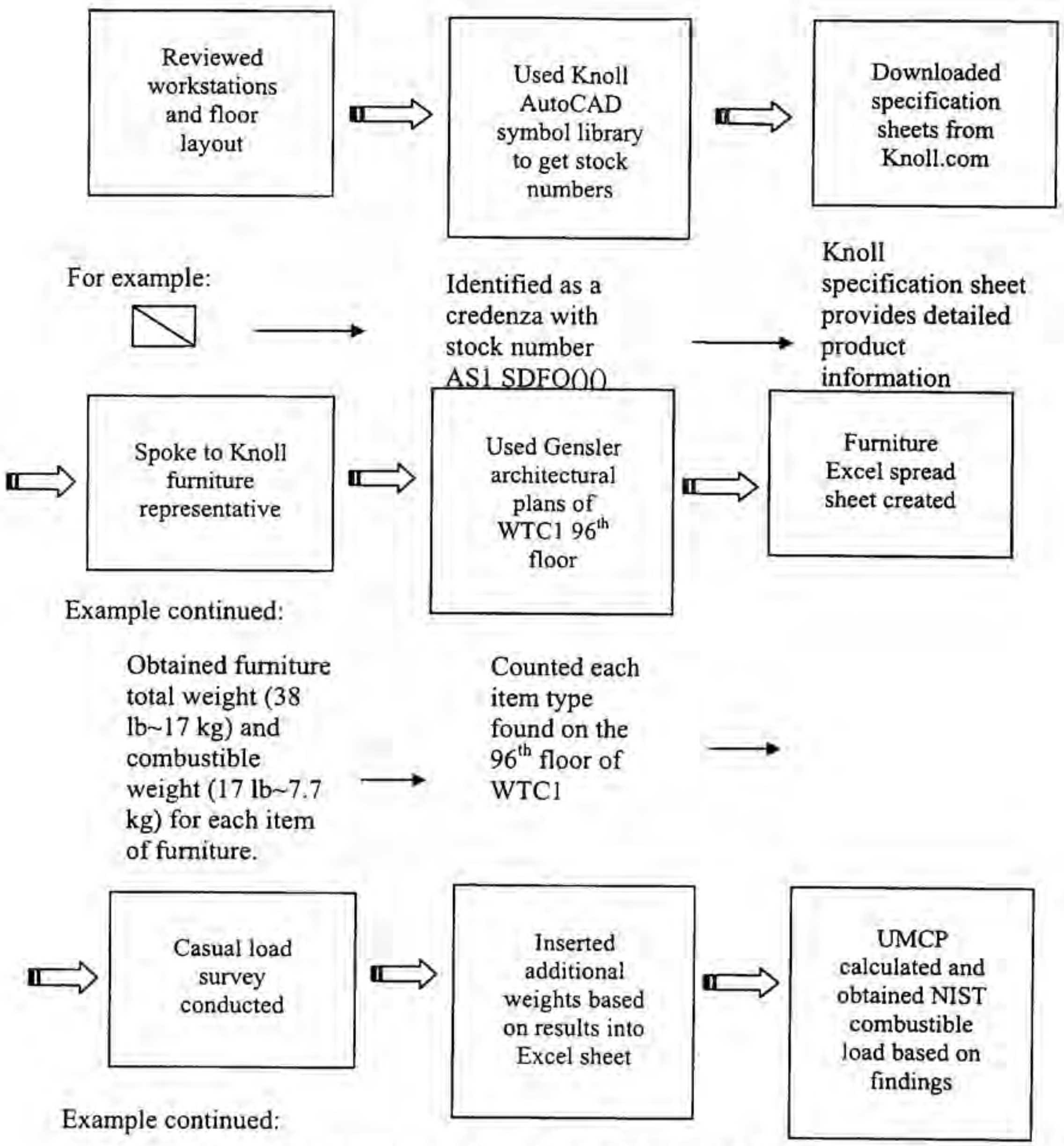

Figure 3. This flow chart demonstrates the methodology used to obtain furniture identifications.

Comparisons

The following comparison table is provided to sum-up the previously mentioned information and to clearly layout the three groups being compared.

Table 1.

	COMPARISON				
TOTAL WORKSTATION WT.	Average	High	Low		
description	UMCP			NIST	FEMA
Number of desks	211			204	
Total psf(*combined contents)	14.3				
Combustibles only desk wt	179441	1429	341		
Paper weight (lbs)	302062			134640	
Empty furniture weight (lb)	265162			191760	
Full furniture weight (lb)	441868			326400	248103
30% paper weight (lb)	90619				
Building area (ft^2)	42932				42932
Core area (ft^2)	11919			11745	11919
Area that furniture sits on	30930			31000	31013
Common file cabinets (lb):					
noncombustible	37626			0	
combustible	36,437			0	
combust. stored on top	255				
Total	74318				
Conf. rms/areas & pantries(lb)	7117			0	
***Combustible Material (psf)**	**10**			4 psf	8psf (39 kg/m^2)
SINGLE WORKSTATION WT.					
Combustible wrkstn weight	862	1443	341	660 lbs	
Total				1600lbs	
Wrkstn. weighted average (lb)	862				
Added Combustibles:					
workstation paper (lb)		370	6	160	
additional (lb)		30	0	0	
File cabinets:					
contents (lb)		424	124	40	
top (lb)		6	3	0	
workstation foot print	8'x8' (2.41 m * 2.41 m)			8'x8'	
paper NIST left out	71,844 lbs				

Comparison of fuel load between UMCP and NIST:

Table 2.

	NIST	UMCP
Total floor weight (combustible + noncombustible)	1600 lbs x 204 stations=326,400lb	210 stations x 1433 lb =301,012 lb
Total Combustibles Weight	134,640 lb/30930 ft^2= 4.3 lb/ft^2 combustibles only	301,012 lb/30930 ft^2 = 9.7 ~ 10 psf
*Paper weight for floor distributed per station	60,242 lb/204 wrkstns = 295 lbs.	176,706 lb /210wrkstns = 841 lbs.

*paper weights for NIST and UMCP are different because UMCP included common lateral files and paper storage whereas NIST did not.

**The reason for 1141.4 lbs of combustible per station is based on the accessible fuel per NIST. However, this is too low an estimate due to the fact that common files were not taken into account, nor conference rooms etc…

***This is the weighted average of the workstations.

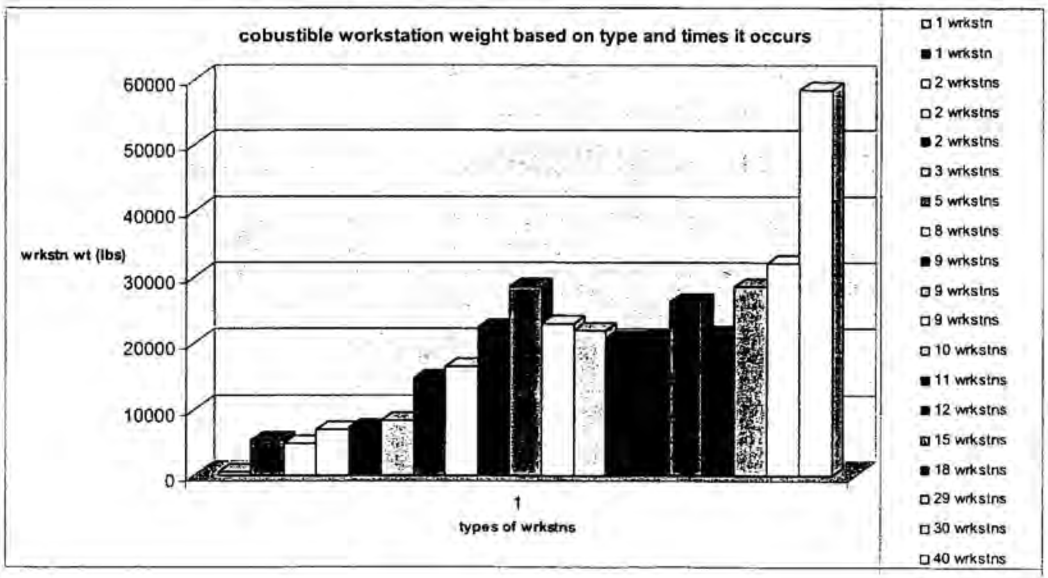

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Figure 4. UMCP chart showing weight of workstation type plotted against the number of times the workstation type occurs on the 96th floor.

Recommendation

Use the NIST data for the temperature of steel then make a plot versus temperature of the outer steel insulation. The purpose of this plot is to help linearly estimate, based on corrected fuel load/fire size, the possible range of steel temperatures. Then, using something like SAFIR or lumped heat capacitance or maybe T. T. Lie's work, there would be a reference check as to the validity of the results.

From the above described course of action, a strong enough case can be made, which may prove to NIST that a re-examination of their original fuel load estimates is worthwhile.

References

1. McAllister, T., et al. FEMA WTC report "Chapter 2" page 2-1
2. McGrattan, K. "Simulation of the fires in WTC 1 and 2" BFRL, NIST, US Department of Commerce, October 19, 2004, slide 2.
3. NIST Preliminary WTC report 2004, Appendix J.

Other References not specifically cited:

4. NIST AND THE WORLD TRADE CENTER website "Status of Data Collection Efforts"
5. McGrattan, K. "Simulation of the fires in WTC 1 and 2" October 19, 2004. BFRL, NIST, US Department of Commerce.
6. McGrattan, K. "Simulation of the fires in WTC 1 and 2" October 19, 2004. BFRL, NIST, US Department of Commerce.
7. Knoll furniture catalog www.knoll.com/products

	wish to send confirmation of combustible weights via email).
H5 & I5	Combustible weight in lbs and kgs respectively
J3-J4	Weight of paper in one item is an estimate of the amount of paper to be found in/on a particular piece of furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
J5 & K5	Paper weight in lbs and kgs respectively
J9	Calibre cabinet was not given a paper weight of 15 lbs each but rather an estimate for clothing, note pads and other office items. The 15 lbs were put under weight of paper for ease of reference.
L2-L4	Total weight of paper for all items means that the weight of paper for one furniture item has been multiplied by the number of items on the floor.
L5 & M5	Total paper weight in lbs and kgs respectively
N2-N4	Combined weight for one full item means combustible and noncombustible weight of one full item. This column provides the total weight of one piece of a particular furniture type; self weight plus paper weight.
N5 & O5	Total furniture weight in lbs and kgs respectively
P2-P4	Total weight of combustible material for full item, this column provides the combustible weight of the furniture plus the added paper weight for one piece of a particular furniture type.
P5 & Q5	Combustible material weight in lbs and kgs respectively
R2-R4	Total combustible weight is the weight of combustible material times (x's) number of items. This means that the total combustible weight (P column) was multiplied by the number of times that piece of furniture was found on the 96th floor (G column).
R5 & S5	weight in lbs and kgs respectively
T2-T4	Total combustible and noncombustible weight provides the furniture self weight plus the added paper weight.
T5 & U5	Total weight (combustible + noncombustible) for 96th floor in lbs and kgs respectively

V3-V4	Total weight of the furniture only (both combustible and non-combustible furniture weight. Note, there is no added paper weight here)
V5 & W5	Furniture weight, only, for 96th floor in lbs and kgs respectively
B6-B25	Items that may be located in a workstation, there were different designs; these office items were found among the workstations on the 96th floor.
B27-B30	Common files refer to the lateral files that were either at the end of a workstation grouping or in a common area. (previously left out by NIST)
B32-B39	These are the different types of conference chairs found on the 96th floor.
B41-B45	These are the different types of conference tables found on the 96th floor.
B47-B51	These are the different types of common items found on the 96th floor.
B53-B61	These are the different common/shared rooms located on the 96th floor.
B63	Despite there being different sizes and weights of paper used, the estimate was based on Boise 20weight, 500 sheet 5 lb reams.
Notes:	
C7	The three file credenza was only included by NIST for the brand mane workstation. Appendix J shows that there was not a credenza for the generic workstation but rather a third two drawer file cabinet. If this was to account for the lack of a credenza then the combustible furniture weights were significantly different. (Credenza combustible weight of 17 lbs vs. all metal for the two drawer lateral file). If this was an attempt to account for the files at the end of workstation groupings then they should have been placed outside the workstation and the credenza would have been negated.
C9	The Calibre cabinet was not shown in any of the Appendix J photos but was present on the 96th floor, per Gensler, in the amount of 62 units with a **combustible** weight estimate of 175 lbs each!
Row 66	Provides 'sum' of columns
NIST	
A1	For ease of identification when printed I inserted column and row details.
A68	Row and designations for ease of reference.

B70	Heading to show that the following data is from NIST, Appendix J of preliminary report.
B71	Classification for the description of where the furniture item may typically found on the 96th floor from Appendix J.
C70	Item type refers to the physical description of an individual item found on the 96th floor as obtained from Gensler Architectural plans and Appendix J of the NIST preliminary WTC report.
D70	Stock identification numbers were obtained from comparing the Gensler Architectural plans to the AutoCAD symbol library obtained from www.Knoll.com
E69	Total weight of each item refers to the weight of one piece of furniture as it is, complete and unpacked. These weights were obtained from a Knoll Sales person.
E70	Weight of furniture in pounds (lbs)
F70	Weight of furniture in kilograms (kgs)
G68-G69	Number of items refers to the number of items found on the 96th floor of WTC 1. This information was obtained from Gensler Architectural plans except that the number of desks came from the FDS office graphic in Appendix J.
H68-H69	The weight of combustible material for empty furniture item refers to the amount of material for a single, unused piece of furniture (obtained from Knoll sales person who was referring to either a binder or computer when we spoke but did not wish to send confirmation of combustible weights via email).
H70 & I70	Combustible weight in lbs and kgs respectively
J68-J69	Weight of paper in one item is an estimate of the amount of paper to be found in/on a particular piece of furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
J70 & K70	Paper weight in lbs and kgs respectively
L68-L69	Total weight of paper for all items means that the weight of paper for one furniture item has been multiplied by the number of items on the floor.
L70 & M70	Total paper weight in lbs and kgs respectively

N68-N69	Combustible and noncombustible weight of one full item, this column provides the total weight on one piece of a particular furniture type, self weight plus paper weight.
N70 & O70	Total furniture weight in lbs and kgs respectively
P68-P69	Total weight of combustible material for full item, this column provides the combustible weight of the furniture plus the added paper weight for one piece of a particular furniture type.
P70 & Q70	Combustible material weight in lbs and kgs respectively
R68-R69	Weight of combustible material times (x's) number of items means that the total combustible weight (P column) was multiplied by the number of times that piece of furniture was found on the 96th floor (G column).
R70 & S70	weight in lbs and kgs respectively
T68-T69	Total combustible and noncombustible weight provides the furniture self weight plus the added paper weight.
T70 & U70	Total furniture weight for 96th floor in lbs and kgs respectively
B71-B84	Items that may be located in a workstation, there were different designs; these office items were found among the workstations on the 96th floor.
Notes:	
C73	The three file credenza was only included by NIST for the brand mane workstation. Appendix J shows that there was not a credenza for the generic workstation but rather a third two drawer file cabinet. If this was to account for the lack of a credenza then the combustible furniture weights were significantly different. (Credenza combustible weight of 17 lbs vs. all metal for the two drawer lateral file). If this was an attempt to account for the files at the end of workstation groupings then they should have been placed outside the workstation and the credenza would have been negated.
C72	The Calibre cabinet was not shown in any of the Appendix J photos but was present on the 96th floor, per Gensler, in the amount of 62 units with a **combustible** weight estimate of 175 lbs each!

Row 86	Provides 'sum' of columns
R86	Is the amount of combustible weight calculated by UMCP using NIST data however, it does not include carpet tiles and ceiling tiles. That contributes to the discrepancy UMCP(106,705 lbs) vs. NIST (660 lbs * 204 desks-134,640 lbs)
T86	Is the amount of total weight calculated by UMCP using NIST data however, it does not include carpet tiles and ceiling tiles. That contributes to the discrepancy UMCP(247,098 lbs) vs. NIST (1600 lbs * 204 desks-326,400 lbs)

Table 2. For Excel sheet 'wrkstn wts'

Column designation	Description of how the value was obtained and/or what it means/relevance
A1	Row and column designations for ease of reference.
B2	Heading to show that the following data is calculated from information obtained by Quintiere & Stewart of UMCP.
C2	WTC1 96th floor ('wrkstn wts') to let reader know which printed sheet they are viewing.
E3, H3, P2, Z2 & AM2	These are sub category designations.
G2	All weights on this sheet are in pounds.
B4	Description refers to designation of the employee who was originally assigned to that desk location on the 96th floor.
C4	Station identification is the number assigned on the architectural plans for a particular desk location.
D4	Telephone extension for a particular workstation
E4	Staff refers to the COMBUSTIBLE weight of one staff chair.
F4	Visitor refers to the combustible weight on staff chairs that can be attributed to that workstation.
G4	Conference refers to the conference area/room chairs that correspond to the

	designated location.
H4	J-shape refers to the style of knoll table that can be found at that workstation location; combustible weight is provided and does not include mounting or legs.
I4	Is the paper weight most likely to be found on the J-shape table and is an estimate of the amount of paper to be found on furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
J4	½ round table refers to the style of knoll table that can be found at that workstation location; combustible weight is provided and does not include mounting or legs.
K4	Is the paper weight most likely to be found on the ½ round table and is an estimate of the amount of paper to be found on furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
L3-L4	Teardrop or circular table refers to the style of knoll table that can be found at that workstation location; only combustible weight is provided and does not include mounting or legs.
M2-M4	Is the paper weight most likely to be found on the teardrop or circular tables and is an estimate of the amount of paper to be found on furniture. These two tables were grouped together because they have nearly identical weight as provided by Knoll customer service representative. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
N4	This is the boat shaped conference table that is located in the following conference rooms: NE, NW, SE, & SW
O3-O4	Is the paper weight most likely to be found on the boat shaped table and is an estimate of the amount of paper to be found on this furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
P2-P4	Wall Panels: 4 foot high and two feet wide privacy panels used at each desk. The weight of 3 panels*14 lbs = 42 lbs.
Q3-Q4	Is the paper weight most likely to be found on the three privacy panels and is an

	estimate of the amount of paper to be found on these pieces of furniture. One privacy panel was observed to have 0.15 lbs of paper attached to it which is ~ 15 sheets of standard paper. This information was obtained by casual load observations and calculations of privacy panel decorations, calendars and other items.
R3-R4	Wall Panels: 4 foot high and three feet wide privacy panels used at each desk. The weight of 3 panels*24 lbs = 72 lbs.
S3-S4	Is the paper weight most likely to be found on the three privacy panels and is an estimate of the amount of paper to be found on these pieces of furniture. One privacy panel was observed to have 0.15 lbs of paper attached to it which is ~ 15 sheets of standard paper. This information was obtained by casual load observations and calculations of privacy panel decorations, calendars and other items.
T3-T4	Wall Panels: 5 foot high and three feet wide privacy panels used at each desk. The weight of 1 panel*35 lbs = 35 lbs.
U3-U4	Is the paper weight most likely to be found on the three privacy panels and is an estimate of the amount of paper to be found on these pieces of furniture. One privacy panel was observed to have 0.15 lbs of paper attached to it which is ~ 15 sheets of standard paper. This information was obtained by casual load observations and calculations of privacy panel decorations, calendars and other items.
V3-V4	Overhead cabinet refers to the double door cabinet that attaches to the five foot high privacy panel. The estimated combustible weight provided.
W2-W4	Paper weight for the overhead cabinet obtained from NIST Appendix J
X3-X4	Combustible weight of the Calibre cabinet (not included by NIST at all)
Y3-Y4	Additional weight is the added combustible weight for this furniture item.
Z2-Z4	Credenza 3-drawer is another furniture item that NIST did not include but rather per appendix J, equated cabinet fronts, presumably to justify negation
AA2-AA4	Paper weight for the one horizontal file drawer, one slender drawer and another miscellaneous storage drawer. Again, this information was obtained by weighing the file contents of two different ENFP horizontal drawers and adding additional

	weight for note pads etc…
AB2-AB4	Lateral file two-drawers refer to the all metal personal lateral files found at each workstation.
AC2-AC4	This is the paper weight contained in the lateral files, capacity is 150 lbs per drawer but I used 100 lbs per drawer based on the file contents of the horizontal drawer survey mentioned previously.
AD3-AD4	Common files used a wood counter-top
AE2-AE4	Paper weight likely to be found on wood counter-tops
AF3-AF4	This is the standard desk, Morrison, as obtained the Gensler architectural drawings and AutoCAD symbol library. This is the combustible weight of the desk only and does not include the mounting or table legs.
AG3-AG4	Paper weight that is likely to be found on this desk, it is a conservative estimate, and the information was obtained from a casual load survey.
AH2-AH4	Supplementary worktable (square or one rounded edge), these are added to the Morrison desk set-up based upon the workstation design, as obtained from Gensler architectural drawings. This is the combustible weight of the desk only and does not include the mounting or table legs
AI3-AI4	Paper weight that is likely to be found on this desk, it is a conservative estimate, and the information was obtained from a casual load survey.
AJ3-AJ	Computer monitor at workstation. Not all workstations appear to have a computer and there is '?' for any location that I was unsure about.
AK2-AK4	Computer hard drive at workstation.
AL3-AL4	Additional – unable to id means that there was something at that workstation that unidentifiable from Gensler architectural drawings.
AM2-AM4	Some workstations have additional chairs attributed to them; that is all this column is referencing.
AN2-AN4	Lateral files: 3 drawer metal file cabinets that is part of the common files.
AO2-AO4	Lateral files: 4 drawer metal file cabinets that is part of the common files.
AP2-AP4	Common files used a wood counter-top
AQ2-AQ4	Paper weight likely to be found on wood counter-tops

AR2-AR4	Corresponding panels refer to the panels that line some parts of the file cabinet groups.
AS2-AS4	Comment on which workstation design repeats; designated by employee.
AT2-AT4	Total times it occurs refers to the number of times that workstation design can be found on the 96^{th} floor.
AU2-AU4	Combustible weight for an individual workstation type
AV2-AV4	Combustible sum of workstation weight per type
AW2-AW4	Combustible weight of file cabinets that NIST left out from their experimental burns.
AX2-AX4	Noncombustible weight of file cabinets that NIST left out from their experimental burns, 3 drawer cabinet.
AY2-AY4	Noncombustible weight of file cabinets that NIST left out from their experimental burns, 4 drawer cabinet.
AZ2-AZ4	Noncombustible weight of open metal shelving units that NIST left out from their experimental burns, 6 metal shelves.
BA	Sum of the combustible weight of other rooms on the 96^{th} floors.

A.8 Excel Sheets

(attached)

Subject: NIST NCSTAR 1 draft feedback
From: "Elliott, Robert" <Robert.Elliott@FMR.COM>
To: <wtc@nist.gov>

I read the report and think the recommendations are excellent. Here are some notes I made as I read it. Some may be too specific or tactical to include in the recommendations, but am passing them along anyway.

- Removing the state law that prevents the use of stairwells during drills is a good first step, however this should go further and should highly recommend or require that full building evacuations should be practiced - have employees sign waivers if it is a liability issue. (we have seen landlords in other states not allow these drills due to the liability of someone getting injured.) It is important that employees be aware of egress routes. It is also important that employees be physically able to do the descent - this can be a challenge even for the fittest individuals descending from upper floors. The evacuation will be hampered by the slowest moving person ahead of the crowd in the stairway. Having a target evacuation time is an excellent idea and can be used to evaluate if improvements need to be made. The learning's from the full building evacuation in 1993 were instrumental in the safe evacuation of so many people from WTC1 and 2 and other buildings in the complex on 9/11.
- Require the provision of communication devices for floor wardens - including cell phones, pagers etc. This could be combined with pre-established communication groups using tools like Envoyworldwide tool - mass distribution of messages to email, office phone, cell phone call or text messaging. Many new technologies are now available and should be leveraged. A large percentage of employees now carry cell phones.
- Create an egress plan that prevents bottlenecks. If occupants of upper floors are using the same stairway exit routes as lower floors, stairways should get progressively wider the lower you go in the building. (building lobbies may become a bottleneck, create additional escape routes).
- Position stairways on all 4 corners of the building and two in the core of the building to maximize the separation of escape routes - total of 6 stairways (or more). Perhaps upper floors only need 4 stairways while on lower floors there may be 8 and up to 12 on the lowest parts of the building. Perhaps leverage scissor design to incorporate the stair traffic from the upper floors into the lower floor stairwells.
- Make sure all doors go to "fail-safe" mode in an emergency - this prevents employees becoming trapped in workspaces or public areas.
- Create removable escape hatches or trapdoors to bypass devastated floors, so occupants could drop onto the floor below. Office furniture could be positioned to create a ladder system / climbing blocks.
- Even though roof escape is not a primary evacuation option - why not allow doors to roof to be opened. It seems wrong to trap people inside. Having a supply of ropes and rappelling equipment available could potentially provide one more option??
- Recommend the use of elevators to evacuate when available unless it is obviously not safe to do so - especially for higher floors. Have procedures for when it is safe to use them and do drills. (e.g. max load - procedure to bypass floor when fully loaded to maximize the number of trips)
- Provide additional training around breaking vs. not breaking windows.
- Require that evacuation information be provided for visitors to buildings and all new employees undergo training on day1?.
- Use RFID sensors in buildings to monitor heat, detect anomalies, failures, etc. These should be used to gather critical data that could be of use to firefighters and occupants looking for a safe egress route. RFIDs could also be incorporated into floorwarden equipment to track progression of evacuation. These could also be used to record data should there be a full building failure.
- Create a new material that is used in conjunction with the fire retardant foam on the structural steel. This material when exposed to flame (due to the failure of the foam) would itself convert into a fire retardant. (similar to the way ash becomes an insulator)
-

Thank you for the opportunity to contribute. If you have any questions or further explanation, please feel free to contact me.

Regards,

Rob

Robert Elliott, CISSP, CBCP
Director IT Risk Management,
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X-Sieve: CMU Sieve 2.2
X-Sender: cauffman@mailserver.nist.gov
X-Mailer: QUALCOMM Windows Eudora Version 6.0.0.22
Date: Tue, 26 Jul 2005 09:49:36 -0400
To: wtc@nist.gov
From: "Stephen A. Cauffman" <cauffman@nist.gov>
Subject: Fwd: Author Peter Josyph re: FINAL REPORT re: WTC
X-NIST-MailScanner: Found to be clean
X-NIST-MailScanner-From: cauffman@nist.gov

Michele,

Please include this comment on the draft final report in the database.

Thanks,

Steve

> X-Sieve: CMU Sieve 2.2
> Date: Mon, 11 Jul 2005 23:55:56 -0400
> From: newman@nist.gov
> To: sunder@nist.gov, stephen.cauffman@nist.gov
> Subject: Fwd: Author Peter Josyph re: FINAL REPORT re: WTC
> User-Agent: Internet Messaging Program (IMP) 3.2.1
> X-Originating-IP: 129.6.220.35
> X-NIST-MailScanner: Found to be clean
> X-MailScanner-From: newman@nist.gov
>
> Note the mention of a mistake on a map in the Final Report.
>
> ----- Forwarded message from Barbara Mann <drmann@optonline.net> -----
> Date: Mon, 11 Jul 2005 22:41:40 -0700
> From: Barbara Mann <drmann@optonline.net>
> Reply-To: Barbara Mann <drmann@optonline.net>
> Subject: Author Peter Josyph re: FINAL REPORT re: WTC
> To: michael.newman@nist.gov
>
> Dear Michael:
>
> I have just received a copy of the Final Report on the collapses of the WTC, for which I am extremely grateful.
>
> You might wish to pass along to the authors of the document (in case it is reprinted) that in the map of the WTC which appears on p.3, the South Bridge is incorrectly identified as the bridge that crosses Liberty Street. In fact the South Bridge was the bridge that crosses West Street, seen on the map south of the North Bridge. The North Bridge was demolished in the attacks, the South Bridge survived and it stands on West Street today, acting as a way to walk from the World Financial Center to the pedestrian walk on Liberty Street. The bridge over Liberty Street that is wrongly identified on the map was also destroyed in the collapses.

Best

Peter Josyph
Author/Filmmaker

----- End forwarded message -----

Stephen A. Cauffman
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==
CONFIDENTIAL AND PREDECISIONAL COMMUNICATION
==

John G. Degenkolb
FIRE PROTECTION ENGINEER - CODE CONSULTANT
71 Gold Hill Drive, Carson City, Nevada 89706
Telephone: (775) 883-4544

July 26,2005

National Institute of Standards and Technology
Gaithersburg, MD

Re: Recommendations resulting from the World Trade Center Investigation

To Whom It May Concern:

Because of limited access to discussions and recommendations being made as the result of the World Trade Center disaster, the subject matter of this letter may not be exactly what NIST is looking for where improvements in building safety are concerned. Much has been written and said in discussing the matter but my concern is almost solely based on the subject of positioning of egress stairways.

In my opinion, based on that information available to me, primarily the FEMA World Trade Center Building Performance Study, Second Printing; articles in Architectural Record; and articles written by Richard Schulte in Plumbing Engineer; insufficient attention is being given to the positioning or placement of exit stairways.

Quoting from the FEMA report: 1) Executive Summary (page 3) "Similarly several design features have been identified that may have played a role in allowing the buildings to collapse in the manner that they did and in the inability of victims at and above the impact floors to safely exit" and "grouping emergency egress stairways in the central building core, as opposed to dispersing them throughout the structure". 2) "Egress systems currently in use should be evaluated for redundancy and robustness in providing egress when building damage occurs, including the issue of transfer floors, stair spacing and locations, and stairwell enclosure impact resistance".

Then in Chapter 1, Section 1.5 Overview of Building Codes and Fire Standards 1.5.1, next to last paragraph – "At least two stairways must be provided with widely separated entry points". But, in my opinion, it is even more essential, in light of the World Trade Center tragedy" that the stairway enclosures be well separated.

In Chapter 2, Section 2.2.1 concerning WTC 1 is a statement to the effect "Partial collapse of floors in this zone appears to have occurred over a horizontal length of approximately 65 feet. The 65 foot figure would be sufficient to effect all 3 stairways. Section 2.2.1.3 Evacuation, concerning WTC 1 and 2 contains the statement "People within and above the impact are could not evacuate, simply because the stairways in the impact area had been destroyed". So, even though the buildings remained standing for more than an hour, persons above the 2-4 impact areas no longer had a stairway to use.

Under Section 2.3 Observations and Findings (page 2-38) is a reference to "Several building design features". "These features should not be regarded either as design deficiencies or as features that should be prohibited in future building codes. Rather these are features that should be subjected too more detailed evaluation. These include the following:...grouping emergency egress stairways in the central building core, as opposed to dispersing them throughout the structure".

Surprisingly, in spite of all the above information, the Recommendations Section 2.4 is completely silent on the subject of stairway separation and location.

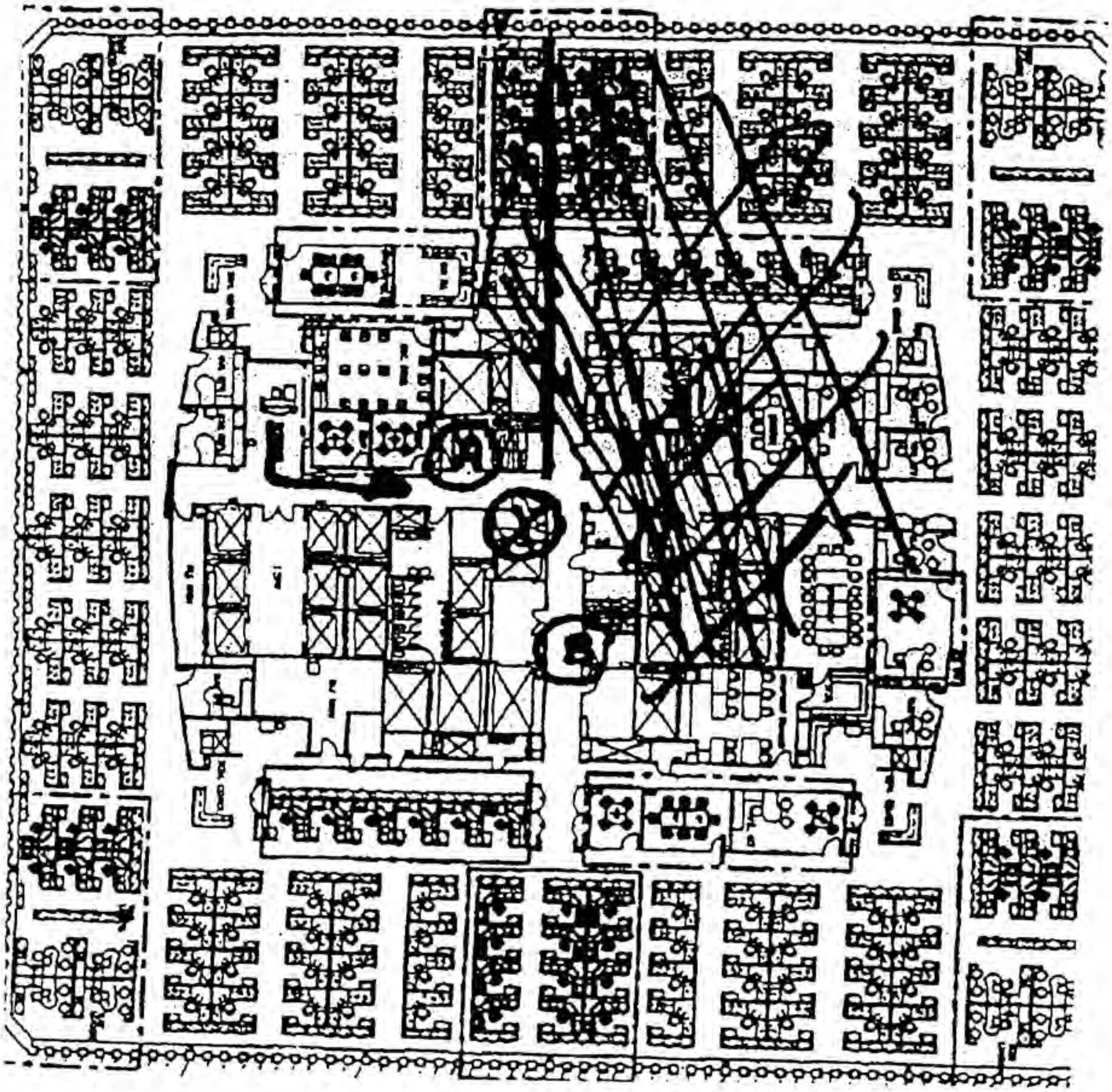
In August, 2002 I sent a letter to both the New York Fire Department and Building Department Commissioners. These letters outlined just how building codes had modified exit stairway requirements. A copy of that letter is enclosed. I believe that will adequately clarify my position. Had the 3 stairways been "widely separated", at least one would have been available for the use of those above the fire involved floors.

Sincerely,

John Degenkolb

John "Gus" Degenkolb
Fire Protection Engineer – Code Consultant

Figu
Appi
flooi



APPROXIMATE DEBRIS LOCATION ON THE 91st FLOOR OF WTC 1

// John G. Degenkolb

71 Gold Hill Drive, Carson City, Nevada 89706
Telephone: (775) 883-4544

24 August 2002

Chief Daniel Nigro
Fire Department of New York
9 Metrotech
Brooklyn. NY 11201

Commissioner Nicholas Scoppetta
City of New York Fire Department
9 Metro Tech
Brooklyn. NY 11201

Patricia Lancaster, Commiddioner
New York Department of Buildings
280 Broadway
New York, NY 10007-1860

Dear Commissioner and Fire Chief:

I am writing to express my concern regarding the arrangement of exit stairways in high rise buildings as a result of the World Trade Center disaster.

I am a retired Battalion Chief of the Los Angeles Fire Department and for years represented the California Fire Chiefs to the International Conference of Building Officials (ICBO). publishers of the Uniform Building Code. After retiring I worked as a Fire Protection Engineer and Code Consultant. I was a member of the International Committee formed by the U. S. General Services Administration to study the fire problem involving high rise buildings following several such fires here in the United States. That Committee's findings were instrumental in developing building code requirements for such buildings and which appeared in the three model building codes. As a result of that work. I became acquainted with Chief O'Hagan. your Fire Marshal. and another Deputy Chief whose names I have forgotten.

My concern over the arrangement of exit stairways as I understand were in the World Trade Center buildings is based on radio. television, newspaper, and magazine reports. I have not seen any official reports so my understanding may be inaccurate. It is my understanding that the stairway enclosures were a part of the center core of the buildings. relatively close to each other. Because of this proximity to each other, when one was blocked. so was the other and all the building occupants above that blockage level had no means of escape.

Having worked with building codes for many years, and since all three of the model codes are reasonably similar. I would like to examine the code changes made in the Uniform Building Code and with a final look at the requirements of the International Building Code - 2000 and the NFPA Life Safety Code. 2000. At least as early as 1949. buildings five or more stories in height were required to have "one of the required exits shall be a smokeproof enclosure." That would mean that there was to be no opening directly into the interior of the building by that enclosure. Access was to be via a vestibule opening into the building itself. The vestibule was to have one door to the interior of the building and one to the stairway as a smokeproof enclosure. No point in the building was to be more than 150 feet from an enclosed stairway. In 1964 this distance was increased to 200 feet in a sprinklered building.

As to the location of exit stairways, "If two or more exits are required, they shall be arranged a reasonable distance apart so that if one becomes blocked the other will be available." This was later modified to require "If only two exits are required they shall be placed a distance apart equal to not less than one-fifth the perimeter of the room." The measurement was to be in a straight line between exits. The reference to two exits was later changed to three.

In 1970 or 1973 the code was modified to permit the smokeproof enclosure to be as stated above (natural ventilation) or by mechanical ventilation as would be necessary with a central core concept. The central core concept placed the elevators, stairways, restroom facilities, janitor closets, etc. in a limited rectangular area in the center of the building. Exit stairs were no longer on the outer edge of the building. The central core concept was adopted to provide more rental space and more desirable locations in the building. As to the Arrangement of Exits "If only two exits are required they shall be placed a distance apart equal to not less than one-half of the length of the maximum overall diagonal dimension of the building or area to be served measured in a straight line between exits." An Exception was made to permit "exit separations may be measured in a direct line of travel within the exit corridor. Enclosure walls shall be not less than 30 feet apart at any point in a direct line of measurement." The 30 foot figure was selected when I objected to having two exits immediately adjacent but separated by a 2-hour fire resistive wall. I objected because I had seen too many holes or breaks in that wall. So a required separation of 30 feet was suggested without any particular reason except that it sounded like a good round figure.

Then in the 1990's further relaxations were made where exits are concerned. (See enclosures.) The distance of travel from any point in a building to an exit could be increased to 250 feet in a sprinklered building. By some interpretations this could be increased to 350 feet.

The International Building Code – 2000 further reduced the separation distance requirement between exits to one-third of the length of the maximum overall diagonal dimension of the area served by the building if it is sprinklered. This was probably taken from the 1997 NFPA Life Safety Code.

It is interesting to note that the Life Safety Code permits "Interlocking or scissors stairs shall be permitted to be considered separate exits if enclosed in accordance with 5-1.3.2 and separated from each other by 2-hour fire-resistance noncombustible construction. There shall be no penetrations or communicating openings whether protected or not between stair enclosures." Such permission almost assures close proximity of exits and the penetration of the walls has been quite normal.

So, to recap what has happened to exit requirements where the location of exits are concerned, this is what I see. In my opinion there has been a relaxation of reduction in safety, particularly in tall buildings. Where originally any point in a building was required to be within 150 feet of an enclosed stairway as measured along the path of travel, 200 feet if the building was sprinklered. Where two exits were required, they were to be positioned a distance apart equal to not less than one-fifth of the perimeter of the building. One of the required stairways had to be a smokeproof enclosure. Originally that meant that the required vestibule (between the building interior and the enclosed stairway) had to be open to outside air. It had to exit into a public way or into a fire-rated passageway leading to a public way. That passageway was to be without other openings along the route to the outside. Where three or more exits are required, they were required to be "a reasonable distance apart so that if one became blocked others would be available."

Today it is quite different. With the addition of mechanically ventilated smokeproof enclosures; i.e. the vestibule under negative pressure and the stairway under positive pressure. both exits are to be smokeproof enclosures. When two exits are required, they are to be separated from each other by one-half of the length of the maximum overall dimension of the building measured in a straight line between exits. If there are additional exits provided. they shall be a reasonable distance apart, etc. The distance of travel from any point in the building to an exit may be 200 feet in a non-sprinklered building. In a sprinklered building the travel distance may be 250 feet. The travel distance may be increased an additional 100 feet provided that the last portion of the travel distance is within a fire-rated corridor. The travel distance is measured along the direct path of travel. There must be a minimum of 30 feet between the walls of exit enclosures measured in a straight line.

The International Building Code has added an Exception for sprinklered buildings. The separation between exit doors shall be not less than one-third of the length of the maximum overall diagonal distance of the area served.

The NFPA Life Safety Code has this same one-third distance requirement. It does not specify the number of feet of separation required. Interlocking or scissors stairways are permitted with no separation distance required but just a 2-hour fire resistive wall between adjacent stairs.

I recognize that New York City has its own building and fire codes and is probably quite similar to that of the model codes. I believe that New York is a dominant figure in the design and construction of tall buildings. So, I would like to request that you examine the current provisions for exiting stairways and make a determination as to the need for revisions. What New York does in this regard may well influence the rest of the country.

Respectfully,

John "Gus" Degenkolb

General (Cont'd.)

(g) More Than One Occupancy. The capacity of a room or building which is used for different occupancies at different times shall be determined by the occupant load which gives the largest number of persons.

(h) Exit Obstruction. No obstruction shall be placed in the required width of an exit.

(i) Room Capacity Posted. The maximum room capacity shall be conspicuously posted by the owner of the building by means of durable metal signs placed in each assembly room, auditorium or room used for a similar purpose where fixed seats are not installed, and it shall be unlawful to remove or deface such notice or to permit more than this legal number of persons within such space.

(j) Change in Elevation. Changes in elevation of less than twelve inches (12"), along any means of egress within a building, shall be by means of ramps, except for occupant loads less than ten (10).

Exits Required

Sec. 3302. (a) Number of Persons. The number of persons permitted in any building or portion thereof shall not exceed those set forth in Table No. 33-A, except that where additional exit facilities are provided the occupancy load may be increased in accordance with Section 3302 (b) and (c).

(b) Number of Exits. Group D and Group H occupancies having an occupant load of more than 10 shall have not less than two exits.

Other occupancies having an occupant load of more than 50 shall have not less than two exits.

Buildings or portions thereof having an occupant load of 500 to 999 shall have not less than three exits.

Buildings or portions thereof having an occupant load of 1000 or more shall have not less than four exits.

(c) Width. The total width of exits in feet shall be not less than the total occupant load served divided by 50. Such width of exits shall be divided approximately equally among separate exits.

The width of exits from any story of a building shall be determined from the occupant load in that story plus one-half the tributary occupant load in the story next above or below, provided the resulting width is not less than that required for the upper story considered separately. The maximum exit width required for any story shall be maintained until egress is provided from the structure.

(d) Arrangement of Exits. If only two exits are required they shall be placed a distance apart equal to not less than one-fifth of the perimeter of the room. Where three or more exits are required they shall be arranged a reasonable distance apart so that if one becomes blocked others will be available.

No point in an unsprinkled building shall be more than one hundred fifty feet (150') from an exterior exit, a horizontal exit, or an enclosed stairway, measured along the line of travel.

In a building of Type I or Type II construction or where the building is completely sprinklered, the above distance from exits may be increased to two hundred feet (200').

Sec. 3301. (a) Purpose. The purpose of this Chapter is to provide minimum standards of egress facilities for occupants of buildings.

(b) Scope. Every building shall be provided with exits as required by this Chapter. Where there is conflict between a general requirement and a specific requirement for an individual occupancy, the specific requirement shall be applicable.

(c) Definitions. "Occupant Load" is the total number of persons actually occupying a building or portion thereof at any one time, but shall never be assumed to be less than the result obtained by dividing the floor area by the square feet per occupant set forth in Table No. 33-A for the occupancy housed therein.

(c) Number of Exits. Group D and Divisions 1 and 2 of Group H occupancies having an occupant load of more than 10 shall have not less than two exits.

Other occupancies having an occupant load of more than 50 shall have not less than two exits.

Buildings or portion thereof having an occupant load of 500 to 999 shall have not less than three exits.

Buildings or portion thereof having an occupant load of 1000 or more shall have not less than four exits.

If two or more exits are required, they shall be arranged a reasonable distance apart so that if one becomes blocked the other will be available.

(d) Distance from Exit. No point in any building shall be more than one hundred fifty feet (150') from an exterior exit, a horizontal exit, an enclosed stairway, or a fire-resistive passageway, measured along the line of travel.

Smokeproof Enclosures

Sec. 3309. (a) General. A smokeproof enclosure shall consist of a continuous stairway enclosed from the highest point to the lowest point by walls of two-hour fire-resistive construction. The supporting structural frame shall be of four-hour fire-resistive construction.

(b) Where Required. In buildings five stories or more in height, one of the required exits shall be a smokeproof enclosure.

(c) Construction. Stairs in smokeproof enclosures shall be of incombustible construction.

(d) Access. There shall be no opening directly into the interior of the building. Access shall be through a vestibule open to the outside having an exit door from the interior of the building and an exit door leading to the smokeproof enclosure. In lieu of a vestibule, access may be by way of an exterior open balcony of incombustible materials.

(e) Doors. Exit doors to smokeproof enclosures shall be self-closing Class "B" fire doors.

(f) Outlet. A smokeproof enclosure shall exit into a public way or into a passageway leading to a public way. The passageway shall be without other openings and shall have walls of two-hour fire resistance and floors and ceilings of two-hour fire resistance.

(g) Barrier. A smokeproof enclosure stair shall not continue below the grade level exit unless a barrier is provided at the ground floor level to prevent persons from continuing on into the basement.

xits Required
Continued)

The total exit width required from any story of a building shall be determined by using the occupant load of that story, plus the percentages of the occupant loads of floors which exit through the level under consideration as follows:

1. Fifty per cent of the occupant load in the first adjacent story above (and the first adjacent story below, when a story below exits through the level under consideration)

2. Twenty-five per cent of the occupant load in the story immediately beyond the first adjacent story.

The maximum exit width required from any story of a building shall be maintained.

(c) Arrangement of Exits. If only two exits are required they shall be placed a distance apart equal to not less than one-fifth of the perimeter of the area served measured in a straight line between exits. Where three or more exits are required they shall be arranged a reasonable distance apart so that if one becomes blocked others will be available.

(d) Distance to Exits. No point in an unsprinklered building shall be more than one hundred and fifty feet (150') from an exterior exit door, a horizontal exit, exit passageway or an enclosed stairway, measured along the line of travel.

In a building equipped with a complete automatic fire-extinguishing system the distance from exits may be increased to two hundred feet (200').

ors

Sec. 3303. (a) General. This Section shall apply to every exit door serving an area having an occupant load of more than 10, or serving hazardous rooms or areas. Subsections (h) and (i) shall apply to all doors, regardless of occupant load.

(b) Swing. Exit doors shall swing in the direction of exit travel when serving any hazardous area or when serving an occupant load of 50 or more.

Double acting doors shall not be used as exits serving a tributary occupant load of more than 100, nor shall they be used as a part of a fire assembly, nor equipped with panic hardware. A double acting door shall be provided with a view panel of not less than two hundred square inches (200 sq. in.).

(c) Type of Lock or Latch. Exit doors shall be openable from the inside without the use of a key or any special knowledge or effort.

EXCEPTION: This requirement shall not apply to exterior exit doors in a Group F or G Occupancy if there is a readily visible, durable sign on or adjacent to the door stating "THIS DOOR TO REMAIN UNLOCKED DURING BUSINESS HOURS." The sign shall be in letters not less than one inch (1") high on a contrasting background. The locking device must be of a type that will be readily distinguishable as locked. The use of this Exception may be revoked by the Building Official for due cause.

TABLE NO. 33-A—AVAILABLE SQUARE FEET PER OCCUPANT

Use[1]	Minimum of Two Exits Required Where Number of Occupants Is Over	Square Feet Per Occupant
Aircraft Hangars (No repair)	10	500
Auction Rooms	30	7
Assembly Areas, Concentrated Use (without fixed seats) Auditoriums, Bowling Alleys (Assembly areas), Churches and Chapels, Dance Floors, Lodge Rooms, Reviewing Stands, Stadiums	50	7
Assembly Areas, Less-concentrated Use: Conference Rooms, Dining Rooms, Drinking Establishments, Exhibit Rooms, Gymnasiums, Lounges, Skating Rinks, Stages	50	15
Children's Homes and Homes for the Aged	5	80
Classrooms	20	20
Dormitories	10	50
Dwellings	10	300
Garage, Parking	30	200
Hospitals and Sanitariums-Nursing Homes	5	80
Hotels and Apartments	10	200
Kitchen—Commercial	30	200
Library Reading Room	50	50
Locker Rooms	30	50
Mechanical Equipment Room	30	300
Nurseries for Children (Day-care)	5	50
Offices	30	100
School Shops and Vocational Rooms	50	50
Stores—Retail Sales Rooms: Basement	50	20
Ground Floor	50	30
Upper Floors	10	50
Warehouses	30	300
All Others	50	100

[1] Refer to Sections 3318, 3319, 3320 for other specific requirements.

Flush bolts or surface bolts are prohibited.

Doors (Continued)

EXCEPTION: Surface bolts of not less than one-half inch (½") [illegible] stock with a three-fourths inch (¾") minimum diameter control knob may be permitted. There shall be no more than [illegible]

For purposes of this section, basements and occupied roofs shall be provided with exits as required for stories.

EXCEPTIONS: [illegible] Group R, Division [illegible] occupancy [illegible] not [illegible] [illegible] square feet and [illegible] [illegible] immediately above the second story.

Floors complying with the provisions for mezzanines as specified in Section [illegible] shall be provided with exits as specified therein.

The second story shall be provided with not less than two exits when the occupant load is [illegible] or more. Occupants on floors above the second story and in basements shall have access to not less than two separate exits from the floor or basement.

EXCEPTIONS: 1. Two or more dwelling units on the second story or in a basement may have access to only one common exit when the total occupant load served by that exit does not exceed 10.

2. Except as provided in Table No. 33-A, only one exit need be provided from the second floor or a basement within an individual dwelling unit or a Group R, Division 3 congregate residence.

3. When the third floor within an individual dwelling unit or a Group R, Division 3 congregate residence does not exceed 500 square feet, only one exit need be provided from that floor.

4. Floors and basements used exclusively for service of the building may have one exit. For the purposes of this exception, storage rooms, laundry rooms, maintenance offices and similar uses shall not be considered as providing service to the building.

5. Storage rooms, laundry rooms and maintenance offices not exceeding 300 square feet in floor area may be provided with only one exit.

6. Elevator lobbies may have one exit provided the use of such exit does not require keys, tools, special knowledge or effort.

For special requirements see the following sections: Group A, Section 3317; Group E, Section 3318; Group H, Section 3319; Group I, Section 3320; Rooms Containing Fuel-fired Equipment and Cellulose Nitrate Handling Rooms, Section 3321; Reviewing Stands, Grandstands and Bleachers, Section 3322; Laboratories, Sections 702 (c) and 802 (d); and Open Parking Garages, Section 709 (g). For stage exits, see Section 3903 (f).

Every story or portion thereof having an occupant load of 501 to 1,000 shall not have less than three exits.

Every story or portion thereof having an occupant load of 1,001 or more shall not have less than four exits.

The number of exits required from any story of a building shall be determined by using the occupant load of that story plus the percentages of the occupant loads of floors which exit into the level under consideration as follows:

1. Fifty percent of the occupant load in the first adjacent story above and the first adjacent story below, when a story below exits through the level under consideration.

2. Twenty-five percent of the occupant load in the story immediately beyond the first adjacent story.

The maximum number of exits required for any story shall be maintained until egress is provided from the structure. (See Section 33[illegible].)

(b) **Width.** The total width of exits in inches shall not be less than the total occupant load served by an exit multiplied by 0.3 for stairways and 0.2 for other exits, nor less than specified elsewhere in this code. Such widths of exits shall be divided approximately equally among the separate exits.

The maximum exit width required from any story of a building shall be maintained.

(c) **Arrangement of Exits.** If only two exits are required, they shall be placed a distance apart equal to not less than one half of the length of the maximum overall diagonal dimension of the building or area to be served measured in a straight line between exits.

EXCEPTION: Exit separations may be measured along a direct line of travel within the exit corridor when exit enclosures are provided as a portion of the required exit and are interconnected by a one-hour fire-resistive corridor conforming to the requirements of Section 3305. Enclosure walls shall not be less than 30 feet apart at any point in a direct line of measurement.

Where three or more exits are required, at least two exits shall be placed a distance apart equal to not less than one half of the length of the maximum overall diagonal dimension of the building or area to be served measured in a straight line between the exits, and the additional exits shall be arranged a reasonable distance apart so that if one becomes blocked the others will be available.

(d) **Distance to Exits.** The maximum distance of travel from any point to an exterior exit door, horizontal exit, exit passageway or an enclosed stairway in a building not equipped with an automatic sprinkler system throughout shall not exceed 150 feet, or 200 feet in a building equipped with an automatic sprinkler system throughout. These distances may be increased a maximum of 100 feet when the increased travel distance is the last portion of the travel distance and is entirely within a one-hour fire-resistive corridor complying with Section 3305. See Section 3318 for Group E Occupancy and Section 3319 for Group H Occupancy travel distances.

In a one-story Group B, Division 4 Occupancy classified as a factory or warehouse and in one-story airplane hangars, the exit travel distance may be increased to 400 feet if the building is equipped with an automatic sprinkler system throughout and provided with smoke and heat ventilation as specified in Section 3206.

In an open parking garage as defined in Section 709, the exit travel distance may be increased to 250 feet which may be measured to open stairways which are permitted in accordance with Section 3309 (a).

(e) **Exits through Adjoining Rooms.** Rooms may have one exit through an adjoining or intervening room which provides a direct, obvious and unobstructed means of travel to an exit corridor, exit enclosure or until egress is provided from the building, provided the total distance of travel does not exceed that permitted by other provisions of this code. In other than dwelling units, exits shall not pass through kitchens, storerooms, restrooms, closets or spaces used for similar purposes.

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1004.2.3.4 Additional access to exits. Access to not less than three exits, exit-access doorways or combination thereof shall be provided when the individual or cumulative occupant load served by the exit access is 501 to 1,000.

Access to not less than four exits, exit-access doorways or combination thereof shall be provided when the individual or cumulative occupant load served by the exit access exceeds 1,000.

1004.2.4 Separation of exits or exit-access doorways. Where two or more exits or exit-access doorways are required from any level or portion of the building, at least two of the exits or exit-access doorways shall be placed a distance apart equal to not less than one half of the length of the maximum overall diagonal dimension of the area served measured in a straight line between the center of such exits or exit-access doorways. Additional exits or exit-access doorways shall be arranged a reasonable distance apart so that if one becomes blocked, the others will be available.

> **EXCEPTION:** The separation distance determined in accordance with this section may be measured along a direct path of exit travel within a corridor serving exit enclosures. The walls of any such exit enclosure shall not be less than 30 feet (9144 mm), measured in a straight line, from the walls of another exit enclosure.

1004.2.5 Travel distance.

1004.2.5.1 General. Travel distance is that distance an occupant must travel from any point within occupied portions of the exit access to the door of the nearest exit. Travel distance shall be measured in a straight line along the path of exit travel from the most remote point through the center of exit-access doorways to the center of the exit door. Travel distance shall include that portion of the path of exit travel through or around permanent construction features and building elements. Travel around tables, chairs, furnishings, cabinets and similar temporary or movable fixtures or equipment need not be considered as the normal presence of such items is factored into the permitted travel distance.

Unless prohibited elsewhere in this chapter, travel within the exit access may occur on multiple levels by way of unenclosed stairways or ramps. Where the path of exit travel includes unenclosed stairways or ramps within the exit access, the distance of travel on such means of egress components shall also be included in the travel distance measurement. The measurement along stairways shall be made on a plane parallel and tangent to the stair tread nosings in the center of the stairway.

1004.2.5.2 Maximum travel distance. The travel distance to at least one exit shall not exceed that specified in this section.

Special travel distance requirements are contained in other sections of this code as follows:

1. For atria, see Section 402.5.
2. For Group E Occupancies, see Section 1007.3.
3. For Group H Occupancies, see Section 1007.4.
4. For malls, see Sections 404.4.3 and 404.4.5.

1004.2.5.2.1 Nonsprinklered buildings. In buildings not equipped with an automatic sprinkler system throughout, the travel distance shall not exceed 200 feet (60 960 mm).

1004.2.5.2.2 Sprinklered buildings. In buildings equipped with an automatic sprinkler system throughout, the travel distance shall not exceed 250 feet (76 200 mm).

1004.2.5.2.3 Corridor increases. The travel distances specified in Sections 1004.2.5.2.1, 1004.2.5.2.2, 1004.2.5.2.4 and 1004.2.5.2.5 may be increased up to an additional 100 feet (30 480 mm) provided that the last portion of exit access leading to the exit occurs within a corridor. The length of [illegible] not be less than the amount of the increase ta[illegible]

1004.2.5.2.4 Open parking garages. In a G[illegible] open parking garage as defined in Section 3[illegible] tance shall not exceed 300 feet (91 440 mm[illegible] equipped with an automatic sprinkler system [illegible] feet (121 920 mm) in a building equipped with [illegible]kler system throughout. The travel distance in [illegible] open stairways which are permitted in accor[illegible] 1005.3.3.1.

1004.2.5.2.5 Factory, hazardous and storage [illegible] one-story building classified as a Group H, Div[illegible] pair hangar, or as a Group F or Group S Occupa[illegible] tance shall not exceed 300 feet (91 440 mm) an[illegible] to 400 feet (121 920 mm) if the building is equi[illegible] matic sprinkler system throughout and is al[illegible] smoke and heat ventilation as specified in Sect[illegible]

1004.2.6 Dead ends. Where more than one e[illegible] doorway is required, the exit access shall be a[illegible] there are no dead ends in hallways and corridors [illegible] (6096 mm) in length.

1004.3 Exit-access Components.

1004.3.1 General. Exit-access components mee[illegible] design of the exit-access portion of the means [illegible] shall comply with the requirements of Section 1[illegible]

1004.3.2 Aisles.

1004.3.2.1 General. Aisles serving as a portion [illegible] in the means of egress system shall comply with [illegible] of Section 1004.3.2. Aisles shall be provided fr[illegible] portions of the exit access that contain seats, tab[illegible] displays, and similar fixtures or equipment.

1004.3.2.2 Width in occupancies without fi[illegible] width of aisles in occupancies without fixed seat[illegible] mined in accordance with the following:

1. In areas serving employees only, the minim[illegible] shall be 24 inches (610 mm), but not less than [illegible] mined as specified in Section 1003.2.3.

2. In public areas of Groups B and M Occu[illegible] assembly occupancies without fixed seats, the [illegible] aisle width shall be 36 inches (914 mm) where se[illegible] nishings, displays and similar fixtures or equipmen[illegible] only one side of the aisle and 44 inches (1118 mm) [illegible] tures or equipment are placed on both sides of the [illegible]

The required width of aisles shall be unobstruct[illegible]

> **EXCEPTION:** Handrails and doors, when fully [illegible] reduce the required width by more than 7 inches [illegible] any position shall not reduce the required width by m[illegible] Other nonstructural projections such as trim and simil[illegible] tures may project into the required width [illegible] inche[illegible] each side.

1004.3.2.3 Occupancies with fixed seats. Aisles [illegible] with fixed seats shall comply with the requirements [illegible]

1004.3.2.3.1 Width. The clear width of aisles shal[illegible] the number of fixed seats served by such aisles. [illegible] width of aisles serving fixed seats shall not be used [illegible] purpose.

The minimum clear width of aisles in buildings wi[illegible] protected assembly seating shall be in accordance [illegible] 10-C.

The minimum clear width of aisles in buildings w[illegible] protected assembly seating [illegible]

From: "Sami Yli-Karjanmaa" <sami@11syyskuu.org>
To: <wtc@nist.gov>
Subject: Comment on Project 6 of the WTC study

To the National Institute of Standards and Technology

The fact that you systematically avoid the most important issues that need clarification is obvious for anyone who has studied the official story of 9/11 and seen through its gaping holes. The inevitable conclusion is that you are involved in the cover-up and protecting the real perpetrators. -- If I am mistaken, please prove that by including in the final report the following:
- modeling of how the collapse was able to proceed through dozens of structurally intact floors: please include analyses of both preservation of momentum and sufficiency of the potential energy available and show that the extreme speed of the collapses was possible without external energy used to break the structures;
- what caused the collapses to be so symmetrical in spite the fires and impact damage having been anything but;
- what forces and energies pulverized the non-metallic materials of the towers so completely;
- what caused the explosions in the lobby of at least the North Tower as well as the widely reported explosions in the basement: if you say it was the jet fuel, please include calculations of how big a pressure it was able to cause on various floors as it went down the elevator shafts, and how much oxygen was needed for that pressure increase to take place;
- what caused the extremely hot spots in the rubble seen in the NASA measurements; and,
- what caused the vaporization (!) of some of the steel of WTC7 of which Prof. Astaneh-Asl has told in public.

The truth is the force that sets us free, and that applies to you, too.

Sincerely,

Sami Yli-Karjanmaa
Helsinki, Finland

Eric Douglas
156-33 94th St
Howard Beach, NY 11414
7-28-05

WTC Technical Information Repository
Attention: Mr. Stephen Cauffman
National Institute of Standards and Technology
Stop 8610
Gaithersburg, MD 20899-8610

RE: Public Comment

Dear Mr. Cauffman,

Please include the enclosed comments into the body of public comments to be considered in revising the current draft of the WTC Investigation reports.

NIST has produced an overwhelming body of data related to the WTC building collapses. Although the investigation has been thorough, I have noticed several issues that have not yet reached full resolution. I very much look forward to the release of the final version of the reports with these and other unresolved issues addressed.

Regards,
Eric Douglas

Email to follow.

REPORT	CHAPTER	PAGE	PARAGRAPH/ TABLE/ FIGURE	SECTION	QUESTION
NIST NCSTAR 1-1					
	8	124	5	8.5.3	WHAT SOURCE SUGGESTED THAT FIREPROOFING WAS MISSING FROM THE 5TH FLOOR OF BLDG #7?
	10	166	2	10.4.8	WHY WERE FIREMEN UNABLE TO DEPLOY OPERATORS TO FIRE PUMPS?
	12	177	1	12.3	WHAT EVIDENCE SUGGESTS THAT THE COLLAPSE OF WTC1 RESULTED IN FRACTURES IN THE FUEL PIPING SYSTEM IN BLDG 7?
	12	177	5	12.3	WHO WAS RESPONSIBLE FOR EXAMINING THE GROUND BELOW THE LOCATION OF THE FUEL TANKS IN BLDG 7?
NIST NCSTAR 1-2					
	EXEC. SUM.	xlix	1	E.3.2	WHAT WAS THE PURPOSE OF THE WIND TUNNEL TEST PERFORMED BY CPP AND RWDI? ARE THE RESULTS OF THESE TESTS AVAILABLE?
	EXEC. SUM.	lxx	2	E.5.3	COMPONENT IMPACT ANALYSIS CONCLUDED THAT THE POST-PENETRATION INERTIA OF A JET ENGINE COULD FAIL, AT MOST, ONE CORE COLUMN. SINCE THE ENGINES WERE, BY FAR, THE DENSEST COMPONENTS, ON WHAT BASIS DOES NIST CONCLUDE THAT MORE THAN TWO CORE COLUMNS COULD HAVE FAILED?
	EXEC. SUM.	lxxv	1	E.7	WHICH PART OF THE COLLAPSE SEQUENCE WOULD NOT HAVE OCCURRED UNDER THE "LESS SEVERE DAMAGE" CASE?
	EXEC. SUM.	lxxxvii	11	E.7.2	WHICH AIRCRAFT COMPONENTS, OTHER THAN THE ENGINES, FAILED CORE COLUMNS IN SIMULATIONS?
	1	4	4	1.3	WHERE IS A COPY AVAILABLE OF THE 2001 RISK ASSESSMENT REPORT PREPARED FOR SILVERSTEIN PROPERTIES?
	1	5	4	1.3	WHY DID BOEING NOT SUPPLY A SUITABLE MODEL OF A 767?
NIST NCSTAR 1-3					
	EXEC. SUM.	xliv	3	E.6	WHY WAS NO STEEL RECOVERED FROM WTC7?
NIST NCSTAR 1-4					
	3	23	2	3.5.1	DOES NIST BELIEVE THAT BLDG 7 WAS INSUFFICIENTLY SPRINKLERED, OR THAT THE SPRINKLER SYSTEM WAS IN ANY WAY COMPROMISED?
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	3	31	3, 4	3.7	IS THERE ANY EVIDENCE TO SUGGEST EITHER A LOSS OF POWER TO THE FIRE PUMP OR SIGNIFICANT DAMAGE TO THE UNDERGROUND CITY MAIN?
	3	35	3	3.9.2	WERE THE OBSERVED FIRES WITHIN BLDG 7 WITHIN THE ESTIMATED CAPACITY OF THE SPRINKLER CONTROL SYSTEM?
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	3	39	3-8	3.10	WITH ONLY ONE OF THREE RISERS COMPROMISED IN WTC2, WHY WAS THE SPRINKLER SYSTEM IN EFFECTIVE?
	3	40	3	3.10	WHO CLAIMED THAT THERE WAS NO WATER IN THE STANDPIPES OF BLDG 7 AND HOW WAS THIS DETERMINED?
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	4	66	4	4.5.2	WHO IS WILLIAMS, WHAT WAS HIS AUTHORITY, AND WHY WAS THE FIRE DETECTION SYSTEM PLACED ON 'TEST' FOR THE SEVEN DAYS PRECEEDING THE COLLAPSE?
	6	93	4		WHY WAS THE ACTIVE FIRE PROTECTION SYSTEM USED IN WTC7 "UNABLE TO PERFORM AS DESIGNED...DUE TO THE SEVERITY OF THE DAMAGE AND SIZE OF THE FIRES"?

NIST NCSTAR 1-5						
	2	9	2-1	2.2.1	WHAT WAS THE "BRIGHT FLASH AT FRONT OF PLANE" AT TIME 0.03 SECONDS?	
	2	15	2	2.2.4	WHAT WAS THE "PRESSURE PULSE" TRANSMITTED TO WTC1 FROM THE COLLAPSING WTC2?	
	2	15	2	2.2.4	WHY DID THIS CAUSE FIRE AND SMOKE TO BE PUSHED OUT OF THE SOUTH FACE OF WTC1?	
	2	15	2	2.2.4	WHAT EVIDENCE SHOWS THIS EVENT?	
	2	15	2	2.2.4	WHY WOULD THE PRESSURE PULSE CAUSE FLAMES TO PUSH OUT OF THE 98TH FLOOR (AND NOT OTHERS)?	
	2	15	3	2.2.4	WHAT WAS THE CAUSE OF THE FLARING AND BRIGHTENING OF FIRES IN WTC1 AT TIME OF WTC2 COLLAPSE?	
	2	17	1	2.2.4	WHAT CAUSED THE BRIGHT FLAMES TO BE EXPELLED FROM THE SOUTHERN SIDE OF THE 98TH FLOOR OF WTC1 3 SECONDS PRIOR TO COLLAPSE?	
	2	22	2-2	2.3.1	WHAT IS THE ORANGE FLASH SEEN AT 0.03 SECONDS AND THE LARGE OBJECT AT 0.50 SECONDS?	
	2	23	2-5	2.3.1	WHAT IS THE FIGURE AT THE RIGHT SIDE OF THE IMAGE NEAR THE TOP OF THE WOOLWORTH BLDG.?	
	2	28	7	2.3.5	WAS ONE (OR BOTH) OF THESE THE LARGE OBJECT FROM TABLE 2-2 AT 0.50 SECONDS?	
	2	31	3	2.3.7	WHAT CAUSED THE "PUFFS OF SMOKE" OBSERVED ON THE 79TH, 80TH, AND 81ST FLOORS?	
	2	32	3	2.3.7	WHAT CAUSED THE "PUFFS OF SMOKE" OBSERVED ON THE 79TH, 80TH, AND 81ST FLOORS?	
	2	34	2,3	2.3.7	WHAT CAUSED THE "PUFFS OF SMOKE" OBSERVED ON THE 79TH, 80TH, AND 81ST FLOORS?	
	3	49	3	3.1.4	SINCE ONLY 2% OF COMBUSTABLES WOULD HAVE BURNED ON OXYGEN-CONTROLLED FLOORS, CAN FIRE FLOORS WITH INTACT WINDOWS BE ASSUMED TO HAVE NOT CONTRIBUTED TO THE COLLAPSE?	
	3	50	3	3.2.1	HOW DOES THE FINDING THAT OFFICE FURNISHINGS CAN SUSTAIN INTENSE FIRES OF AT LEAST AN HOUR'S DURATION COMPARE TO TABLE 3-5 WHICH SHOWS A MAXIMUM TIME TO PEAK OF UNDER 10 MINUTES?	
	6	180	1	6.15	WOULD APPLICATION OF THE FIRE SCENARIOS IN CASES 'A' AND 'C' HAVE LED TO COLLAPSE?	
NIST NCSTAR 1-6						
	EXEC. SUM	lxxii	4,5	E.5.2	HAVE ANY FIRE RESISTANCE TESTS SUPPORTED THE THEORY THAT THE WTC FLOOR ASSEMBLIES WOULD HAVE FAILED DUE TO COMPROMISED SFRM?	
	4	71	1	4.2.2	WHAT EXPLAINS THE DIFFERENCE BETWEEN THE FEA MODEL AND THE FIRE RESISTANCE TESTS, ESPECIALLY WITH REGARD TO THE TRUSSES "WALKING OFF" OF THE SEATS?	
	4	89	10	4.2.5	WHAT EXPLAINS THE DIFFERENCE BETWEEN THE FEA MODEL AND OTHER TESTS WITH REGARD TO KNUCKLE FAILURE?	
	5	121	2	5.1	WHICH KEY OBSERVABLES ARE INCONSISTENT WITH THE LESS SEVERE CASE?	
	5	129	2	5.2.3	WHY IS THE ADHESION/COHESION VALUE OF 12 PSI USED IN SIMULATION INSTEAD OF 185 PSI AND 367 PSI AS LISTED IN TABLE 2-4?	
	5	146	1	5.5	HOW WAS THE IMPACT SPEED OF THE PLANE THAT HIT THE PANTAGON DETERMINED?	
	6	154	6-1	6.2.1	WHAT WAS THE TOTAL TIME OF COLLAPSE OF WTC1?	
	6	167	6-2	6.2.1	WHAT WAS THE TOTAL TIME OF COLLAPSE OF WTC2?	
	7	192	1	7.3.1	WHY WAS THE TENSILE YIELD STRENGTH OF THE CONCRETE MATERIAL MATCHED TO THE COMPRESIVE YIELD STRENGTH?	
	9	275	4	9.1	WHERE IS THE EXPLANATION GIVEN AS TO WHY WTC1 TOOK LONGER TO COLLAPSE THAN WTC2?	
	9	275	5	9.1	WHERE IS THE EXPLANATION GIVEN AS TO WHAT FACTORS COULD HAVE DELAYED THE COLLAPSE?	
	9	310	5	9.4.1	SINCE WTC2'S CORE WAS LESS AFFECTED, WHY WAS ITS TIME TO COLLAPSE SHORTER?	
	9	312	1	9.4.3	OTHER THAN ASYMMETRIC DAMAGE, WHAT EXPLAINS WTC2'S SHORTER TIME TO COLLAPSE?	

INTERIM REPORT, CHAPTER 1			
	6	1.2	What evidence shows that the sprinkler systems were significantly compromised in WTC 1, 2 & 7?
	9	1.2	(finding 1a.7) Why did the aviation unit believe at 10:06 am that WTC1 would soon collapse?
	17	1.3	What initiating event for bldg 7 has been identified and what evidence supports this conclusion?
	17	1.3	What times are found in simulation for vertical and horizontal progression failures in bldg 7?
	17	1.3	Should statement of complete steel collection (sec. 1.2 p 9) be revised?
	17	1.3	Why was no steel collected from building 7?
	18	1.3	(finding 1b.3) How extensive is the damage shown in photographic and videographic evidence of the south face and SW corner?
	18	1.3	(finding 1b.3) How reliable is the report of elevator cars being ejected?
	18	1.3	(finding 1b.4) What initiating event is suggested for the fires on floors 22, 29 & 30 before 2pm?
	18	1.3	(finding 1b.4) What initiating event is suggested for the fires on floors 11 & 12 around 2pm?
	18	1.3	(finding 1b.4) What initiating event is suggested for the fires on floor 7 around 3pm?
	18	1.3	(finding 1b.4) What initiating event is suggested for the fires on floors 8 &13?
	18	1.3	(finding 1b.4) Who knew that there was no water in the standpipe system, how did he know this, and why was this the case?
	19	1.3	(finding 1b.5) Who was the owner of the two 6,000-gal tanks supplying the fifth-floor generators and which was the environmental firm contracted to examine the fuel tanks?
	19	1.3	(finding 1b.5) Who reported that the fuel tanks were full and on what basis?
	27	1.4	What accounts for the difference in fire suppression response between the fire of 2-14-05 and the fire of 9-11-01 in WTC1?
	28	1.4	(finding 2.23) What evidence shows that the water sprinkler system was compromised?
	28	1.4	Who placed the building fire alarm in WTC7 on "test" at 6:47 am on 9-11-01 and why?
	33	1.5	What results were found for the U.L. floor system tests?
	41	1.6	What technical solutions is NIST recommending?
INTERIM REPORT, CHAPTER 2			
	50	2.2.2	(task 3) What information was found regarding the fire protection systems operating procedures, and maintenance history of the WTC7 fuel system?
	64	2.2.5	(table 2-2 #7) Were the sprinkler systems in WTC 1, 2 & 7 in any way sub-optimal prior to aircraft impact?
	66,67	2.2.6	What evidence shows whether the shut-off system for the transfer pump was activated?
	67	2.2.6	Is there any evidence that power failure activated the emergency generators, thus pressurizing the fuel lines?
	93	2.5.4	(see sec. 1.2 p 6)
	93	2.5.5	Why was no specific fire information sent to the monitoring site?
	94	2.5.5	Who was the bldg manager and why did he place the fire alarm system in a "TEST: ALL" condition at 6:47 am on 9/11/01?
	94	2.5.5	Who was AFA operator "RIC" and what role did he play?
	94	2.5.5	Who was "Williams" and what authority did he have?
	94	2.5.5	Why was the system placed on test every day from 9-4-01 to 9-11-01?
	94	2.5.5	What triggered the fire condition indicator at 10:00:52 am in WTC7?
	96	2.5.6	Which utilities were in risers in the path of penetrating aircraft and which services were likely unaffected by impact?
	97	2.6.1	What progress has been made in identifying the source and location of fire ignition and the progression of the fire in WTC7?
	122	2.7.5	What are the results of the U.L. tests?
	123	2.7.6	What are the results of the WTC7 model analysis?
	124	2.7.6	Who reported elevator cars ejected from floors 8 or 9, at what time, and what are the details surrounding this event?
	124	2.7.6	What path of fire progression is speculated to have caused fire first to appeatr on floor 7 of WTC 7 at 3pm?
	124	2.7.6	What evidence suggests that fires on floor 5 ignited, received adequate ventilation, reached the fuel distribution system, and progressed vertically without being visually identified on floor 6?
	127	2.7.6	What analysis suggests that vertical supports would fail (in bending) before horizontal connections (in tension)

INTERIM REPORT, APPENDIX 'L'						
		17	11,12	L.2.1	WHY DID THE EAST & WEST STAIRWELLS FILL WITH DUST & SMOKE AND LOSE LIGHTS JUST BEFORE THE COLLAPSE OF WTC1?	
		17	13	L.2.1	WHY DID FLOORS 7 AND 8 LOSE POWER AND THE AIR BECOME UNCLEAR JUST BEFORE THE COLLAPSE OF WTC1?	
		18	10	L.2.1	WHY WERE ELEVATOR CARS EJECTED FROM THEIR SHAFTS ON THE 8TH AND 9TH FLOORS AND WHO REPORTED THIS CONDITION?	
		18	12	L.2.1	WHY WERE PEOPLE STILL IN THE BLDG ON FLOORS 7 AND 8 AT 12:10PM?	
		18	13	L.2.1	WHAT WAS THE SOURCE OF THE DUST AND SMOKE ON FLOOR 8 AT 12:10PM?	
		18	14	L.2.1	WHY WAS THERE A CUBICLE FIRE ON THE WEST WALL ON FLOOR 7 AT 12:10PM?	
		18	15	L.2.1	WHY WAS NO HEAVY DEBRIS IN THE LOBBY IF THE ELEVATOR CARS WERE EJECTED NEARBY?	
		22	5	L.2.2	HOW WAS THE FIRE DETECTED ON FLOOR 23 FROM FLOOR 22?	
		27	L-1	L.2.3	WHAT WAS THE ESTIMATED TIME OF COLLAPSE OF BLDG 7?	
		30	3	L.2.4	HOW COULD THE BREAKING OF A BOTTOM WINDOW AND THE SIMULTANEOUS KINKING IN THE EAST PENTHOUSE BE THE RESULT OF A SINGLE INITIATING EVENT?	
		30	6	L.2.4	WHAT INITIATING EVENTS COULD HAVE LED TO COLLUMN FAILURE?	
		33	2	L.2.5	BY WHAT MECHANISM DID BLDG 7 COLLAPSE "FROM BELOW THE VISIBLE AREA" AND AT THE PENTHOUSE WITHOUT VISIBLE COLLAPSE TAKING PLACE INBETWEEN?	
		35	2-34	L.3.1	WHY DID CONNECTIONS NOT FAIL IN TENSION TO PREVENT "HORIZONTAL PROGRESSION"?	
		36	6	L.3.2	WHY DID DEBRIS DAMAGE SEVER INTERIOR COUMNS AND NOT EXTERIOR COLUMNS?	
		38	5	L.3.2	WHY WOULD "THERMAL CONTRACTION FORCES" NOT HAVE SIMPLY SHIFTED LOADS BACK TO THEIR ORIGINAL VECTORS?	
		39	4	L.3.2	WOULD THE "COVER PLATE WELD...BEGIN TO YIELD AT A MEAN TEMPERATURE OF 490C" WITH UNCOMPROMISED FIRE PROTECTION?	
		41	2	L.3.3	DID THE "COLLAPSE MECHANISM MODEL" THAT DISPLAYED THE "KINEMATICS OF THE COLLAPSE MECHANISM" SHOW A HORIZONTAL PROGRESSION?	
		45	1	L.3.3	WHY WAS THE LINE OF BROKEN WINDOWS NOT OBSERVED PROGRESSIONG UP FROM LOWER FLOORS?	
		47		L-46	HOW WELL DO SCENARIOS H2.2, H2.5, AND H2.7 AGREE WITH THE KINEMATIC MODEL?	
		51	6	L.3.5	TO WHICH PRECEDENTS OF "CLASSIC PROGRESSIVE COLLAPSE" DOES NIST COMPARE THE WORKING HYPOTHESIS OF THE BLDG 7 FAILURE?	
		52	2	L.3.6	WHICH "SCENARIOS THAT ARE NOT PREDICTED TO MATCH THE OBSERVED DATA" WILL NIST BE TESTING?	

Subject: WTC Comments
From: "Rhonda Lynn" <RLynn@iccsafe.org>
To: <wtc@nist.gov>

Attached are the comments submitted by the International Code Council on the World Trade Center Investigation Draft Final Reports.

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WTC Comments Final 7-05.pdf

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August 4, 2005

WTC Technical Information Repository
Attention: Mr. Stephen Cauffman
National Institute of Standards and Technology
Stop 8610
Gaithersburg, MD 20899-8610

Subject: Responses to Request for Public Comments on WTC Investigation Draft Final Reports (70 Fed Reg 38105 et. sec., July 1, 2005)

Dear Mr. Cauffman:

The International Code Council® (ICC®) submits the attached comments to the National Institute of Standards and Technology (NIST) on the draft NIST reports concerning the WTC investigation (70 Fed Reg 38105). The ICC would like to commend NIST and its subcontractors on the quality and thoroughness of the reports. The level of effort, complexity of the issues, organization and presentation, thoroughness and professionalism associated with and exhibited by the reports is commendable and well represents to others in the U.S. and the world the technical and management capabilities and expertise of the U.S. public and private sectors.

The ICC is a membership association dedicated to building safety and fire prevention. The ICC mission is to provide the highest quality codes, standards, products, and services for all concerned with the safety and performance of the built environment. This mission and the activities of the ICC directly relate to providing a safe physical environment through the adoption, implementation and use of codes and standards developed under the auspices of the ICC and the provision of a robust infrastructure to support those codes and standards. These codes and standards, and the support infrastructure ICC provides for them, coupled with the ICC membership in the public and private sector, are a vehicle through which NIST and others can realize change in and enhancements to the built environment.

The codes developed under the auspices of the ICC, with the involvement of all interested and affected parties, serve as a baseline for the design, construction, operation and maintenance of the majority of both public and private sector buildings in the U.S. Through their adoption and implementation by Federal, state and local government, buildings are increasingly safer and more responsive to the growing challenges we all face.

The ICC Codes (I-Codes®) are readily recognized and understood by building owners, product manufacturers, designers, contractors, code officials and all others involved in building design, construction, approval, and operation. The International Fire Code®, International Building Code®, International Existing Building Code® and 11 other ICC codes contribute to making the built environment safer. Once these reports are finalized ICC encourages NIST to take an active role in the ICC code development process and/or assist others who are motivated to use the research NIST has conducted related to the WTC. ICC staff has provided briefings to NIST staff on this process and will be pleased to provide additional assistance as required by NIST to facilitate bringing the results of the NIST investigation to the public forum managed by ICC.

The attached comments focus on specific areas in the NIST reports that are associated with building regulations, codes, standards and related issues. All comments are in the form requested by NIST, listing the report number, page, sentence and paragraph and then the comment, reason and suggested revision. In some instances the comments are editorial in nature or suggest clarifying language. Other comments are more substantive in nature and we trust they will be considered in the collaborative and supportive manner in which they are intended.

One common thread in a number of ICC's comments is the manner in which the reports refer to building regulations, codes, model codes, building codes, standards, and similar terms and then also refer to specific documents such as the NYC Building Code, BOCA Basic Building Code, ICC International Building Code, etc. As different NIST authors and contractors were involved in writing the reports it is understandable that different terms associated with building codes, standards, regulations, etc. would be used. Being intimately familiar with the U.S. system of development, adoption, implementation and enforcement of building regulations, ICC had some difficulty with these aspects of the reports and at times questioned the accuracy of portions of the reports.

As these reports will be read with interest by a vast world-wide audience, ICC feels it is important to be clear, consistent and precise when discussing building regulations and associated terms, whether in general or with respect to specific documents. For this reason a number of ICC's comments have attempted to revise the reports so they are consistent and more accurate. In addition, as the U.S. system of building regulations is unique and can be quite confusing to others not intimately familiar with the U.S. system, the ICC has also recommended that an appendix document be developed for the reports that provides an overview of the U.S. system and can serve as a needed foundational piece for better understanding the reports and implementing the recommendations. ICC would be pleased to work with NIST staff on the creation of such an appendix to the reports.

The ICC appreciates the opportunity to provide this input to NIST. Once again ICC would like to commend NIST for the valuable and comprehensive work that has been performed in completing the subject reports. Should additional information be needed, or should NIST want to participate in the code development process or involve ICC further through our relationship with state and local officials and the building community, please do not hesitate to contact us.

Sincerely,

Sara C. Yerkes

Sara C. Yerkes
Senior Vice President of Government Relations

Comments on NIST Reports on World Trade Center Investigation

International Code Council Staff

August 4, 2004

The following comments apply to the report number indicated and are in order of the presentation of reports by NIST (e.g. 1, 1-1, 1-2, etc.). Where comments are made on a particular report and review of reports that form a basis for that particular report (e.g. 1-4D forming a basis for 1-4) indicates the same comment would be applicable ICC assumes that in accepting the comment to the primary report (e.g. 1-4) that the text upon which the primary report is based will be similarly corrected in the supporting report (e.g. 1-4D) and has, therefore not restated the comment from the primary report in its review and comment of the supporting report.

Report Number: NCSTAR 1 (Executive Summary of the Final report)

Page Number: Section E.1 page xli

Paragraph/Sentence: 2nd bullet and item 4

Comment: The terms "codes, standards, and practices" and "building and fire codes, standards and practices" are used and area focus of the objectives of the study.

Reason for Comment: Clarification and to establish an understanding early on the role codes, standards and practices can play in addressing building safety and performance.

Suggestion for Revision: Add a footnote to provide further clarification to the above citations as follows: "The enhancement of building design, construction, and operation can be affected trough mandatory means such as building construction regulations. It can also occur through market forces that create change in the absence of regulatory action. The terms building and fire codes, standards and practices are presented in a generic sense. It is recognized that these documents are typically developed within the U.S. voluntary sector and then made available for adoption as a basis for building regulations as well as voluntary programs outside the regulatory community. In using the terms "codes, standards, and practices" throughout these reports it is the intent of NIST to recommend enhancement, revision, and improvement to such documents as well as to foster their increased adoption and implementation through appropriate building regulatory and voluntary market driven mechanisms."

Page Number: xlv and 172

Paragraph/Sentence: 1st paragraph second sentence on page xlv and last bullet on page 172

Comment: The statement that egress capacity from current building codes is based on single floor calculations should be changed if it is intended to apply to model building codes or clarified if it applies to current NYC building codes.

Reason for Comment: As presented the statement is misleading. First, as noted above, the appropriate term in this case is building regulations. Building codes are one vehicle to address this issue but there are other documents that, while not specifically named building codes, address this issue and are part of a larger set of regulatory documents. From a technical standpoint the issue of egress is based on occupant load and not single floor calculations. Pursuant to Chapter 10 of the International Building Code (IBC), a document adopted by the vast majority of federal, state and local agencies, required egress width is determined based on the total occupant load served by the means of egress. In multi-story buildings the occupant load associated with each floor would be additive with the load from above stories in determining egress capacity moving downwards through the building.

Suggestion for Revision: "Egress capacity required by the building codes adopted and enforced for the WTC buildings …."

Page Number: xlv

Paragraph/Sentence: First full bullet

Comment: The report refers to the New York City Building Code. It is not clear at this point in the report if the reader fully understands that building codes, fire codes, standards and practices in New York City are different than most other areas of the United States. This is because presently NYC develops its own building code as opposed to basing their code on national model codes.

Reason for Comment: As written the report is misleading and confusing as to the subject of building codes.

Suggestion for Revision: "…deck, the building code that was applicable to the WTC buildings, which was the New York City building code, required ….." (e.g. be specific as to the code that the WTC was required to be designed and constructed to.)

Page Number: xlv

Paragraph/Sentence: Second full bullet, last sentence

Comment: The cause of the shaft enclosures not being fire rated is not presented.

Reason for Comment: As written the report is misleading.

Suggestion for Revision: "…but under the codes that governed the design and construction of the WTC they were not required to…"

Page Number: xlvi

Paragraph/Sentence: Second bullet, first sentence

Comment: the term "external building code" is confusing. Note also in following the above comments there is a pattern within the report of using different terms to refer to building codes. Each is different and has a specific meaning within the context in which they are used. It is strongly suggested that the report provide, possibly in the footnote suggested above, an overview of the code environment applicable at the time of the construction of the WTC. This should highlight the existence of national model codes, standards and practices on the voluntary sector side as well as the existence of a state code in New York, a separate NYC code and then a separate code for Port Authority structures that applied to the WTC.

Reason for Comment: To clarify the report.

Suggestion for Revision: "…. buildings were not subject to other Federal, state or local codes that might have applied had the Port Authority not been considered as a separate "municipality".

Page Number: xlvi

Paragraph/Sentence: Second bullet, all but the first sentence

Comment: The text may not adequately present the intended conclusion in a defensible manner. As there were a considerable number of "other" building codes at that time it is not likely that the design was compared to those codes. In addition the concept of approval processes is raised. While it is relevant to refer to the approval processes of the Port Authority compared to those of the city, the statement about "other building codes of that time" is not relevant to approval processes as they are determined by state and local government.

Reason for Comment: To improve the accuracy of the report and eliminate confusion between code requirements and approval processes.

Suggestion for Revision: "Nevertheless, the actual design and approval process produced two buildings that appear generally consistent with nearly all of the provisions of the New York City Building Code and the approval processes of the city in effect at that time. The loads for which the building was designed exceeded those of the New York City Code. The quality of the structural steels was consistent with the building specification. The departures from the New York City building code did not have a significant effect on the outcome of the events of September 11."

Page Number: xlvi

Paragraph/Sentence: Fifth bullet, first sentence

Comment: the term "selected other building codes of the day" is too general and misleading. Some readers may also be confused because other building codes applicable in other areas would not logically have wind loading criteria for NYC in them.

Reason for Comment: improve the accuracy of the report.

Suggestion for Revision: "…Code and the wind loads found in national model codes and standards available at the time the WTC was designed." Alternatively note by name the specific "building codes of the day" that were selected and upon which this portion of the report is based.

Page Number: xlvii

Paragraph/Sentence: First paragraph, second sentence

Comment: the term "building codes" is not broad enough to address the point being made. Building codes are a subset of a larger body of requirements commonly considered building construction regulations. Such regulations include the building code but also fire codes, structural design and loading standards and a number of other relevant criteria not found in a "building code" but relevant to the subject of design to address the impact from aircraft.

Reason for Comment: clarify the report.

Suggestion for Revision: "…severity; building construction regulations do not…."

Page Number: xlvii and 200

Paragraph/Sentence: First bullet and item 1

Comment: standards cover the design and construction of structural systems

Reason for Comment: clarification

Suggestion for Revision: "…and the design and construction of …"

Page Number: xlvii and 200

Paragraph/Sentence: Second and third bullets and items 2 and 3

Comment: procedures and practices do address fire resistance but so to do codes and standards

Reason for Comment: clarification

Suggestion for Revision: "The codes, standards and practices used to ensure…"

Page Number: xlvii and page 200

Paragraph/Sentence: Third bullet and item 3, last sentence

Comment: technical standards are not necessarily barriers to the introduction of new materials. For instance all codes typically include a section on alternative methods of construction and materials that allow anything to be used as long as it can be shown to be no more hazardous or less safe than something specifically allowed by the codes. Through testing, simulation, calculations, etc. such equivalency can be supported. The key, however, is that the barriers are not in the technical or standards side as much as they are in the availability of regulatory officials to review and consider such alternatives and/or the reluctance of building owners and designers to try them due to the additional work that must be undertaken to secure their approval.

Reason for Comment: to ensure the report accurately reflects what is available to facilitate the introduction and use of new technology.

Suggestion for Revision: replace the last sentence as follows: "The introduction of new materials and technologies should be encouraged through increased use of provisions in codes and standards that allow for the assessment of new technology on the basis of performance and education of the design, construction and regulatory communities on ways to measure, express and access such performance."

Page Number: xlviii and page 200

Paragraph/Sentence: second bullet and item 7

Comment: no mention is made of code administration and enforcement. Code administration and enforcement are critical elements in making sure that what is provided by designers and others as meeting code is reviewed at the time of design submittal for code compliance and is then checked during construction to ensure the final building meets code. The recommendation speaks to design, construction, etc. and encouraging code compliance by non-governmental and quasi governmental entities. In reality all buildings of the nature addressed by the WTC investigation will be designed and constructed under federal, state and/or local codes and standards. A recommendation to encourage code compliance is misplaced.

Reason for Comment: as presented the recommendation does not focus on a key component that will ensure better building performance.

Suggestion for Revision: revise the recommendation to read as follows: "The procedures and practices used in the design, construction, review, approval and maintenance and operation of buildings should be enhanced to further ensure that the plans and specifications meet or exceed code. This should be provided at initial occupancy and during the life of the building. The records associated with as-built and operational conditions should be retained during the life of the building. Technological changes applicable to egress and fire detection and protection should also be applied to existing buildings."

Page Number: xlviii and page 200

Paragraph/Sentence: Third bullet and item 8

Comment: there is a need to train all those associated with building design, construction, operation, maintenance, review and approval. As written the focus is on professionals with no inclusion of the individuals in the building regulatory or fire service sectors.

Reason for Comment: increase scope of recommendation to apply to all those who can impact building safety.

Suggestion for Revision: add a second sentence as follows: "The skills of building regulatory and fire service sector individuals should also be upgraded so as to compliment the enhanced skills of building designers and enhance their knowledge of building technology, conformity assessment and other factors affecting delivery and maintenance of safe buildings.

Page Number: xlviii

Paragraph/Sentence: fourth paragraph

Comment: a statement is made about waiting for codes, standards and practices to change. While these documents are relevant to improvements in building safety, as previously noted these documents are part of a larger set of building regulations. In addition, since codes and standards are developed in the voluntary sector, it is more appropriate to recognize that one should not wait until building regulations change.

Reason for Comment: clarification

Suggestion for Revision: "....without waiting for changes to occur in building regulations."

Page Number: xlviii

Paragraph/Sentence: last paragraph

Comment: as written the text does not address federal buildings.

Reason for Comment: clarification and enhancement.

Suggestion for Revision: change to read as follows: "NIST further urges federal, state and local agencies having any responsibility for building design, construction, approval, inspection, operation and maintenance to rigorously implement and enforce building regulations to ensure that the level of safety intended by those regulations is actually delivered at initial occupancy and during the life of the building. Unless they are satisfied, the best building regulations, codes and standards which make up those regulations and their foundational research cannot effectively provide for the intended public safety."

Page Number: xlix

Paragraph/Sentence: headings under "responsible community"

Comment: the titles applied to "responsible community" are confusing. These need to be changed to more clearly designate who is responsible for each action.

Reason for Comment: clarification

Suggestion for Revision: Change the designations of responsible community to actual job descriptions or titles so individuals will know who has what responsibility. For instance "adoption and enforcement" should be changed to "federal, state and local government agencies". Education and training could be changed to university and college, trade associations, and government.

Page Number: 1

Paragraph/Sentence: last paragraph, second sentence

Comment: the term building codes, as noted before, can have different meanings to different people. The focus should be on the building regulations or building construction regulations, which include building codes but many other requirements such as fire, mechanical, zoning, etc.

Reason for Comment: clarification

Suggestion for Revision: change building codes to building construction regulations (e.g. building, fire, mechanical, electrical, etc. codes, zoning regulations, etc.) It is also suggested that consideration be given to the use of the term building construction regulations or building regulations as appropriate throughout the document when referring to the broad body of requirements applied to buildings and more specific documents such as building code, fire code, etc. when a more precise focus is warranted.

Page Number: 6

Paragraph/Sentence: Second paragraph, last line

Comment: the text refers to allowance by some state and local codes for alternative designs. It is assumed that NIST researched this and the statement is based on code in effect in the late 60's. Virtually all current state and local codes have provisions for acceptance of building designs, materials, and technologies on the basis of equivalent performance. As written the text suggests that "some" do, which may not adequately describe the degree to which performance equivalency is allowed.

Reason for Comment: Clarification.

Suggestion for Revision: change "some" to "most" or if statistical data were not developed that support "some" then eliminate the subjective statement and simply report that state and local codes provide a performance alternative without trying to equate or report how many.

Page Number: 6

Paragraph/Sentence: footnote 3

Comment: reference is made to the prescriptive codes. It is unclear which codes the report is referring to.

Reason for Comment: clarification.

Suggestion for Revision: "...was not accounted for in the building regulations that governed the design and construction of the WTC towers."

Page Number: 8

Paragraph/Sentence: second paragraph

Comment: the report mentions the unique nature of the pre-fabricated modular approach to constructing the steel structural elements but does not appear to cover (at least on page 8) the impact that this has on inspection associated with building regulatory compliance as well as design verification. The report should mention how fabrication of the structural steel elements was inspected off-site, by whom and was determined to satisfy the design, specifications and relevant codes and standards adopted as part of the building regulations.

Reason for Comment: enhance value of the report and to cover the issue of off-site steel assembly fabrication and conformity assessment that is an important element to verifying the building satisfies relevant criteria.

Suggestion for Revision: no suggested revision other than to add a paragraph on the issue or if included elsewhere in the report add a reference to the subject of off-site steel assembly fabrication and conformity assessment activities that occurred to ensure design, specification and building regulatory compliance.

Page Number: 11 and page 12

Paragraph/Sentence: first title on page 11 and last paragraph on page 12

Comment: the title of the section is fire protection systems but the text discusses fire-resistance ratings. Fire protection systems are typically considered sprinklers, standpipes, fire alarm and detection systems, alarms, and smoke control systems. In other words items that protect once a fire has been detected and is underway. The text presented refers to fire-resistance ratings and might not be readily distinguished as fire protection systems. The last paragraph of page 12 then describes the previous discussion about ratings as passive fire protection and then initiates a discussion about sprinklers.

Reason for Comment: increased accuracy for experts and clarification for those who may not recognize the difference between fire protection systems and fire-resistance rated construction

Suggestion for Revision: change title to read "Building construction with respect to resistance against fire" and then add a new title at the bottom of page 12 to read "Fire protection systems". In the alternative leave the text as presented and add an introductory paragraph or "sidebar" to explain the subtleties between active and passive fire protection systems.

Page Number: 15

Paragraph/Sentence: third paragraph, second sentence

Comment: the text suggests that automatic sprinklers, covered in detail on page 12, were installed after the building was initially designed and occupied. This would seem to be a significant fact that may not be readily apparent to most readers. It also appears that the application of automatic sprinklers allowed the removal of some of the passive fire protection systems (e.g. fire-rated construction).

Reason for Comment: enhancement of information on the WTC buildings as designed and as they existed in 2001.

Suggestion for Revision: include text that better covers the as built situation regarding active and passive fire protection and what occurred over time and the end result with respect to these issues in 2001. Include also the driving forces for these changes (e.g. addition of sprinklers and elimination of passive fire protection assemblies).

Page Number: 15 to 17

Paragraph/Sentence: all text

Comment: after considering the above comment and reading further there is discussion about food service, stairways from floor to floor, etc. that would make it appear that over the life of the building that renovations, tenant build-outs, and other modifications were made to the tenant spaces. These could have an impact on the building systems, egress, fire protection, etc. associated with the building. They may or may not have tracked with the Port Authority requirements or building construction regulations and codes, standards and practices that were considered current at the time.

Reason for Comment: the report seems to be missing needed information on how the buildings were modified over time.

Suggestion for Revision: include a few paragraphs describing what occurred in the building over time related to major change to tenant spaces and how that was addressed by the relevant building regulations, if at all.

Page Number: 26

Paragraph/Sentence: sidebar

Comment: the text refers to the NYC building code as not requiring the roof to be accessible for emergency escape. As noted in previous comments if the building was not under the NYC building code but instead that of the Port Authority then it would seem the sidebar should cover what the Port Authority required at the time. In addition it may be relevant to cover if and when such roof access became prevalent in model building codes and why the WTC had not modified the buildings to allow for roof access either voluntarily or in response to renovation or building modification that would have caused some upgrading of the building.

Reason for Comment: clarification and accuracy

Suggestion for Revision: change sidebar to refer to what the Port Authority required and as necessary include addition coverage in the text on the issue of roof access as suggested in the comment above.

Page Number: 28

Paragraph/Sentence: last paragraph, second sentence

Comment: it is noted that temperature is provided in degrees C (SI) while dimensions in the report, such as on the next page, are given in IP dimensions. There should be consistency throughout the reports with respect to the convention chosen.

Reason for Comment: clarity and consistency

Suggestion for Revision: use throughout the document IP with (SI)

Page Number: 51

Paragraph/Sentence: second paragraph, first sentence

Comment: model codes are not developed by model code organizations themselves but are developed under the processes and procedures they provide for the public at large, building industry, designers, government and all interested parties to come together and address building safety issues.

Reason for Comment: clarification

Suggestion for Revision: change sentence to read "…(model codes) developed under the auspices of private sector organizations through the involvement of all interested and affected parties in the development process."

Page Number: 51

Paragraph/Sentence: second paragraph, second sentence

Comment: the text does not accurately describe the model code process and the issue of development is now covered in the above comment.

Reason for Comment: clarification

Suggestion for Revision: delete the sentence as it is covered by the comment below.

Page Number: 51

Paragraph/Sentence: second paragraph, other than first two sentences

Comment: The text is not accurate with respect to the process.

Reason for Comment: clarification and accuracy.

Suggestion for Revision: Change the remainder of the paragraph (that not covered by the previous two comments) to read as follows: "Proposals to update the ICC model codes, submitted by individuals, organizations and any interested party, are published and made available for public comment at public hearings where a committee of balanced interests recommends a disposition on each proposal. The results of those hearings are published for public comment and a second hearing is held to discuss those proposals on which a public comment was submitted. The final disposition of all proposed changes is through a vote by federal, state and local government agency participating in this second hearing. The result of the process is published as a new edition of the code (every three years) or as a supplement to the code (18 months between each new edition). Federal, state or local government who regulate building design and construction will adopt these model codes as a basis for their building construction regulations. Adoption typically lags publication of new editions of the model code by 6 to 18 months and may also involve amendment of the model code by the adopting entity. To a lesser and decreasing extent, federal, state and local government have developed their own unique building construction regulations until now no state and only a handful of local governments do not use the model codes as a basis for their regulations. The federal government role in this process has increased due to the National Technology Transfer and Advancement Act and most federal agencies with authority to adopt and implement building regulations adopt model codes pursuant to 40 USC Chapter 12 Section 619 or refer to the state or local code applicable where the federal building is located."

Page Number: 51

Paragraph/Sentence: third paragraph, first sentence

Comment: standards developers do not develop the standards but instead provide a process by which interested parties come together to develop standards.

Reason for Comment: clarification.

Suggestion for Revision: revise sentence to read as follows: "The model codes adopt by reference a number of standards developed within the voluntary sector under the auspices of a sponsoring organization."

Page Number: 51

Paragraph/Sentence: fourth paragraph

Comment: stakeholder groups are not necessarily responsible for the codes via the code development process. They do participate but, as written, the text seems to convey that they have more control over the process. These groups are not the only entities that provide training. The entities under which the model codes and standards are developed also provide training. In addition the frequency of participation by the general public and building occupants, while true, is confusing. The processes are totally open and all can participate.

Reason for Comment: clarification.

Suggestion for Revision: change to read: "…that participate in the code development process and through this participation and other mechanisms not related to the codes influence the design, construction, operation and maintenance of buildings. These include… and insurers. Organizations representing these groups, in addition to the codes and standards organizations provide training on the aforementioned regulations and this training has a significant impact on the implementation of the codes on a federal, state and local level."

Page Number: 51

Paragraph/Sentence: last paragraph

Comment: it is not clear to the reader, given the previous discussion on model codes and standards, what the basis for the NYC code is or was.

Reason for Comment: clarification.

Suggestion for Revision: Add a sentence or sidebar statement indicating to the reader that the NYC code has been a "home grown" city-developed code since its inception and only now with the planned adoption of the International Building and Fire Codes will NYC become one of the last local jurisdictions yet to migrate from development of their own self-written regulations to basing them on a model code.

Page Number: 52

Paragraph/Sentence: first paragraph, last sentence

Comment: changes to building construction regulations are not typically retroactive until an existing building undergoes renovation. As presented, the reader is under the impression that new code provisions would never apply to an existing building.

Reason for Comment: clarification and accuracy.

Suggestion for Revision: change sentence to read: "In general changes to building regulations will not apply retroactively to existing buildings that are not undergoing any renovation or major work. Existing buildings that are having work done will typically have the work being done covered by the code in effect at the time of the work and depending on the extent of the work the entire building could be required to comply with the code as if it were new construction."

Page Number: 54

Paragraph/Sentence: first paragraph

Comment: the report notes a comparison of the 2001 NYC code to the 1968 edition. It would be important to point out how the 1965 BOCA Basic Building Code had changed over the years and compared to the 2000 International Building Code, which took the place of the BOCA code.

Reason for Comment: three documents available in 1965 are mentioned and compared to the NYC code and then the old and new editions of the NYC code are compared. The latter comparison suggests that there was little change. There most likely was considerable change in the model codes over that same period and that should be highlighted.

Suggestion for Revision: Include a sentence indicating (after review and confirmation) that there were significant changes in the model codes during the same comparative period; changes that addressed new technology and building safety and then list some of the more important innovations.

Page Number: 55

Paragraph/Sentence: second paragraph, first sentence and last sentence

Comment: it is unclear which model building codes are being referred to. Previous text has referred to model codes in general, the BOCA Basic Building Code, etc. The text should be specific as to which model codes and what editions or make the statement more general as suggested below. The last sentence is also confusing as there are no Class 1B standards per se.

Reason for Comment: clarification.

Suggestion for Revision: revise to read as follows: "Model building codes typically classify…"Classes," and in some cases subdivisions within a Class." Also "The Port…..to provide the WTC towers with fire protection as required for Class 1B buildings under the NYC Building Code."

Page Number: 57

Paragraph/Sentence: fifth paragraph, last sentence

Comment: as occupant load is additive and would be expected to increase in lower stories as additional floors are added the codes need not refer to building height when the codes provide for total available egress width as a function of occupants served.

Reason for Comment: clarification

Suggestion for Revision: re-review the codes and as warranted correct the text to address the concept that as building height increases the occupant load would increase and the methodology for establishing required egress width would automatically account for an increased occupant load attributable to multiple stories.

Page Number: 57

Paragraph/Sentence: last paragraph, second sentence

Comment: it is noted that the 2003 edition of two codes are used and the 2000 edition of the IBC. The 2003 edition of the IBC was available at the time this work was performed and should have been used. Also delete the reference to NFPA 5000. The criteria for egress are found in NFPA 101 (Life Safety Code) and, as that document was previously referenced in the report, it should be a basis for comparative work on egress.

Reason for Comment: consistency and comparability.

Suggestion for Revision: any work that requires consideration of contemporary model codes should be based on the latest available documents and where multiple documents are used they should be comparable (e.g. all 2003). Also delete the reference to NFPA 5000 and replace it with a reference to the Life Safety Code.

Page Number: 58

Paragraph/Sentence: second paragraph

Comment: See comment to page 57 regarding reference to the Life Safety Code and comparability of editions of referenced documents (e.g. all 2003).

Reason for Comment: see comment to page 57

Suggestion for Revision: see comment to page 57

Page Number: 173

Paragraph/Sentence: first bullet

Comment: it is stated that the building was constructed with three independent means of egress but that the NYC Building Code would have required four. As noted on pages 51 and 52 the buildings were not required to comply with any building code but the Port Authority directed they comply with the NYC Building Code (2nd and 3rd drafts of what would become the 1968 NYC Building Code). Given that directive it is unclear how the building, as reported on page 173, could have been built with three instead of four independent means of egress.

Reason for Comment: inconsistency in the report.

Suggestion for Revision: while no specific language suggestions can be provided it is suggested that the report address why if the Port Authority required compliance with the NYC Building Code that in the case of independent means of egress the building was provided with only three instead of the required four means.

Page Number: 174

Paragraph/Sentence: first bullet and fourth under objective 3

Comment: the bullet indicates that the design and approval process produced buildings that were consistent with nearly all the provisions of the NYC Building Code and other building codes of the time. What are the other codes? Throughout the report mentions the New York State code, the BOCA Basic Code and other state and local codes. This can be confusing for the reader and should be clarified or a footnote added in the report that explains what NIST considers "other building codes" either in general or by specifically naming them. It also indicates that the design loads exceeded those of the codes. Which codes? The last sentence then refers to departures from the codes and standards. Which codes and standards? This seems to conflict with the previous sentence in the paragraph that indicates that the buildings were nearly consistent with the codes. The fourth bullet also refers to "other selected building codes of the day". Which ones?

Reason for Comment: clarification

Suggestion for Revision: provide the reader information on what "other codes" were considered and additional insight into where the buildings were not consistent with the provisions of the NYC Building Code and those other codes. NIST may want to consider including an article on the status of federal, state and local building code adoption and implementation in the late 60's and beyond that the reader can refer to for additional information. In having such an article, sidebar, appendix or document available then terms such as "other codes" could be clearly used and understood by the reader.

Page Number: 189

Paragraph/Sentence: fifth bullet

Comment: the report mentions that design drawings and other documents related to building approval are not normally required to be remotely stored from the building. This is not correct. Federal, state and local authorities having jurisdiction that are involved in building approval will have copies of design drawings and approval files. The second sentence adds nothing to the report other than to establish a baseline for expressing the performance regarding document retention. The inaccuracy of the sentence establishes the comparative baseline lower than it should be.

Reason for Comment: clarification

Suggestion for Revision: delete the second sentence.

Page Number: 189

Paragraph/Sentence: sixth bullet

Comment: the statement about a fire protection engineer still not required to be involved in the building design may be true with respect to the NYC Building Code, but that is unclear in the report. Contemporary model codes would require construction documents be prepared by a registered design professional, which is determined by state and local rule and would typically include a fire protection engineer on a building of this nature.

Reason for Comment: clarification

Suggestion for Revision: indicate that the statement applies to the current NYC Building Code or clarify it so it represents what is currently required by state and local building regulations.

Page Number: 191

Paragraph/Sentence: last sentence

Comment: the previous text refers to the differences associated with the 1938 and 1968 NYC Building Codes and their impact on the WTC design and by inference safety. The last sentence says these reductions are contained in current codes. Which ones? More importantly a reduction requires two reference points of comparison. Is the statement that current codes contain these reductions based on their comparison to the 1938 NYC Building Code, previous versions of those codes, or some other baseline? As written the statement would lead a reader to conclude that current codes are not satisfactory based on the 4 comparative points presented when in fact buildings are now considered as entire systems more today than in the past and there are numerous technologies available that make such reductions possible while ensuring safety to life. Consider fire escapes. Does their elimination as a requirement in new buildings mean such buildings were no longer safe?

Reason for Comment: the text is misleading

Suggestion for Revision: delete the sentence as it adds little to the report or if it is to be retained then provide specifics as to which codes are considered, the basis for comparison, and quantify exactly which and how many of the items in question are relevant.

Page Number: 192

Paragraph/Sentence: last bullet

Comment: it is noted that no code provision for fire testing existed. Which code? As previously noted the report has references to specific codes and codes in general. It is important in making statements to be specific as to the code in question. In this instance it is likely the NYC Building Code applies yet the more general term code is used, creating confusion. Where a generic "code" is intended then a footnote or other information as previously suggested that provides an overview of the "code situation" outside NYC at the time and today would be helpful to readers as they encounter more generic references to "code" in the report.

Reason for Comment: clarification

Suggestion for Revision: cite the specific code, which is assumed to be the NYC Building Code.

Page Number: 193

Paragraph/Sentence: first bullet

Comment: the current edition of the IBC is the 2003 and should be referenced as previously noted (as 2003 editions of other codes were referenced). Also the parenthetical (one of two current model codes) is misleading and unnecessary. The IBC is the only current model code. The other document that is available for adoption is a standard and not a model code. This, coupled with the reference in the bullet to the UBC, highlights the need for an appendix to the report or associated document that can explain the entire subject of codes and standards development, adoption, implementation and enforcement in general terms both in the late 60's and now. Availability of this information would allow the reader to more clearly understand the situation outside NYC rather than interpret "code", "contemporary codes", "model codes", etc.

Reason for Comment: consistency and accuracy

Suggestion for Revision: change 2000 to 2003 and delete the parenthetical statement about number of model codes.

Page Number: 193

Paragraph/Sentence: third bullet

Comment: the first sentence indicates that there are no inspection requirements for inspection of SFRM. This may be true for the NYC Building Code but the statement, coupled with previous references back and forth between specific code titles and more general terms such as "current codes" could lead the reader to conclude that no where are such inspections required. This is not the case as indicated in Section 1704.11 of the 2003 IBC.

Reason for Comment: the report is misleading and depending upon interpretation incorrect

Suggestion for Revision: change the first sentence to refer to the NYC Building Code by name as the source upon which the statement about lack of required inspections is based.

Page Number: 194

Paragraph/Sentence: second bullet

Comment: the term building code is not specific

Reason for Comment: clarification

Suggestion for Revision: refer to the NYC Building Code

Page Number: 194

Paragraph/Sentence: sixth bullet

Comment: the term current model building codes is not specific

Reason for Comment: clarification

Suggestion for Revision: as previously noted the report should be specific where possible. In this case either name those codes or provide in a separate appendix as previously suggested general information on code development, adoption, implementation and enforcement to assist readers who may not fully understand the subtleties of the U.S. building regulatory system. This is important for U.S. readers but even more important for readers outside the U.S. who are more likely used to a national code developed in a more governmental setting than our voluntary system and consideration of state and local government authority.

Page Number: 197

Paragraph/Sentence: title of section

Comment: the words "who is in charge?" will suggest different things to different people; especially the legal community and those outside the U.S. In addition, as previously commented the broad subject may be better conveyed as building regulations.

Reason for Comment: to present the U.S. system in an accurate manner

Suggestion for Revision: change title to read as follows: "Building Regulations"

Page Number: 197

Paragraph/Sentence: first paragraph

Comment: see comments to page 51 which includes the same text

Reason for Comment: see comments to page 51

Suggestion for Revision: see comments to page 51

Page Number: 197 and 198

Paragraph/Sentence: all of the text

Comment: the information is not presented in the correct order, includes information that is not relevant and has some errors that should be corrected

Reason for Comment: accuracy and clarification

Suggestion for Revision: Revise section 9.1 to read as follows:

"Building construction regulations for the ......hand.

The United ..... to development, adoption, implementation and enforcement of building construction regulations. In virtually...national building construction regulations. In the U.S. the private sector develops model codes and standards with active participation by the building regulatory community and government. These model codes and standards are adopted by state and local government, who are granted the authority under the U.S. Constitution for such action, to govern building design, construction, operation and maintenance. In some states the adoption applies statewide while in others adoption may only apply to state-owned buildings with regulations for private sector buildings up to local government control. They are also adopted by Federal agencies to address Federal construction and in some cases are the basis for Federal rules that apply throughout the country (e.g. minimum energy efficiency of heating and air conditioning equipment). Once adopted, they are implemented by those responsible for building design and construction and enforced by authorized agencies of state and/or local government. Due to many factors in the public and private sectors Federal, state and local government building construction regulations have become increasingly uniform.

With some exceptions the building construction regulations adopted by Federal, state and local government are based on ..... Columbia adopt the ...Columbia adopt the...is adopted in ... all jurisdictions.

Model codes are developed under the auspices of private sector organizations such as the ICC. Proposals to update the model codes, submitted by individuals, organizations and any interested party, are published and made available for public comment at public hearings where a committee of balanced interests recommends a disposition on each proposal. The results of those hearings are published for public comment and a second hearing is held to discuss those proposals on which a public comment was submitted. The final disposition of all proposed changes is through a vote by federal, state and local government agency participating in this second hearing. The result of the process is published as a new edition of the code (every three years) or as a supplement to the code (18 months between each new edition). As covered above, Federal, state or local government who regulate building design and construction will adopt these model codes as a basis for their building construction regulations. Adoption typically lags publication of new editions of the model code by 6 to 18 months and may also involve amendment of the model code by the adopting entity. To a lesser and decreasing extent, federal, state and local government have developed their own unique building construction regulations until now no states and only a handful of local governments do not use the model codes as a basis for their regulations. The federal government role in this process has increased due to the National Technology Transfer and Advancement Act and most federal agencies with authority to adopt and implement building regulations adopt model codes pursuant to 40 USC Chapter 12 Section 619 or refer to the state or local code applicable where the federal building is located.

The model codes adopt by reference....developed under the auspices of ...coordinates the development of standards in the U.S.

In addition...that participate in the development and adoption of the model codes and standards on behalf of their constituents. These groups, as do the model code and standards developers, also provide training on building design and construction practice and the provisions of the model codes and standards.

Enforcement of the adopted building construction regulations occurs through the submission of plans and specifications and their review for compliance with adopted codes and standards by Federal, state or local government having authority for enforcement where the building is to be located. Compliance is further ensured through on-site inspection during construction by applicable Federal, state and local authorities as well as state and local licensing laws.

The ...NIST is...Commerce. NIST, as with other federal agencies who conduct research and/or participate with the voluntary sector in development of model codes and standards, does not establish building....develop model codes and standards, which....safety.

Rigorous enforcement of building construction regulations by the responsible agencies by well trained and supported agency staff is critical to ensure that what is intended in the model codes and standards is actually delivered at the initial point of occupancy of a building and during the life of the building. They in turn need a reliable conformity assessment system that validates the acceptability of testing labs and quality assurance agencies who act on their behalf. To facilitate implementation of the model codes and standards, the building design and construction community also need training and support. Unless those responsible for determining compliance are trained and adequately supported and those who are regulated have the same basis of knowledge the best model codes and standards, while admirable, are not put into practice and cannot protect the building and its occupants.

Page Number: 198

Paragraph/Sentence: last paragraph, second sentence

Comment: it appears that NIST views its recommendations as making buildings safer. It will be important to review the recommendations to determine which ones can be implemented and apply to existing buildings and which ones cannot.

Reason for Comment: recommendations related to building regulations typically apply to new buildings and existing buildings undergoing renovation or modification. The issue of building safety in existing buildings is difficult to address without building regulatory provisions, which are difficult to impose on existing buildings, or incentives that cause action in the absence of mandate.

Suggestion for Revision: clarify here the degree to which the recommendations apply to new and existing buildings and the manner in which NIST suggests they be implemented.

Page Number: 199

Paragraph/Sentence: first paragraph, first complete sentence

Comment: it appears NIST is recommending codes and standards developers consider the recommendations. With respect to changing model codes and standards, as noted above, the developers in reality oversee and provide a process where interested parties can come together to affect change. It is NIST and other interested parties who are the developers of the model codes and standards and through the processes of the sponsoring organization the recommendations for change can be accepted and implemented.

Reason for Comment: clarification

Suggestion for Revision: revise the text to make a call for all interested parties to work together in developing changes to model codes and standards based on appropriate recommendations.

Page Number: 201

Paragraph/Sentence: first bullet

Comment: the list of responsible communities is confusing as what is listed is not a community but an activity area related to achieving better buildings.

Reason for Comment: clarification and to facilitate implementation of the report recommendations

Suggestion for Revision: suggest changing responsible community to area of focus with the sub-bullets being improve professional practices and guidance, enhance provisions in model codes and standards, further adoption and enforcement of those model codes and standards, conduct research to provide a basis for future change in model codes and standards and their implementation, and develop and deploy education and training for all those involved with building design, construction, operation and maintenance

Page Number: 201

Paragraph/Sentence: recommendation 1, second line

Comment: nationwide adoption could be construed to mean preemptive federal requirements. In addition model codes and standards have been generally referred to throughout the document and should be referred to in this case. Model codes provide the basis for building regulations and standards are referenced in the model codes.

Reason for Comment: clarification

Suggestion for Revision: revise sentence to read as follows: "…development research and documentation to support change and enhancement to model codes and standards to implement the results of the research along with …"

Page Number; 202

Paragraph/Sentence: first paragraph, section under national model codes

Comment: model codes should be referred to simply as model codes. The recommendation that state and local government should adopt and enforce the improved model codes is confusing as a jurisdiction would only need to adopt one model code. It has taken significant effort for the U.S. to get to where it is today with respect to building regulations. With minimal federal preemption the voluntary sector and state and local government are almost on the same page. Furtherance of the objectives of the WTC study will be ensured if all federal, state and local agencies work together and do not dilute the critical mass moving toward a truly national code in the U.S. Note also that incorporation of the reference standard in the model code would allow that standard, after coming out of the standards development process, to be subject to further modification through the model code process.

Reason for Comment: clarification and to facilitate implementation of the recommendations by focusing everyone's efforts on a singular set of model codes and standards.

Suggestion for Revision: revise to read as follows: "…conditions. Model Codes: the standards should be adopted in the model codes by mandatory reference to the latest reference to the standard with any necessary language to facilitate integration of the standard with the code. Federal, state and local agencies should be encouraged to adopt and enforce one singular model code and the referenced standards therein based on…intent."

Page Number: 203, 204, 206 and subsequent pages

Paragraph/Sentence: recommendation 2, last paragraph, last sentence, recommendation 3, last sentence, recommendation 5, last sentence, recommendation 6, last sentence, and numerous subsequent places in the report

Comment: that incorporation of the reference standard in the model code would allow that standard, after coming out of the standards development process, to be subject to further modification through the model code process. This could overly complicate and confuse the development and adoption of the standard.

Reason for Comment: to ensure the report provides appropriate recommendations

Suggestion for Revision: delete ", or incorporation of,"

Page Number: 205

Paragraph/Sentence: first paragraph

Comment: the recommendation that model building code committees review, develop and submit changes to the codes is not consistent with the processes by which the codes are developed. As such the recommendation has little chance of being implemented.

Reason for Comment: the model codes are developed with input from all interested and affected parties and in the case of the ICC process there is strong reliance on individuals, organizations and others to prepare and submit code changes as opposed to that being done by committee. The ICC does have the ability to establish ad hoc committees and has done so on many emerging issues. That being said all interested and affected parties must work together to develop, submit and support proposed changes to the codes. NIST should consider working with interested parties to actually generate appropriate code changes to accomplish the recommendations in the reports.

Suggestion for Revision: change to read as follows: "Interested and affected parties working cooperatively under the auspices of an unbiased third party organization such as the National Institute of Building Sciences (NIBS) should undertake....above and then adapt that work as proposed revisions to the national model codes and undertake the necessary steps to secure approval of those revisions."

Page Number: 206

Paragraph/Sentence: second bullet

Comment: the report states that SFRM inspection procedures are not required by codes. This is not true as previously noted. Chapter 17 of the International Building Code covers special inspections and Section 1704.11 specifically addresses SFRM. While the investigation may have determined that codes related to SFRM inspection might not have been enforced with respect to the WTC buildings, the data forming the basis for the report do not support NIST being able to make any broad statement that essentially reports, "existing standards of practice related to SFRM inspection and codes are not enforced".

Reason for Comment: accuracy of the report

Suggestion for Revision: "... they are not required by all codes (the 2003 IBC in Chapter 17 does require such inspections). Further.... recommendation"

Page Number: 206

Paragraph/Sentence: recommendation 6

Comment: add a new bullet to address in-situ monitoring of SFRM adherence and retention in place

Reason for Comment: technology exists by which building materials, products and systems can be continuously monitored to ascertain their performance when such materials, products or systems are not readily available for inspection.

Suggestion for Revision: add a new bullet to read: "Current and developing technology should be reviewed and research conducted with the intent of developing remote means to monitor and report on the in-situ condition of SFRM on an ongoing basis."

Page Number: 207, 208, 209 and subsequent pages

Paragraph/Sentence: first paragraph and recommendation 8, last sentence to recommendation 10, last sentence to recommendation 11 and numerous other locations in the report

Comment: the use of the term "national" to describe model codes is misleading. While the model codes are developed by organizations that have a national scope the use of the term conveys that as developed these are national documents. While they certainly address national needs and variables such as wind and snow load, the term national in our voluntary system is really placed on a code based on its level of adoption. These documents are simply model codes or model building codes where the subject is referring just to the building code. Also note that federal agencies are adopters of model codes.

Reason for Comment: accuracy and clarity

Suggestion for Revision: delete the term "national" where the term "model building codes" is used. Also change the last sentence to read as follows: "Federal, state and local....one of the model building codes."

Page Number: 207 and 208

Paragraph/Sentence: recommendation 9

Comment: NIST recommends performance-based standards and code provisions and then references a number of standards and standards organizations that should focus on that issue. Then NIST recommends that the model building codes adopt those performance standards. See previous comments on the issue of incorporation of standards into the model code and use of the term "national" when describing the model codes. The text does not recognize the ICC International Building Performance Code that provides performance-based code provisions already to address the subject issue. If NIST believes that code does not adequately address this issue then certainly, as suggested in other recommendations, interested organizations and individuals should work to develop and secure enhancements to that code. To recommend the creation of an additional, duplicative model regulation is not in the public's best interest.

Reason for Comment: the report fails to recognize an existing solution that is not included in a recommendation

Suggestion for Revision: revise the first sentence of the recommendation to read as follows: "NIST recommends the development of new and enhancement of existing: (1) performance....."

Revise the recommendation to recognize the ICC International Building Performance Code and recommend whatever enhancements NIST believes are necessary.

Revise the last sentence to read as follows: "Model Codes: The performance code should be adopted as an alternate method in the model building codes by mandatory reference to the latest edition of the performance code. In addition the International Building Performance Code should be reviewed and enhanced if necessary."

Page Number: 211, 212 and subsequent pages

Paragraph/Sentence: last paragraph to recommendation 16 and recommendation 17 and subsequent places in the report

Comment: the report references NFPA 101 as a standard when it is a code entitled the Life Safety Code. As such it provides a model on the issue of egress that federal state and local jurisdictions can adopt if they so choose and should not be included as a standard but considered as part of the model building and fire codes. Also with respect to recommendation 17 there is an additional standard (ICC/ANSI A 117.1) that should be referenced with respect to design and egress for persons with disabilities; an issue mentioned in the report.

Reason for Comment: clarification

Suggestion for Revision: delete reference to NFPA 101 as a national standard and change the last paragraph of recommendation 16, 17 and subsequent recommendations as warranted to read as follows: "Model Building, Fire and Life Safety Codes: These documents should be updated and enhanced as warranted to so as to not restrict or impede building occupants from evacuation drills and to the degree possible support the conduct of such drills".

Delete NFPA 101 as an affected standard in recommendation 17 and add as suggested above to as a model life safety code. Also add ICC/ANSI A117.1 to the list of reference standards as it addresses access to building for persons with disabilities and is the logical source document for addressing how such individuals would be addressed in building evacuation.

Page Number: 211

Paragraph/Sentence: last sentence to recommendation 16

Comment: this appears to be the only recommendation where the issue of affected organizations is addressed and selected entities are listed. Why is this not the case with other recommendations? In reality there are many organizations that can and should take lead and secondary support roles in addressing all of these recommendations. Rather than list a few for this one recommendation it may be more appropriate to cover this issue in a general statement preceding all the recommendations. With respect to this particular recommendation we can think of a number of organizations that should be listed as being affected (either because they can take some action or would be affected by the actions of others). Recognize also that every person in the United States and many outside the U.S. will be impacted by the recommendations in this report.

Reason for Comment: clarification and consistency throughout the report

Suggestion for Revision: delete any listing of affected national organizations for this recommendation and include a general discussion on the subject of interested and affected parties and organizations and their roles at an appropriate place in the report.

Page Number: 218

Paragraph/Sentence: Group 8 on education and training

Comment: the focus of this group is on professional skills of building and fire safety professionals (engineers and architects). Certainly they can and do have a significant impact on the development and implementation of designs and technology to address many of the issues raised in the report. They can also affect change in codes and standards and to the degree to which they are retained during construction or required by code to be on-site they can have an impact on actual construction. The report also mentions code officials, the fire service and other individuals involved in implementation and enforcement of the codes and standards that the report addresses and suggests are improved. These individuals are not only responsible for initial design and construction but for the building as occupied, years after the design professionals are out of the picture. The building regulatory and fire service should also be addressed via enhanced education and training.

Reason for Comment: the report does not support a significant opportunity to enhance future building safety

Suggestion for Revision: add a new sentence to read as follows: "The skills of the building regulatory and fire service should be comparably upgraded to ensure they have the same baseline understanding as design professionals and the necessary skills to conduct building review, inspection and approval tasks for which they are responsible."

Also develop and include a new recommendation to address continuing education curricula and programs targeted at the building regulatory and fire service sectors.

Page Number: 222

Paragraph/Sentence: Table 9-2a

Comment: ICC/ANSI A 117.1 dealing with access to buildings for persons with disabilities is relevant and should be added. NFPA documents such as 1, 70 and 101 are not standards but are model codes that cover specific subjects that can be adopted and implemented directly.

Reason for Comment: accuracy and clarification

Suggestion for Revision: add ICC/ANSI A 117.1 to the list of standards. Move NFPA 1, 70 and 101 to the list of model codes.

Page Number: 224

Paragraph/Sentence: Table 9-2b

Comment: the International Building Performance Code is another model code that is relevant to the report and provides an opportunity to affect change

Reason for Comment: accuracy and completeness of the report

Suggestion for Revision: add International Building Performance Code to the table for groups 2 and 7 and recommendations 1-24, 26-29

Page Number: 224

Paragraph/Sentence: Table 9-2c

Comment: the ICC is affected by many more of the recommendations

Reason for Comment: accuracy

Suggestion for Revision: the ICC is in some way, as a publisher of model codes, developer of standards and provider of products and services in support of those codes to the entire building community, affected by all the recommendations and consideration should be given to listing ICC with other recommendations.

In reality many more organizations can and should be added to the report and through the public review process it is assumed they will step forward.

Report Number: NCSTAR 1-1 Design, Construction, and Maintenance of Structural and Life Safety Systems

Page Number: xxvi

Paragraph/Sentence: last bullet

Comment: the term national building and fire codes is misleading in that it suggests that the U.S. has such documents within the federal sector. As suggested under comments to Report Number NCSTAR 1, NIST should use the terms building code, fire codes, standards or model codes throughout the documents. Further explanation of how the U.S. system works regarding development, adoption, implementation and enforcement of these documents is also needed for both U.S. and foreign readers that may not fully understand the U.S. system. NIST is encouraged to use "Getting Building Technology Accepted", produced for and available from the U.S. Department of Housing and Urban Development as a basis for this needed general treatise on the subject.

Reason for Comment: clarification and to enhance the application and intent of the reports by entities who may not fully understand all the nuances of the U.S. system.

Suggestion for Revision: delete "national" and use the term "model building and fire codes, voluntary standards, and practices" throughout when referring to the broad group of documents that are the target for change pursuant to the WTC reports.

Page Number: xl

Paragraph/Sentence: first full paragraph

Comment: It is noted that Section E.3 provides information on codes in effect during the 1960's and compares those codes to the NYC Building Code of the time. This establishes as basis for comparison amongst different documents of the time. Then certain reference standards are included in the comparison. Finally the comparison is updated as to the then and 2001 NYC Building Code and certain reference standards. Since the "jump" is made with respect to comparison of certain reference standards there should also be a "jump" made for contemporary model building codes. It is suggested that a comparison with the 2000 or 2003 International Building Code also be included as a basis of reference with the model building codes of the time (e.g. BBC and UBC referenced in the document).

Reason for Comment: completeness of the document and to address comparability of current and past model codes with the companion comparisons for NYC codes and reference standards.

Suggestion for Revision: the comparative work is not complete and when completed should be appropriately referenced and highlighted in the report.

Page Number: xlvi

Paragraph/Sentence: first paragraph, second sentence

Comment: it is not normal practice to apply building code changes to existing buildings when such buildings are not undergoing renovation, repair, and other changes. It is, however, a requirement in most codes that existing buildings undergoing renovation, repair, addition, etc. meet certain provisions of the codes based on the nature of the work being undertaken in the existing building. This may not be clearly conveyed as currently written in the report.

Reason for Comment: clarification

Suggestion for Revision: revise second sentence to read as follows: "...changes to existing buildings not undergoing renovation, repaid, addition or other change, but the ...."

Page Number: xlvi and 149

Paragraph/Sentence: fourth paragraph, last sentence and fourth paragraph, last sentence

Comment: a reference is made to requirements for voice systems and the text infers that such requirements appeared in national standards. Standards typically provide guidance on product and system design, construction and performance. Codes would typically indicate if and to what degree such systems were required and mandate a level of performance. In addition, as previously suggested, the term national may be misinterpreted by those familiar with the U.S. system.

Reason for Comment: clarification

Suggestion for Revision: revise the last sentence to read: "Standards for voice systems were first developed in the early 1980's and requirements for such systems first appeared in model codes in the mid 1980's, at the...."

Page Number: xlviii

Paragraph/Sentence: third paragraph, last sentence

Comment: it is not clear which "code" is being referred to in the text. Since the terms code, model code, national building code, NYC Building Code, etc. are used throughout the document it is important that a clear convention be established so there is no confusion.

Reason for Comment: clarification

Suggestion for Revision: specify the "code" being referred to (which is assumed to be the NYC Code).

Page Number: xlviii

Paragraph/Sentence: fourth paragraph, first sentence

Comment: as previously noted there are instances where existing buildings are covered retroactively by the building code.

Reason for Comment: clarification

Suggestion for Revision: revise to read as follows: "...retroactive requirements or when the existing building may have renovation or repair work causing application of the adopted and current building and/or fire codes to the existing building."

Page Number: xlix

Paragraph/Sentence: second paragraph, last sentence

Comment: the name of the firm is Jaros, Baum and Bolles

Reason for Comment: typo

Suggestion for Revision: change Guam to Baum

Page Number: lv

Paragraph/Sentence: finding 16, first and second sentence

Comment: the text is incorrect in indicating that inspection procedures do not exist in codes. Chapter 17 of the 2003 IBC addresses special inspections and Section 1704.11 covers sprayed fire-resistant materials including an assessment of structural member surface conditions, application, thickness and density. The text is also incorrect in stating that provisions are not available to address installed thickness and variability compared to that specified in the plans and specifications.

Reason for Comment: clarification and accuracy

Suggestion for Revision: change the first sentence to indicate (if warranted) that more rigorous provisions beyond those in current model codes are needed (based on an assessment covered in the report indicating why such requirements such as those in Section 1704.11 of the IBC are not rigorous enough. If such data do not exist to show how these provisions are inadequate or not rigorous enough then delete the second sentence.

Page Number: lv

Paragraph/Sentence: finding 17

Comment: the ICC International Performance Code for Buildings and Facilities does address structural design and includes consideration of the magnitude of different events including technological hazards associated with fires and explosions. To infer in the report that no such performance criteria exist is misleading.

Reason for Comment: clarification

Suggestion for Revision: mention the ICC Performance Code, cover any limitations that NIST feels the document has, and provide recommendations for enhancement of the code to address NIST's concerns.

Page Number: 2

Paragraph/Sentence: second bullet

Comment: BOCA is Building Officials and Code Administrators International, now consolidated with the other 2 U.S. model code organizations at the International Code Council (ICC)

Reason for Comment: clarification

Suggestion for Revision: change conference of America to code administrators international.

Page Number: 3

Paragraph/Sentence: last paragraph

Comment: the term "codes" is used throughout and it is not clear which codes are being referred to in specific or general terms.

Reason for Comment: clarification

Suggestion for Revision: throughout the reports where specific codes (e.g. NYC Building Code) are the subject of the text then use the name of the specific code. Where the term is broader such as model codes then use that term and if the intent of the text is to apply to all codes or codes in general then use that term. Explain this distinction in a footnote in each report the first time any of these terms are used or alternatively include a discussion on the topic in the introductory material to each report.

Page Number: 4

Paragraph/Sentence: second paragraph, first sentence

Comment: federal, state and local government adopt codes

Reason for Comment: accuracy

Suggestion for Revision: change to read as follows: "….adopted by federal, state and local authorities establish…"

Page Number: 37

Paragraph/Sentence: third paragraph, first sentence

Comment: the model code organizations consolidated and amalgamation does not appropriately describe what occurred. State and local jurisdictions also adopted their codes, and the subsequent ICC Codes. Stating that state and local codes were patterned after these model codes can convey to someone not familiar with the situation that state and local agencies did not really adopt these model codes. Also of note with respect to adoption of model codes throughout the documents NIST regularly refers to state and local agencies but rarely federal agencies. It is important that NIST convey to the reader that federal agencies such as GSA, DOE, NASA, DoD, and others adopt these model codes and standards as a basis for regulations covering their own buildings.

Reason for Comment: clarification

Suggestion for Revision: change amalgamation to consolidation and revise the sentence to read as follows: "....most state and local government agencies adopting building codes adopted one of the three model building codes and now adopt the ICC Codes which have taken their place pursuant to the consolidation."

Page Number: 43 and 141

Paragraph/Sentence: third paragraph, second sentence and second paragraph, third sentence

Comment: the BOCA BBC was adopted by localities around New York but was also adopted by some states at the state level. Readers need to understand that some states have state adoption authority and referral only to local adoption is confusing.

Reason for Comment: clarification and accuracy

Suggestion for Revision: change the second sentence to read as follows: "...typically adopted by state with state code adoption authority and local jurisdictions...."

Page Number: 54

Paragraph/Sentence: last paragraph

Comment: it is noted that the comparative discussion is focused on the NYC and three other building codes of the time and then also the 2001 NYC code. This provides a good basis for comparison for "now and then" for the NYC code and across codes of the 1960's. It leaves open a question about how those other codes (NYS, BOCA and Chicago) have changed over time as well. It is suggested that NIST also look at how the BOCA code and NYS code of the time compare with the 2000 IBC, which has taken the place of the BOCA code and has been adopted by the state of New York.

Reason for Comment: completeness of the report

Suggestion for Revision: add details in the report on how the BOCA and New York state codes of the day compare with the 2000 IBC.

Page Number: 142 and 144

Paragraph/Sentence: third paragraph, first sentence and last paragraph, last sentence

Comment: the use of the term national model codes is possibly confusing to readers unfamiliar with the nuances of the U.S. system. National can suggest that these documents are developed by the U.S. government or that they have some special standing. Note the first sentence of the next paragraph refers to these as model building codes and the sentence noted above on page 144 refers to national model building codes.

Reason for Comment: clarification and consistency

Suggestion for Revision: revise sentence to read as follows: "bore on the model building codes."

Page Number: 143

Paragraph/Sentence: fourth paragraph, second sentence

Comment: a parenthetical comment is made about poor record keeping associated with tracking changes to codes. NIST likely reviewed this issue with respect to NYC but did not likely review how BOCA for instance kept records. As presented one could interpret the statement as an inappropriate and unsubstantiated assessment of how the model code organizations kept records.

Reason for Comment: clarity

Suggestion for Revision: revise the sentence to read as follows: ".... (record keeping associated with the development and maintenance of codes and standards in New York City was...."

Page Number: 145

Paragraph/Sentence: third paragraph

Comment: it is noted that the 2003 IBC is referenced. Other places in the report refer to the 2000 edition of the IBC. As previously commented, given the timeframe of the report the 2003 IBC should have been used exclusively by NIST. Citations of different years mean the report is inconsistent in its treatment of current codes.

Reason for Comment: consistency and accuracy

Suggestion for Revision: base all work in which the IBC or other ICC codes are relevant on the 2003 edition of those codes throughout the reports or explain where the 2000 editions are used why they are used instead of the 2003 editions.

Page Number: 145

Paragraph/Sentence: second paragraph

Comment: the document refers to Section 703.3 of the IBC and lists 3 alternative methods for determining fire resistance. The IBC actually contains 5 such methods and all should be referenced.

Reason for Comment: accuracy

Suggestion for Revision: Add two new bullets as follows: "engineering analysis based on a composition of building element designs having fire-resistance ratings determined by ASME E 119" and "alternative protection methods as allowed by the IBC under alternative methods and materials when approved by the code official"

Page Number: 153

Paragraph/Sentence: last paragraph, first sentence

Comment: the text refers to the IBC and NFPA 5000. It is noted elsewhere in the report that both the 2000 and 2003 IBC are referenced as well as the 2003 NFPA 5000. In this instance no edition date is presented, leading to reader confusion over which edition of the IBC is relevant.

Reason for Comment: clarification and consistency

Suggestion for Revision: cite the edition year of each document and for consistency throughout the document base the report, analysis and related findings to the 2003 IBC.

Page Number: 157, 158, 160 and 164

Paragraph/Sentence: last paragraph on page 157, first sentence in first and second paragraphs on page 158, last paragraph on pages 160 and 164, and first paragraph on page 165.

Comment: the text suggests that ASME 17.1 covers elevator design and operation in all building codes. While this is likely true it should be noted that there are different editions of ASME 17.1 that could be adopted and there are no data provided that indicate that all building codes, which we assume NIST intends to mean federal, state or local codes, adopt ASME 17.1. In addition NIST again refers to elevator and building codes. Having referred throughout the document to national model codes, model building codes, and specific building codes like the NYC Building Code, the term "building codes" is not specific enough. The use of the term "building codes" continues in other paragraphs and should be clarified as to which codes are addressed (e.g. model codes, specific codes, or as a general statement to refer to federal, state and local building codes). If the latter then data indicating a research basis for such a broad statement must be provided and if no data exist then specific codes and/or model codes should be cited. On page 160 the term "many other codes" is used and it is not clear as to the scope of that statement (e.g. federal, state and local, model codes, or other documents). On page 164 the term "codes" is used and it is assumed the report means the NYC codes but one could also conclude that the report refers to codes in general. The report needs to be specific when referring to a particular code or codes and when the report is referring to codes in general it should have introductory materials, as previously suggested, so the reader has a clear understanding of scope when a general statement on codes is made. On page 165, first paragraph, the term "all current building codes" is rather broad. It is likely NIST meant model codes as opposed to all federal, state and local codes in effect in the late 1960's. This needs to be clarified as discussed above.

Reason for Comment: clarification

Suggestion for Revision: revise sentence on page 157 to read as follows: "...design and operation in the vast majority of buildings via its adoption in federal, state and local building regulations." Revise first sentence in first paragraph on page 158 to read as follows: "The vast majority of elevator and building codes in effect at the federal, state and local level require..." Revise second sentence in second paragraph on page 158 to read as follows: "The model building codes in the U.S. as well as codes such as the NYC Building Code...." Also clarify what is intended by "many other codes" on page 160 and "the codes" in the last sentence on page 164. Also clarify "all current building codes" on page 165.

Page Number: 165

Paragraph/Sentence: last sentence

Comment: it is unclear what code is being referred to when the statement about no code requirements is made.

Reason for Comment: clarification

Suggestion for Revision: revise to refer to NYC Building Code (which is assumed to be the subject as opposed to codes in general).

Page Number: 167

Paragraph/Sentence: fourth paragraph

Comment: a statement is made about Port Authority inspections and surveys and compares them to requirements in New York City and other codes and practices. This is a comparison of apples and oranges and inappropriately suggests that "other codes" are inferior. The Port Authority is in essence the building owner and regardless of codes and practices would logically want to inspect and survey these buildings on their own above and beyond any state or local requirements. In addition the highly visible nature of the buildings suggests that any owner, regardless of location or codes, would likely undertake such activities. Note also "requirements in NYC" is not specific as to codes but is general enough to cover many other requirements and law beyond codes.

Reason for Comment: clarification and accuracy in making comparisons.

Suggestion for Revision: revise sentence to read as follows: "...in New York City and in other localities with similar buildings, and generally ...."

Page Number: 168

Paragraph/Sentence: last sentence

Comment: the term "building code standards" is undefined and given previous comments about the use of specific and general terms to address codes is confusing.

Reason for Comment: clarification

Suggestion for Revision: cite the specific "building code standards" to which the comparative statement and subsequent points apply. If there is no specific document but the statement is attributable in general to codes of the day then state so in the report. Also do not use the term "building code standards" unless referring to specific standards referenced in and part of the building code.

Page Number: 180

Paragraph/Sentence: finding 4

Comment: the statement about document retention should be clarified and supported with documentation. Section 106.5 of the 2003 IBC does address retention of construction documents and requires 180 day retention or as required by state or local law. Section 105.4.6 of the 2003 IFC requires retention of construction documents until final approval of the covered work is completed. Section 106.5 of the 2003 IEBC also addresses the issue of retention, requiring one set of approved documents be retained by the code official for the period required for retention of public records. Clearly these documents and we are sure others, address retention of documents. While maybe not as long at NIST would prefer or was warranted for the WTC, a statement that state and local jurisdictions do not require retention of documents would not appear to be substantiated unless NIST has done the required research of all state and local laws and regulations to support such a statement.

Reason for Comment: statement made concerning state and local requirements for retention of records is in error and does not appear to be substantiated. This is then portrayed against the situation regarding record retention with the WTC and essentially makes all state and local government look significantly less competent that the Port Authority. The report only need address the findings of record retention by the Port Authority and addressing how state and local government or the private sector address document retention is not necessary. Moreover we cannot find any data submitted by NIST to substantiate the statements concerning state and local government.

Suggestion for Revision: Delete the first three sentences and simply report the finding related to the Port Authority. If that is not acceptable then revise the first two sentences to read as follows: "Requirements for retention of construction documents vary from state to state and sometimes within states. Such documents ...."

Page Number: 183

Paragraph/Sentence: finding 14

Comment: reference to the IBC is not consistent throughout the NIST report. As the 2003 edition of the IBC was available and is used as a reference elsewhere in the report the 2003 edition should be referenced instead of the 2000 edition.

Reason for Comment: consistency and accuracy

Suggestion for Revision: change 2000 IBC to 2003 IBC

Page Number: 184

Paragraph/Sentence: finding 16

Comment: NIST incorrectly infers that as-applied fire protection thicknesses are not the same as those specified such that what is anticipated in the design is actually delivered in the building. NIST also indicates that in-service inspection requirements are not available. The IBC in Section 1704.11 provides criteria for special inspections of sprayed fire-resistant materials intended to ensure that what is anticipated based on the design is actually delivered in the building. Section 703.1 of the IFC also addresses the maintenance of required fire-resistance ratings of construction. Finding 16 is somewhat misleading in that it infers nothing is available to address these issues. While possibly not as rigorous and NIST would like, the IBC and IFC do address these issues. As such the report is misleading and makes the current situation seem worse that it really is.

Reason for Comment: inaccuracy

Suggestion for Revision: finding 16 should be rewritten to indicate that the issues addressed in the finding are covered in current model codes but based on the findings of the WTC investigation enhancements to those codes and others addressing those issues would be beneficial.

Page Number: 189

Paragraph/Sentence: reference to BOCA

Comment: BOCA is incorrectly spelled out

Reason for Comment: accuracy

Suggestion for Revision: change to Building Officials and Code Administrators from Building Officials Conference of America

Report Number: NCSTAR 1-2 Baseline Structural Performance and Aircraft Impact Damage Analysis of World Trade Center Towers

Page Number: li

Paragraph/Sentence: first bullet, second sentence

Comment: a reference is made to building codes of the time. It is not clear, having read the other documents associated with the WTC report what documents are being considered or if this is just a general statement. As the bullet addresses comparative analysis NIST must have based the analysis on some specific "building codes of the time". For this reason the text should be clarified to identify the codes upon which the statement is based.

Reason for Comment: clarification

Suggestion for Revision: add a footnote or parenthetical statement indicating which building codes the statement is based upon.

Page Number: liii

Paragraph/Sentence: first paragraph, first sentence

Comment: the report indicates that "current building codes do not specify a drift limit for wind design" but does not provide any specifics as to which codes (e.g. state, local, model, etc.). As previously noted the use of the terms codes, model codes, building codes, national codes, etc. are used repeatedly and interchangeably throughout the report and yet they can and do have different meanings. The next sentence of the first paragraph then refers to ASCE 7 and discusses drift limits related to that document. As ASCE 7 is adopted by reference in "current building codes" the statement in the second sentence would seem to contradict the statement in the first sentence.

Reason for Comment: clarification

Suggestion for Revision: revise the first sentence so that it is specific as to which building codes do not address drift limit and in discussing ASCE 7 on this topic note that model building codes such as the IBC adopt by reference ASCE 7 such that anything relevant to ASCE 7 would, by reference, be relevant when discussing the IBC.

Page Number: 51 and 295

Paragraph/Sentence: third paragraph and finding 1

Comment: BOCA is Building Officials and Code Administrators and as the sentence addresses codes the title of the relevant BOCA code should be included.

Reason for Comment: clarification

Suggestion for Revision: change Building Officials Conference of America to Building Officials and Code Administrators (BOCA) Basic Building Code

Page Number: 57

Paragraph/Sentence: listing of references

Comment: as the NIST report refers to the International Building Code it should also be included in the list of references

Reason for Comment: completeness of the report

Suggestion for Revision: add the following reference: "International Building Code, International Code Council, Falls Church, VA, 2003."

Page Number: 64, 91 and 296

Paragraph/Sentence: second paragraph, first sentence on page 64, first paragraph, third sentence on page 91 and finding 5 on page 296

Comment: the term "current building codes" is used and is a very general non-specific term. As previously commented such terms need to be qualified so readers can understand if the statement is related to one or more specific codes or just codes in general and if the statement applies to model codes or actual federal, state and/or local codes.

Reason for Comment: clarification

Suggestion for Revision: identify the specific building codes NIST reviewed and upon which the statement is made or if the statement is intended to generally apply to building codes as a whole without citing any specific codes then include a footnote that clarifies that for the reader.

Report Number: NCSTAR 1-4 Active Fire Protection Systems

Page Number: 32

Paragraph/Sentence: fourth paragraph, last sentence

Comment: a reference is made to the "model code" but the specific model code is not referenced. Earlier in the report references are made to the NYC Building Code and NFPA standards related to sprinklers and standpipes. While the term "codes and standards" is used as well, it is used in very general terms. Up to this point in the report the reader has also not been made aware that model codes, such as the BOCA Basic Building Code applicable at the time of WTC construction or the current ICC International Building Code, exist, how they are used as a basis for building regulations and the degree to which the refer to documents such as NFPA 13 and 14. The term "model code" at this point is confusing and should be replaced with a specific reference. In addition, in doing so, other parts of the report leading up to this section should at least introduce the concept of a model code and advise readers that such codes reference NFPA standards such as 13 and 14, and through those references such standards are applied in building regulations.

Reason for Comment: clarity and to make the report complete with respect to its treatment of codes and standards

Suggestion for Revision: revise the sentence in question to specifically address the model code by name. Also add descriptive text as appropriate in prior portions of the report to explain the difference between a model code and a standard, what model codes and standards were/are available to address active fire protection, and that through model codes and their reference to standards building regulatory agencies derive the basis of their building regulations. The fourth paragraph on page 45 covers this issue. NIST should consider including such information at the beginning of this report, other applicable project reports and the main WTC report. This paragraph also addresses the issue of conformity assessment, a critical part of ensuring code compliance and building and system performance but an issue that is not adequately addressed in the reports at times when it is relevant.

Page Number: 45

Paragraph/Sentence: fifth paragraph, first two sentences

Comment: the text confuses installation, conformance to product standards, code requirements.

Reason for Comment: clarification

Suggestion for Revision: revise the first two sentences to read as follows: "The ...is dependent upon the standards covering the design and performance of the fire alarm system, the testing and quality assurance activities associated with ensuring compliance with those standards, and the degree to which the installation is in accordance with those standards, manufacturer's direction and applicable codes."

Page Number: 71

Paragraph/Sentence: last paragraph

Comment: ASHRAE is incorrectly named. In addition ASHRAE has a number of Handbooks and the specific handbook should be referenced.

Reason for Comment: editorial and clarification

Suggestion for Revision: change refrigeration to refrigerating and cite the specific ASHRAE Handbook being referenced in the text.

Page Number: 71

Paragraph/Sentence: entire section 5.1.2

Comment: the report does not include any discussion of how model codes have played a role in fostering the introduction and use of smoke management systems. As these model codes, which reference a number of the standards noted in the report, serve as the basis for building regulations and contain specifics as to when, where and how to install such systems their contribution should also be noted. Moreover, the model codes, unlike specific standards, address the entire building and effectively integrate smoke management with the myriad of other building design and construction issues that affect building safety and performance.

Reason for Comment: the report is missing needed information

Suggestion for Revision: add a new paragraph noting the existence of the model codes, how they include references to standards, how they serve as a basis for federal, state and local codes and what their contribution over time has been with respect to fostering the installation and acceptance of smoke management systems.

Page Number: 73

Paragraph/Sentence: first sentence

Comment: the NYCBC is not a model building code and should not necessarily be compared to one. The purpose of the sentence is to convey the concept that the NYCBC differs from other building codes (e.g. state or locally adopted building regulations) in that local laws in NYC can apply building code provisions retroactively to existing buildings. If there is a need to address how model building codes address the issue of retroactive treatment of existing buildings then an additional sentence or discussion should be added, possibly in the main WTC report. As the purpose of the sentence is to focus on how NYC compares with others the appropriate basis for comparison is with building codes at the state and local level as opposed to model building codes. As information the ICC International Existing Building Code and ICC International Fire Code provide criteria applicable to existing buildings.

Reason for Comment: clarification

Suggestion for Revision: delete the word "model".

Page Number: 85

Paragraph/Sentence: third paragraph

Comment: the text refers to a requirement for exhaust to be the greater of six air changes per hour or 1 cubic foot per minute per square foot of floor area. The text incorrectly indicates that the latter at 48,000 cfm would be the requirement. Given the floor area and an assumed 10 foot height the volume of each floor was on the order of 480,000 cubic feet. In order to achieve 6 air changes per hour the exhaust rate would have to be 80,000 cfm (480,000/6). Since 80,000 cfm is greater than 48,000 cfm the former would apply. Note that this comment also apples to page xl of the 1-4D report and the third line of the relevant paragraph in that report incorrectly shows floor area as 40,000 square feet.

Reason for Comment: technical accuracy

Suggestion for Revision: correct the paragraph using the correct code-required exhaust rate.

Page Number: 88

Paragraph/Sentence: last sentence

Comment: the text states that best practices in smoke management design are enforced in many jurisdictions in the U.S. There is a significant difference between best practice and minimum code and it is doubtful that local jurisdictions would require best practice design when they have adopted and enforce building regulations, unless such regulations were written to say "designers shall use best practice in the design of smoke management systems."

Reason for Comment: text incorrectly suggests that local officials require best practice as a basis for building regulations or in the absence of building regulations simply require best practice.

Suggestion for Revision: delete the words "enforced in many jurisdictions in the United States" and replace with "considered relevant".

Report Number: NCSTAR 1-4D Smoke Management Systems

Page Number: 5 and 108

Paragraph/Sentence: Section 2.1 in general and Section 9.2.1 in general

Comment: the report refers to codes as defining the objectives of smoke management systems and then lists and discusses specific standards and guideline documents related to the subject. As the NIST reports refer to codes and model codes in a number of other instances, the absence of any discussion on the relevance of Section 909 of the IBC dealing with smoke management systems would appear to be a significant omission in the report. For instance the presentation on the exhaust method suggests that the "model building codes" have adopted the NFPA 92B provisions. Section 909.8 of the IBC covers the exhaust method and does not adopt NFPA 92B. It may be better to suggest that standards such as NFPA 92B form a technical basis for model codes and can either be adopted by reference and through the code integrated with provisions covering other issues or if not adopted by reference can and often do form the basis for the provisions in the model codes. It is unfortunate that this section of the report discusses the exhaust, pressurization and airflow design methods of smoke management and not once refers the reader to Section 900 of the IBC, which forms the basis for "building codes enforced in the United States" (see next comment).

With respect to current practice, which is the timeframe in which the presentation in section 2.1 is set, the IBC by virtue of its adoption at the federal, state and local level should be addressed in this report.

Reason for Comment: address a significant omission in the report relating to current practice concerning smoke management systems.

Suggestion for Revision: include in the report as applicable a discussion on the provisions in the IBC on smoke management and their relevance to building design and operation as well as a discussion on how the model codes are developed and the different ways they rely on reference standards.

Page Number: 10 and 11

Paragraph/Sentence: last sentence on page 10 and first sentence on page 11

Comment: a general reference to building codes enforced in the U.S. is made but no specifics are provided as to what building codes. As these building codes are based on model codes, the report would be clearer on this point if it covered the model codes and the adoption of those codes by federal, state and local government.

Reason for Comment: clarification

Suggestion for Revision: add the following after United States: "(which are generally based on the IBC)"

Page Number: 17

Paragraph/Sentence: second and third paragraphs

Comment: certain standards are referenced with respect to maintenance of smoke removal systems. Unfortunately the International Fire Code is not mentioned and should be referenced. Section 909.21 of the 2003 IFC addresses the maintenance, testing, record keeping, etc. associated with smoke removal systems in existing buildings and should be addressed in the report. The third paragraph, also suggests that the referenced standards as guidelines were not written into the model codes. This may be true but the absence of any treatment of the IFC as suggested above, while supporting the report's statement that maintenance and testing is not generally required by jurisdictions, means the report is totally incorrect.

Reason for Comment: the report is not complete

Suggestion for Revision: add discussion on page 17 of the report to address how the IFC addresses maintenance of smoke management systems. Also change the third paragraph completely to advise the reader that where the IFC is adopted there are provisions that jurisdictions can and do adopt to address maintenance of smoke management systems.

Page Number: 21

Paragraph/Sentence: fourth paragraph, third sentence

Comment: it is noted that the BOCA code was selected since it covered the majority of the NE US until 1999. This statement is misleading and leads the reader to ask – what happened after 1999?

Reason for Comment: accuracy of the report

Suggestion for Revision: change the third sentence to read as follows: "The BOCA code was selected for comparison because this code was the predominant code adopted by state and local government in the North East. The last edition of the BOCA code was published in 1999, and is being replaced by adoption of the International Building Code, now the primary basis for building codes throughout the U.S."

Page Number: 23

Paragraph/Sentence: first paragraph, first two sentences

Comment: the BOCA, ICBO and SBCCI codes are inanimate objects and cannot do anything as suggested by the text. The report is misleading and does not convey exactly what happened with respect to the model codes and the organizations that sponsored them.

Reason for Comment: correct errors in the report

Suggestion for Revision: change the second sentence to read as follows: "The model code groups formed the International Code Council (ICC) and proceeded to develop one singular family of model codes for the United States that would replace their individual model codes. The first complete set of ICC International Codes was completed in 2000 and replaced at that time the three model codes developed by the founding members of the ICC (BOCA, ICBO and SBCCI). In 2003 the three founding members of ICC consolidated their operations as the ICC. Since that time the ICC Codes have been updated every 18 months and federal, state and local government that had widely adopted one of the three model codes have adopted the ICC Codes as they have updated their building and fire regulations.

<u>Report Number: NCSTAR 1-6 Structural Fire Response and Probable Collapse Sequence of the World Trade Center Towers</u>

Page Number: 14

Paragraph/Sentence: last paragraph

Comment: the terms building codes, current codes and some codes are used in the paragraph but it is unclear which codes. The statements made in the report about fire ratings are very important and the manner in which the report describes the reduction of required fire ratings necessitates that the specific codes upon which the statements are derived be referenced.

Reason for Comment: clarification and technical accuracy

Suggestion for Revision: delete the terms building codes, current codes and some codes and replace them with a reference to the specific codes upon which the presentation on reduction in required fire ratings are based.

Page Number: 15

Paragraph/Sentence: second paragraph, first sentence

Comment: it is reported that the architect selects establishes fire ratings, thermal protection, etc. requirements. While correct the text leaves the reader with the idea that when that is done the work is completed and construction proceeds. After the architect or registered design professional prepares the design and specifications, they are subject to review by the appropriate building and fire authorities who will either approve what has been selected or advise the architect of changes needed to achieve code compliance.

Reason for Comment: increase accuracy of the report with respect to the building design and approval process.

Suggestion for Revision: add a new sentence after the first that reads as follows: "Subsequent to that selection by the architect or registered design professional the authority having jurisdiction (code official, fire service, etc.) will review those selections as part of the building regulatory process and where necessary advise of needed corrections to address code compliance issues."

Report Number: NCSTAR 1-6A Passive Fire Protection

Page Number: xxxi

Paragraph/Sentence: third paragraph, first sentence

Comment: the term U.S. building regulations is used and then later in the executive summary the term building codes is used. While related these are not necessarily the same. Readers, especially those unfamiliar with building codes, standards and regulations as well as non-U.S. readers unfamiliar with the "U.S. system" can be easily confused and mislead if the correct terminology is not used throughout the report. For instance on page xxxii, first paragraph, a reference is made to a non-specific term "building codes". It is assumed that the authors intend to make a general statement and that building codes applies to federal, state or local building codes that are law. One, however, could also assume this refers to the model building codes, or some specific building codes. Following the statement on page xxxi referring to building regulations enhances the need for clarification and consistency on this issue.

Reason for Comment: clarification

Suggestion for Revision: the NIST report should include a general overview and discussion on how codes, standards, etc. are developed, adopted, implemented and enforced in the United States. This overview can then be referred to as needed throughout all the NIST reports as necessary to address the many and varied ways in which codes, model codes, standards, building codes, building regulations and other terms are relevant to the information in the reports.

Page Number: xxxii and 7

Paragraph/Sentence: third paragraph and last paragraph

Comment: the terms building codes, current codes and some codes are used in the paragraph but it is unclear which codes. The statements made in the report about fire ratings are very important and the manner in which the report describes the reduction of required fire ratings necessitates that the specific codes upon which the statements are derived be referenced.

Reason for Comment: clarification and technical accuracy

Suggestion for Revision: delete the terms building codes, current codes and some codes and replace them with a reference to the specific codes upon which the presentation on reduction in required fire ratings are based.

Page Number: 5

Paragraph/Sentence: last paragraph

Comment: the term "model building codes" is used but it is unclear what documents NIST used in the investigation and upon which the report is based.

Reason for Comment: clarification

Suggestion for Revision: cite the specific documents that NIST considered in the work either here, and other places where the term is used or in the suggested presentation and discussion on U.S. codes and standards development, adoption, etc. previously suggested.

Page Number: 6

Paragraph/Sentence: third paragraph, last line

Comment: an NFPA standard is referenced. Which one?

Reason for Comment: clarification

Suggestion for Revision: identify the specific NFPA standard to which the report refers.

Page Number: 6

Paragraph/Sentence: last paragraph

Comment: the report, in addressing building code requirements, mentions the historical BOCA and SBCCI documents but does not mention the IBC that supersedes those legacy documents and is used as a basis for virtually all U.S. building construction regulations.

Reason for Comment: the report should be complete in reporting information on current building codes.

Suggestion for Revision: add similar text with respect to the requirements in the 2003 IBC.

Report Number: NCSTAR 1-7 Occupant Behavior, Egress and Emergency Communications

Page Number: 24

Paragraph/Sentence: third paragraph, first sentence

Comment: the text refers to two model building codes, one by name of the code and the other by the name of the organization sponsoring the code. It is appropriate and correct when referring to such documents to refer to them by title and publisher.

Reason for Comment: clarification and for consistency throughout all NIST reports associated with the WTC investigation

Suggestion for Revision: refer to the IBC and the ICC 2003 International Building Code (IBC) and add "ICC International Code Council" to the list of acronyms in the report

Page Number: 34 and page 35

Paragraph/Sentence: third paragraph, last sentence

Comment: the use of the term U.S. building codes is misleading and could be misinterpreted by those unfamiliar with the U.S. system that the United States promulgates building codes. See previous comments on other portions of the NIST report that raise the same issue and propose solutions.

Reason for Comment: clarification

Suggestion for Revision: revise sentence on page 34 to read as follows: "....Escalators, which is adopted by reference in the model building codes and through adoption of those codes, or the ASME standard directly, by federal, state and local government agencies forms that basis for the design and operation of elevators." With respect to page 35, the text must be more specific as to what is meant by U.S. building codes or cite the specific codes to which the text is intended to refer.

Page Number: 43

Paragraph/Sentence: section 2.5, second sentence

Comment: the text refers to codes adopted by local jurisdictions. While partially true it does not fully describe the U.S. situation and is therefore misleading. In some instances the adopting entity is the federal government for federal buildings. Interestingly this includes NIST with administration and compliance with the codes addressed by the NIST Plant Division. This also includes state government where states have preemptive authority over local government. Lastly, where of a non-federal nature and not preempted by state government, local government would be the adopting authority.

Reason for Comment: clarification

Suggestion for Revision: revise the sentence to read as follows: "...building codes adopted by federal, state and local government establish..."

Page Number: 44 and 45

Paragraph/Sentence: fourth paragraph, first sentence and first paragraph, third sentence

Comment: the text on page 44 is not clear as to which building codes and should either be specific as to which codes or if a more general statement than report that as well, nothing also that building codes include federal, state and local codes. On page 45 the text refers to "most current codes". It is assumed the intended scope is building codes and as with the text on page 44, the term "most" is undefined.

Reason for Comment: clarification

Suggestion for Revision: cite the specific building codes upon which the report based the measure "some" on page 44 and change page 45 to building codes and cite the specific building codes upon which the report based the measure "most".

Page Number: 45

Paragraph/Sentence: section 2.5.4

Comment: reference is made to the 2000 IBC. Other parts of the NIST reports reference and are based on the 2003 IBC. For consistency and based on the availability of the 2003 IBC at the time the reports were developed the reports should uniformly refer to and rely on the 2003 IBC.

Reason for Comment: uniformity and accuracy throughout the reports

Suggestion for Revision: revise the text in section 2.5.4 and other relevant portions of the report based on the 2003 IBC.

Page Number: 47

Paragraph/Sentence: section 2.5.5

Comment: reference is made to NFPA 5000 and NFPA 101 with the text citing various applicable sections but is not specific as to which document. A review of NFPA 5000 indicates that the referenced sections do not exist or do not contain the materials presented in the report. The text in the report is based on NFPA 101 and as such a reference to NFPA 5000 is incorrect and unwarranted unless the text indicates that NFPA 101 is the source document and NFPA 5000 simply references or reproduces the egress provisions of NFPA 101. Note also that further text in Chapter 2 references appropriately NFPA 101 and not NFPA 5000. As NFPA 5000 has no basis as a source document for egress provisions and based on the egress issue being addressed within NFPA 101 the reference to NFPA 5000 is unwarranted.

Reason for Comment: accuracy

Suggestion for Revision: delete the reference to NFPA 5000.

Page Number: 47

Paragraph/Sentence: section 2.5.6

Comment: the comparison of NFPA 101 and the IBC may not be based on the appropriate edition of the IBC and the report therefore does not present an appropriate, current or valid comparison. The text in section 2.5.4 references the 2000 edition, the text in this section simply refers to the IBC and then table 2-3 refers to the 2003 IBC.

Reason for Comment: technical accuracy

Suggestion for Revision: revise the comparison using the 2003 IBC as a basis and if the comparison was based on the 2003 then the report should reference the 2003 IBC throughout, not only in report 1-7 but in all the NIST WTC reports.

Report Number: NCSTAR 1-8 Emergency Response Operations

Page Number: xxxvii

Paragraph/Sentence: second bullet

Comment: the text refers to the purpose of the effort as identifying issues that need to be addressed in codes. A review of report 1-8 indicates that there is only one mention of codes on page li (see below). This leads the reader to expect to see in this report some specific items that are either not currently addressed in codes and should be addressed or are addressed but not as rigorously as the authors would like. These comments assume the term codes refers to building codes, fire codes and other regulations.

Reason for Comment: the stated purpose of the report was not completely fulfilled.

Suggestion for Revision: list out those issues that relate to emergency response operations that should be addressed by codes or delete codes from the scope of the report and change the second bullet to read as follows: "identifying issues related to emergency response operations that should be addressed through changes to policy, practices, guidelines and other means of affecting enhanced emergency response operations."

Page Number: li

Paragraph/Sentence: second bullet under command and control

Comment: the text refers to the availability of effective codes as a key issue in addressing command and control. The term codes should be further defined. A review of the ICC International Fire Code shows that Section 509 addresses the establishment of a fire-command center for fire department operations in buildings. This portion of the report seems to be focused on the establishment and operation of a command center once a building issue necessitates one be established. The availability of the location and facilities with which to establish and operate such a center is covered by codes. The actual processes by which such a center is established and operated may not be specifically addressed in code.

Reason for Comment: clarification

Suggestion for Revision: change the term "codes and protocols" to "guidelines, procedures and protocols."

Comments on NIST—NCSTAR Federal Building and Fire Safety Investigation of the World Trade Center Disaster, Especially NIST NCSTAR Reports 1 and 1-7

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The NIST website (http://wtc.nist.gov/comments_submission.htm) contains the following instructions:

> To ensure that your comments are properly considered, it is important that they be submitted in the appropriate format to facilitate review and disposition by the report authors. NIST will prepare a public summary of the comments received and their disposition in September when the final report is issued.

The website goes on to stipulate:

> Comments not submitted through the web site should contain the following information:
> Name: (Optional)
> Affiliation: (Optional)
> Contact: Phone number or e-mail address where you can be contacted in case of questions. (Optional)
> Report Number: (e.g., NCSTAR 1-1)
> Page Number:
> Paragraph/Sentence: (e.g., paragraph 2/sentences 2-4)
> Comment:
> Reason for Comment:
> Suggestion for Revision:

Information Not Found Easily Or At All

General comment on comment process: it is ironic that NIST stipulates that comments be very specifically targeted when some topics are not addressed in an easily located, specific fashion in the reports. Also, as illustrated in the second topic area below, "Activity in Exit Stairwell," if something was missed in the study, exactly where in the reports does one reference that deficiency?

If NIST wanted to have a well-organized, easily perused set of comments, it should have provided a well-organized, easily perused set of reports. Report NIST NCSTAR 1-7 does not provide this. Alternatively, if commenters are expected to do so much work to compensate for deficiencies in the reports, NIST should be prepared to compensate the major effort required.

Important Baseline Information. For example, baseline information on the means of egress for the buildings is not all located at one logical place in the reports or even in the individual reports for specific projects (such as Chapter 2 of Report NIST NCSTAR 1-7).

Exit Stairway Step Geometry. Specifically, if one wants to find out what was the actual step geometry of the exit stairways, one has to resort to a word search of the PDF files and, even after this time-consuming process, one never does find out what the step geometry actually was, *only what it was supposed to be relative to code requirements.* Moreover, rather than being in a section on baseline information (such as Chapter 2), some of the means of egress information is buried well on in the occupant behavior report (NIST NCSTAR 1-7) in Appendix D on egress modeling. Also, only at this point (specifically page 240 of this report in Section D.3) is mention made of the number of stair risers between floors—18 to 26—with 19 risers per floor being present for floors 45-49 (according to Section D.4.1 on page 247). A bit further on in this appendix, the step geometry is reported as being "7.5 in by 9.5 in riser tread configuration" which is the NYC Building Code limit for stairs used for assembly occupancy (7.5 inches *maximum* riser height for assembly occupancy; 7.75 inches *maximum* for others) but which is not consistent with the result of a simple calculation dividing the reported (but well buried) typical floor-to-floor height of 12 feet by a typical office floor's 19 risers for a riser height of 7.58 inches. Does this mean—due to the assembly occupancies at the top of the towers—that the exit stair geometry, with the 7.58-inch risers, did not strictly comply with NYC Code requirements?

Even harder to figure out—if the tread depth (run) dimension is questionable also—is what the actual, as opposed to required, (minimum) tread depth (run) dimension was. When I worked in the WTC in 1993 I managed to take one, relatively crude, spot measurement at the 67th floor of Tower 1, which suggested the riser-tread geometry was approximately 7.5 by 9.5 inches.

Landing Geometry. Also, nowhere in the reports do I find a treatment of the size of landings for the exit stairways. Landing size is a key to the capability of the means of egress system to provide rest areas for the many people who reported they stopped occasionally to rest. Does this mean that the NIST team did not examine sufficient construction documents to determine landing geometry or does it mean the team did not consider this important to report?

Also apparently missing from the reports was information on the following building characteristics.

Overall Exit Stairway Area (available for evacuee occupancy). Total area of the stairway system including stair flights, landings and transfer corridors was not found.

Stairway Handrails. Information on the stairway handrails cannot be found anywhere in the NIST report. However, I do have some information. For example, handrail height (at my measurement site on the 67th floor of Tower 1) was about 33 to 34 inches above step nosings with a handrail section size of 1.5 inches diameter with 1.5 inches clearance to the adjacent wall. Also, as was typical with handrails of 1960s vintage, the wall mounted handrails did not extend past the point directly above the lowest step nosing so that some users, for example descending in darkness in 1993 or 2001 evacuations

—accustomed to handrails extending at least one tread depth past the lowest nosing—might not be aware of the lowest step of each flight if they were walking on the wall side of the stairs. Here it should be noted that evacuees walking on the inner side of the exit stairs would have inconsistent handrail extensions with some shorter ones at end-of-flight newel posts. The report does not address the propensity of most evacuees to descend on the wall side of the stairs nor does the report describe the stairs as either turning left or right (relative to a descending person). The former appears to be the case for the two sets of stair photos I have for the 67th floor of Tower 1 but the plan I attach in Appendix 1 to these comments shows both configurations. Without such detail about the handrails, it is not possible to do a full assessment of important ergonomics issues facing evacuees and affecting their egress performance plus safety generally.

Ground-level Egress Activity. Finally, in terms of major omissions, the issue of ground-level egress activity was apparently missed in the investigation/study and the report. Given the nature and scale of the multi-building disaster, it is important to understand what happed to the evacuees once they reached the WTC concourse. Which exits were used from the concourse and how was that process managed by authorities? How did this interface with evacuation from the underground transit stations? What happened to evacuees at ground level after collapse of WTC 2? And what about evacuees from nearby buildings? Over 15,000 evacuees from the two towers alone went somewhere. Where and how? Approximately how many were able to evacuate from the towers only to die at ground level due to the towers' collapses. Generally, urban neighborhood issues need to be addressed when dealing with large, high-occupancy buildings such as in the WTC and surrounding developments such as World Financial Center.

General Criticism about Inadequate Attention to Activity in Exit Stairwells

Relative Emphasis on Evacuation Delay Contrasted with Stairwell Activity. Generally, the arrangement, sizing and—*especially*—the utilization of the exit stairwell system in the towers got short shrift in the NIST study. Contrast, for example, the many questions asked in the telephone interviews about the delay in starting egress down the stairs to the one *single* question related to the difficulties experienced in the extensive behavior of evacuees and others in the exits (described in the interview script, page 201, and reported in Table 10-1, page 151, of NIST NCSTAR 1-7). The one or two questions on difficult conditions during stairway use ("Time Period: 3" having, overall, about a dozen questions) can be contrasted with the two dozen or so questions about delays in initiating egress ("Time Period: 2"). Certainly, pre-evacuation behavior is important (and apparently a pet subject with some of the researchers on the NIST team) but it does not impact means of egress design and codes/standards/regulations deliberations the way that behavior in the exit stairwells does.

Moreover, the fact that both towers provided a rare opportunity to compare evacuation in two different stairway widths—*at a time when this continues to be a "hot" code-change issue* (see next section)—makes the apparent emphasis on pre-evacuation behavior even more questionable. As a well-known researcher on evacuation of a range of buildings—located a mere half-hour drive from NIST—who took the effort to have several NIST staff meet in my office in January 2004 to discuss research needs and opportunities, it is especially galling to see the NIST investigation/study give the stairwell-related activity such relative short shrift.

Information Relevance to Codes. NIST staff knew—or should have known—that the whole topic of exit stair design, especially minimum width in relation to counterflow and other evacuation movement, was a major one within the NFPA process for the Life Safety Code (NFPA 101) and Building Construction and Safety Code (NFPA 5000). They also knew that, unlike in most tall office buildings, there were two significantly different exit stair widths, nominally 44 and 56 inches—the very exit widths being debated in the NFPA standards/codes change process. Why then did NIST not adequately address what happened in the exits?

Difficulties Experienced in the Stairwells. For the especially important question about difficulties in the stairwell, "Did any of the following make your evacuation more difficult while you were in the buildings?" only three of seven options dealt with key pedestrian movement issues—coherent flow (everyone moving more or less as a unified mass with similar descent speeds), counterflow and overtaking movement (what the NIST report refers to as "superflow")—as follows:

> "Crowded stairways"
> "Firefighters or Police moving up stairwell"
> "Disabled or injured people being taken down stairwell."

The coding for these questions was only "Yes," "No," "DK," and "RF." Thus detail on so much important behavior in the exits was not even systematically elicited in the telephone interviews.

Counterflow. Also troubling is the apparent effort by the study team to play down the importance of counterflow, for example, claiming that it was of little importance—*on the basis of an arcane statistical analysis!* If the reasonably detailed questions are not even asked—and responses not coded in detail, no amount of statistical analysis is going to compensate for the deficiency and produce useful, meaningful findings! By way of revision suggestion, instead of trying to misrepresent the findings, it would be better if NIST simply admitted that the appropriate line of inquiry was not used to address the counterflow issue and other evacuee movement issues related to the exit stairways.

Study Constraints. There is some admission of inadequacies with the telephone interview process found on page 138 of NIST NCSTAR 1-7.

> While the multivariate regression analysis of the telephone data has extraordinary power to distill the telephone interview data to the salient features, the analysis was necessarily limited by the constraints of the number and type of questions contained in the telephone interviews. Face-to-face interviews and focus groups provided a more detailed understanding than can be achieved by exclusive use of the telephone interviews.

Questionable Conclusion on Counterflow. Highly questionable as a result is the statement on pages 167-168 of NIST NCSTAR 1-7.

> Contrary to the perceptions of the occupants, counterflow in WTC 1 was determined by causal modeling analysis not to be a significant predictor of increased total evacuation time while in the stairwells when compared to other factors, including evacuation interruption and environmental cues.

Who Influenced Study? In the discussion about "Predicting Normalized Stairwell Evacuation Time In WTC 1 on September 11, 2001," on page 229 of NIST NCSTAR 1-7, there is a note:

> A group of individuals selected for the expertise on human evacuation during high rise fires was assembled. The individual experts developed the final list of variables, and the relationships between them, to use to specify the model used in this analysis.
>
> Second, preliminary statistical analyses were performed to determine which variables thought to be important predictors of normalized stairwell evacuation time by the team of experts had and did not have predictive salience in WTC 1. Those that had no significant impact on normalized stairwell evacuation time were excluded from further consideration. The factors that had salient impacts on normalized stairwell evacuation time were carried forward into the model used in this analysis.

Later, on page 229, after describing the "Causal Modeling," the report states:

> This model is parsimonious, consistent with the input received from high rise fire evacuation experts, and it well-represented the positive findings of our preliminary analyses of the many variables that could have impacted normalized stairwell evacuation time.

Who were these people?

Statistical Manipulations. On page 230, is a potential partial explanation for the relatively good statistical results that are claimed; certain responses were coded to the mean.

> Finally, normalized stairwell evacuation time (X7) was measured by asking respondents how much time passed between the moment they first began their evacuation until they exited the tower. Answers were coded on an interval scale; "don't know" and "refused to answer" responses were coded to the mean. These raw numbers were then normalized. The hydraulic model of people movement dominates the average evacuation time per floor, so it had to be removed from normalized stairwell evacuation time so as to fully explain the fluctuations (denoted by a prime) in reported evacuation time. This was accomplished by a least squares analysis of reported evacuation time against floor for each tower, with statistical outliers removed.

After a few pages of very arcane discussion of statistics, the authors concluded, "All of the equations in the model were statistically significant at the .001 level or better."

There is some truth to the statement about statistics: they tend to conceal more than they reveal. Appendix C is a good example of the misuse of statistics and statistical jargon; here apparently used in an attempt to hide the fact that NIST's interview process was seriously flawed in not probing sufficiently into what happened in the exit stairwells during the evacuation.

"Straightforward and Clear" Process? The stated conclusions of Appendix C are only slightly more illuminating and less arcane than the explanation preceding it (page 235 of NIST NCSTAR 1-7):

> Although each of the aforementioned findings are interesting in and of their own right, the most important findings that we can offer are those that emerged when all of the above findings are brought together and viewed at the same time in the context of the model as a whole (see Figure 1). What doing so revealed was that, based on this analysis, the main process that led to increased normalized stairwell evacuation time in the evacuation of World Trade Center WTC 1 on September 11, 2001, was straightforward and clear. It can be described as follows.
>
> Floor (increased distance to safety) substantially increased the odds that people would encounter environmental cues. Floor also increased delay in starting evacuation, which, in turn, also increased the chances that people would encounter environmental cues. But it was encountering environmental cues (which likely blocked egress) that had a large and direct effect on increasing the amount of time that people spent, on average, to traverse their evacuation stairwell. In addition to this multi-step process with environmental cues as the key predicting variable, interrupting the process of evacuation for any reason also increased the amount of time, on average, that people used to descend their evacuation stairwell.

The foregoing, as well as Appendix C generally, should be edited or rewritten for clarity. What are the authors trying to say? What are they trying not to reveal?

Normalized Stairwell Evacuation Time. So what was the "Normalized Stairwell Evacuation Time" in WTC1? A search for all uses of the phrase in the PDF file for NIST NCSTAR 1-7 revealed it appeared 38 times, *but never in close proximity to the result stated in meaningful form!* So where is the information? Section 10.1.2, "Time and Average Travel Speed in the Stairwells, WTC 1," and Figure 10-4 appear to present the answers (possibly reported by a different writer than the one seemingly infatuated with arcane statistics and the phrase "Normalized Stairwell Evacuation Time" which appears nowhere in Section 10.1.2). The results:

> The reported time spent in the stairwells for occupants of floor 10 to floor 91 in WTC 1, based on the NIST telephone interviews (n=368), yielded a mean normalized travel speed of 1.3 floors per minute. Normalized travel speed is defined as the total time from entering the stairwell until leaving the building, divided by the number of floor that had to be descended. According to Figure 10–4, 25 percent of the occupants traveled faster than 1.5 floors per minute, while 25 percent of the occupants traveled more slowly than 0.9 floors per minute. The median normalized travel speed was 1.2 floors per minute.

The phrase, "According to Figure 10–4," appears in error as the graph shows only 25 data points—not 368—with 7 (28 percent) below 0.9 floors per minute and 12 (48 percent) above 1.5 floors per minute; indeed the median for the data points presented on the graph is 1.5, not 1.3 floors per minute. So even a relatively straightforward presentation of data ends up being confusing.

Stairway Descent Speeds. The report authors go on translate the "floors per minute" to a more standard measure of stairway speed, measured in feet or meters along the stair slope and along the landings, which they estimate at 33 ft (10 m) per floor, "assuming an average floor height of 3.7 m (12 ft)." (The authors' estimate of average travel distance per floor is within a couple of feet of my estimate, based on methods I first used in my high-rise building evacuation studies of 35 years ago in Canada.) They go on to compare their results with the estimates of speed reported in the "published scientific literature" which, logically, should include book chapters, papers and handbook chapters I produced although none of these is referenced in the report. For example, in Figure 14.11 of my chapter, "Building Evacuation: Research findings and recommendations," (D. Canter, editor, Fires and Human Behaviour, Wiley, 1980), a median speed of about 0.65 m/s is shown—representing many samples of speed taken while evacuees were actually moving down stairs, not averages based on an evacuee's entire descent which—depending on building height and population, plus other factors—could include delays where speed was very low if not zero. Thus, the NIST team is comparing apples and oranges when, on page 129, it reports the WTC's estimated speed of 0.2 m/s is "on the slow end of published scientific literature values for stairwell descent speeds."

Key Stairwell Activity Not Addressed. What NIST should have done, among many things that were missed in the WTC study, is to examine exit stairwell activity in much more detail—especially to document where, when and why there were stoppages and other disruptions to movement. Such stoppages are more likely at lower levels of the building but, if the populations were larger—as would be the case at times other than the early morning conditions of 9/11, stoppages would be expected over most of the stairwell height. For example, with 20,000 occupants per tower and a full evacuation of all floors, people on the highest floors could expect to be queuing on the exit stairways or even outside the exits for about one half of the total time taken to descend about 110 stories. This assumes normally observed deference behavior with lower floor occupants allowed into the exits ahead of those already in the exits from upper floors. (Observed deference behavior on 9/11 was apparently not even addressed in the NIST study despite its major implications for specific issues such as average speed and clearance of certain levels preferentially.) Notably, the technical background referred to in the preceding sentences was included prominently in my major presentations during 2002 and 2003. Although some NIST staff attended those presentations, as far as NIST is apparently concerned, these presentations either did not occur or did not matter. A word search of NIST NCSTAC 1-7 found no usage of the relevant terms, "mixing," "merging," "deference" or "precedence" that describe key concepts of exit stairwell use in high-population tall office buildings where evacuees on the stair interact with evacuees desiring to enter the exits from lower floors.

The bottom line is that normal deference behavior and associated queuing alone can account for a potential reduction of average speed down stairways by a factor of two for a building such as the WTC. NIST's reported reductions are factors of about two to three. One of the most important things that NIST could have done in reporting the speed data would be to present speed estimates in relation to where and when the speed occurred.

Failure to Communicate Evacuation Process Effectively. In this regard, one of the huge disappointments I have with NIST's study is the failure to report data in the very effective forms I have been using for 35 years. (See for example Figures 3-13-11 through 3-13-14 of the SFPE Handbook of Fire Protection Engineering, Third Edition, chapter, "Movement of People: The Evacuation Timing," which have been in that handbook since its first edition in 1988—when I was the author.) This involves plotting traces of individual people's movement on a chart with building height on the vertical scale and time on the horizontal scale. Even with the relatively crude, incomplete data collection done by NIST, the researchers could have prepared some of these charts and these would have quickly shown where and when evacuees were experiencing major delays and slowdowns and, by virtue of crossing traces depicting emergency responder counterflow, where and when counterflow occurred. In this regard it is insightful to compare the clarity and informative content of such charts with the dense, arcane discussion of "Normalized Stairwell Evacuation Time" presented in NIST NCSTAC 1-7, particularly on pages 229-235.

Opportunity at NIST WTC Conference. An effort will be made during my intended presentation at the NIST conference in mid September 2005 to compare NIST's presentation of stairway evacuation findings with the much more informative methods I have been advocating for decades. Hopefully NIST conference organizers will permit, indeed welcome, such a different approach to consideration of the WTC evacuation on 9/11. This raises a larger question; will NIST preserve the occupant survey data in the most original form (without divulging names of particular survey respondents) so that other researchers can present the data in more meaningful fashion?

Expert Guidance on High-Rise Evacuation? Generally, this high rise building evacuation expert (indeed likely the most experienced one still active today) has serious heartburn over the study approach and findings presentation for NIST's investigation of occupant behavior and egress in the WTC. Thus I am especially intrigued by the statement on page 229 of NIST NCSTAC 1-7.

> A group of individuals selected for the expertise on human evacuation during high-rise fires was assembled. The individual experts developed the final list of variables, and the relationships between them, to use to specify the model used in this analysis.

Who was in this group of experts? Who on this group of experts had extensive knowledge about, and long experience with, technical bases of requirements for means of egress in model codes and standards—the prime focus for NIST recommendations based on the WTC investigation? Also, why does the NIST NCSTAR 1-7 report not reference the most relevant technical literature about the technical bases for exit stair requirements and about performance of exit stairs in full and phased evacuations?

Inadequate Reference to Evacuation Literature. One final example related to this inadequacy; pages 162-163 of the report describe prediction of total evacuation time including a graph, Figure 10-9, estimating or predicting (minimum) full building evacuation times for various population conditions. No mention is made here of research-based literature I have produced in recent decades on this topic. Especially notable are the office building evacuation time prediction graphs and formulas included in the *SFPE Handbook of Fire Protection Engineering* chapter on Movement of People included in the 1988, 1995 and 2002 editions. Equation 9, in the third edition of the Handbook, offered a simplified formula for estimating minimum total evacuation time by stairs. For 20,000 actual occupants, the predicted time is 98 minutes which should be compared with the roughly 110 minutes shown for 19,800 occupants in Figure 10-9 of the NIST NCSTAR 1-7 report. Even closer was the correspondence between the Figure's linear graph slope—5.2 minutes per 1000 additional occupants or, alternatively stated as 192 persons per minute—and the SFPE Handbook's Table 3-13.5. This Table suggests a value of 216 persons per minute—for "optimum" flow—and 168 persons per minute—for "moderate" flow. In both cases these represent total flow for the combined 12-ft nominal width for all three WTC exit stairwells. Notably, the average of 216 and 168 is 192, the total flow in terms of persons per minute (or 3.2 persons pre second) for the three stairwells combined.

Fruin Levels of Service. Also, although the report references Fruin's classic book, *Pedestrian Planning and Design*, it does not relate estimated WTC stair movement conditions with the "levels of service" described by Fruin. For example, for flow down stairs, using the average flow assumed for Figure 10-9, this assumes a Fruin level of service E, based on a flow of 16 persons per minute per foot of nominal stairway width. This level of service is associated with stairway areas of 4-7 sq ft per person (1.5 to 2.7 persons/m^2) and speeds of about 100 ft/min (0.5 m/sec)—3 stories per min for the WTC stairways (with speed measured along the stair flight slope).

Confusion between Flight and Floor. Incidentally, a word search should be done by authors of the NIST report to find and correct instances where time per flight is noted rather than time per floor (story); typical office floors of the WTC towers had two flights and two landings per floor in a "dog-leg" or "switchback" configuration. (As noted elsewhere in my comments, the authors should also specify the direction of turn to give a complete description of such stairs.)

Key Pedestrian Movement Characteristics Confused. On the topic of Fruin's classic book, *Pedestrian Planning and Design*, the NIST report authors betray a lack of experience in dealing with the key pedestrian movement characteristics, density, speed and flow. On pages 129-130, they state the following (with my underlining added for purposes of my post-quote comment).

> A "rule-of-thumb" for calculating evacuation speed is to assume that a standard size door at the bottom of the stairwell is capable of discharging approximately one person per second. (Fruin 1987)[59] By that logic, with three stairwells, the WTC system would have been capable of moving approximately three people per second from the occupied floors to the Mezzanine or Concourse. In WTC 1, where elevators were not operational for the duration of the evacuation, approximately 7,500 occupants used the stairwells over a 100 minute period, yielding an exit rate of 1.3 people per second from the occupied floors. Even discounting the final 27 minutes (after the collapse of WTC 2 when the evacuation rate dropped significantly), the discharge rate was 1.5 people per second (or 0.5 people per second per door), or about one-half the "rule-of-thumb" discharge rate. This is consistent with the previous observation that the stairwell movement speed was slower than the published literature values would have predicted and that the slower rate was to be expected given the number of obstacles to egress encountered by the evacuees and the total travel distance required.

This discussion confuses "speed" and "flow." The quoted discussion should be referring consistently to "flow" instead of (in sequence as shown underlined in the quote): speed, exit rate, evacuation rate and (twice) discharge rate. Use of "rate" in the last sentence is ambiguous; it apparently refers here to speed but it should be noted that all three of the key movement characteristics are rates.

Confusion about Door Widths. On page 18 of the Report we learn that doors leading to stairs were to be designed at a 3-ft width. However, on page 45 we learn "The 44 in. stairwells were served by doors on each floor measuring 34 in. (1 m) (sic), while the 56 in. stairwell was served on each floor by a door measuring 44 in." Then, on page 46, we learn, "Each stairwell would be required to have a door at least 0.9 m (36 in.) wide" to comply with the 1968 NYC Building Code. Erroneously, at pages 46 and 47 respectively, the report authors state International Building Code and NFPA 101 and 5000 requirements for "door width" as 0.8 m; both actually refer to a minimum clear width of 813 mm (32 in) for the door opening, not the door width. In the egress modeling portion of the report there are a few references to "door width into and out of the stairwell" but, nowhere in the entire report do we authoritatively learn what were the actual door widths (or clear door opening widths) for entry into or discharge from the three exit stairs. Should we assume, in absence of such information in the report, that doors into and from the narrower exit stairs (A and C) were nominally 36 in (32-34 in clear opening) and doors into and from the wider stair (B) were nominally 44 in (about 42 in clear opening) or what? And what are we to assume about doors located at transfer corridors of the exit stairwell system? Errors and omissions in the report on this matter of door width and code requirements should be corrected as a matter of high priority.

Information Lacking about Exit Discharge Doors. Frankly, I was looking not only to a thorough and readily located collection of information on the detailed geometry of the key means of egress components but also for a detailed treatment of how they were utilized by evacuees and emergency responders. For example, how did the exit stairwell discharge doors at plaza and concourse levels serve during periods of counterflow? These are matters of direct relevance to the creation of suggested revisions to codes and standards for means of egress as well as to emergency operations procedures for emergency responders and for occupants.

Study Formulation and Funding. Generally, I am even increasingly convinced that the occupant behavior and egress portion of NIST's investigation was badly under funded and inadequately staffed given the importance of the findings and the great extent of "people committing data" to use the colorful yet apt expression first heard from my late peer, John Archea, then with NIST's predecessor organization, NBS, in the 1970s. At a House Science Committee hearing NIST staff asked for a total of $16 million for the investigation before they were (apparently) convinced by a non-NIST testifier (Prof. Glen Corbett) and the Families to include occupant behavior and egress in the scope of the investigation. Reportedly, this topic was initially given a budget of $1 million but eventually got $2 million (according to a personal communication with Shyam Sunder, 12 July 2005 at the NFPA High Rise Building Safety Advisory Committee meeting at NIST). My early estimate (in late 2001) of what was warranted for the occupant behavior and egress studies alone totaled about $10 million. Given what has been seen in NIST's draft final report (as well as in numerous presentations before that), my early estimate made more sense than NIST's initial estimate.

Remoteness of Exit Stairwells

Generally, I detect two large problems with NIST's treatment of this important topic. First, as it apparently did during the investigation/study, NIST plays down the importance of inadequate exit remoteness as a major factor in the large life loss in the WTC towers. Secondly, I see errors in the analysis done of remoteness requirements and with estimates of actual remoteness in the upper floors, in the vicinity of the impact on WTC1.

Remoteness of Exit Stairwells Requirements in NYC Building Code. In 1968, the location of a floor exit was required to be as remote from the others as practicable. Specifically, according to my records, subchapter 6, Means of Egress, of the 1968 NYC Building Code, Section 27-363, had the following requirements (as subsequently amended).

> **Remote location -** When more than one exit is required from a floor of a building, each exit shall be placed as remote from the others as is

> practicable. Door openings to scissor stairs shall be*(6) at least fifteen feet distant from each other. In all other buildings, the minimum distance between such doors shall be the greater of thirty feet or one-third the maximum travel distance of the floor, provided, however, that where such distance will result in travel distances exceeding those authorized in section 27-357 additional vertical exits shall be provided.

The history of this requirement is described on page 46 of NIST NCSTAR 1-7).

> **2.5.3 New York City Building Code (October 2003)**
>
> As it pertains to the narrow scope of this egress analysis, the requirements related to the egress system in 2003 would be identical to the requirements of 1968, with one significant exception: stairwell remoteness. In 1968, the location of a floor exit was required to be as remote from the others as practicable. New York City Local Law (LL) 16 (1984) imposed a remoteness requirement (not retroactive to an exiting building such as WTC 1 or WTC 2) of 9 m (30 ft) or one-third the maximum travel distance of the floor (55 m [180 ft]), whichever is greater, which for WTC 1 and WTC 2 was 55 m (180 ft). Thus, all floors of WTC 1 and WTC 2 had stairwell separations that exceeded the minimum separation distance requirement of New York City LL 16 (1984).

Page 44-45 of NIST NCSTAR 1-7 provides NIST's findings on exit remoteness in both towers in relation to model code requirements. Note that, as I have indicated with bold italicized text for the concluding sentence, it was found that the remoteness in WTC would ***not*** comply with model code requirements. Also, as discussed below, the 70-foot (21 m) remoteness reported by NIST would just barely comply with NYC Building Code requirements as set out above. *However, as discussed below, NIST's estimate of WTC exit remoteness appears to be overstated by about 10 feet (3 m) relative to my estimate made from a very detailed, dimensioned plan of the floors 84 and higher.* (See appended plan.)

Thus, by my analysis, there would have been a lack of compliance with NYC code—including LL 16 (1984), and model code requirements. Quoting from page 44-45 of NIST NCSTAR 1-7:

> In addition to local changes in the size of the core space, the stairwells in the WTC towers changed floor location throughout the building, as well. This meant that the remoteness (or the distance the stairwells are located apart from one another) of stairwells varied, as well. The greatest separation distance between any two of the three stairwells, as measured by a walking path measurement (assuming that the building is fully sprinklered, which WTC 1 and WTC 2 were) determines the stairwell remoteness. At the two extremes of remoteness found in WTC 1 or WTC 2, floors 83 and higher had Stairwell A and Stairwell B located about 70 ft (21 m) apart, while on floors 77 – 82, Stairwell A and Stairwell C were located approximately 175 ft – 200 ft (54 m – 63 m) apart (depending upon the walking path on a particular floor). Coincidentally, WTC 1 was

most heavily damaged on floors in the 90s (where the stairwells were the closest together) and all three stairwells were destroyed, while WTC 2 was attacked in a region where the stairwells were the most remote (floors 78 through 82) and one stairwell remained passable. The angle of the airplane impact, the length-wise orientation of the core, and the presence of elevator machinery near the passable stairwell may also have been contributing factors to the stairwell survivability, however. For context, most current codes require that two exits be located a distance apart no less than one-third of the diagonal distance of the area served (if the floor has full sprinkler protection) or no less than one-half of the diagonal distance of the area served (if the floor is not fully covered by sprinkler protection). One-half of the diagonal distance of the area served was 147 ft (45 m) and one third of the diagonal distance was 98 ft (30 m). ***Thus, in separate areas within the same building, stairwell remoteness distances would have been less than that required for sprinklered buildings, as well as greater than that required for unsprinklered buildings.***

Not understood is why there is a discrepancy between the maximum travel distance of 180 feet (55 m) noted on page 46 of the NIST report and the maximum travel distance stipulated in the NYC code's section 27-360, which references Table 6-1, with a 200-foot maximum (61 m).

As a logical rule on remoteness, tying it to travel distance makes little sense to me, having first investigated the whole issue of remoteness and its regulation (35 years ago while with NRC Canada as a researcher) and dealt with it through a few decades of committee work, especially with the NFPA Means of Egress Committee. Quantitative remoteness criteria are supposed to be large; travel distance is supposed to be small (i.e., limited by a maximum). But, even by the relatively lax, badly drafted rule based on travel distance (of 200 feet), the NYC code would have required at least 67 feet (20 m) between exit entry doors. Using both the floor plan shown in the report NIST NCSTAR 1 (page 9), Figure 1-5, and a much more detailed, dimensioned, core area plan (Drawing A-B-148) I have of similarly configured floors, the impact floors of Tower One provided only about 45 feet (14 m) measured in a straight line, and about 60 feet (18 m) measured along the path of travel in the corridors, between the most distant of the exit entrance doors. A copy of the detailed core-area plan, marked with my distance estimates is appended to these comments.

According to my analysis of WTC plans, the third- and half-diagonal rules in current model building codes in the USA would require the travel distance between exit doors to be a minimum of about 95 feet or 142 feet (29 m or 43 m)—based on a 284-foot (87 m) diagonal dimension, depending on whether the sprinkler-based relaxation of the rule applies. (The minor differences between my analysis and that by NIST does not affect the conclusion that the WTC would not comply with the diagonal-based rules.) Notably, when initially constructed, the WTC towers were not sprinklered and, on 9/11, sprinklers were not operational.

Thus by all measures, there was not reasonable redundancy—provided to exit remoteness—on critical floors of the WTC and many people above impact areas were trapped. However, this reader of the NIST reports—and frequent attendee at NIST staff presentations—gets the impression that NIST is trying to play down this design defect, including by giving mixed messages about compliance with codes.

Below I reproduce, as my Figure 1, a modified version of NIST's Figure 1-5 which is a simplified version of the plans I had available of comparable floors (with one example appended to these comments).

Figure 1. Floor plan of WTC 1, floor 96. with superimposed circles connecting and enclosing the three exit stairwells, designated as A, B and C. (Derived from Figure 1-5 from NIST NCSTAR 1)

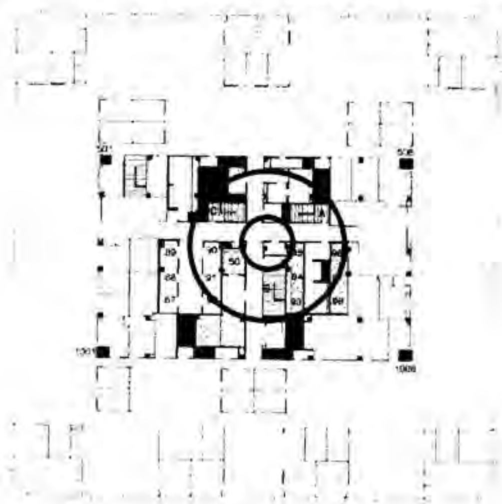


Figure 1 shows the floor plan for WTC1, 96th floor which had a fourth stair (in the upper left corner of the core), a convenience stair between three local floors and not serving as an exit. One of the problems in the World Trade Center towers was the close proximity of all three of the exit stairs on almost all floors and especially on the impact floors for WTC 1, including the 96th floor illustrated in Figure 1. On these floors the direct-line distance separating exit enclosures was, *at best*, only about 21 feet (6 m). Indeed if a triangle were drawn connecting the three exit enclosures, it would have an area of only about 180 sq ft. (17 sq m). This would be relative to an overall (interior) floor plan dimension of about 206 feet (63 m) per side (about 284 feet or 87 m in diagonal dimension) and an area of about 42,000 sq ft (3,940 sq m) according to my estimates.

Superimposed on the plan in Figure 1 are two circles. The smaller circle, touching the closest walls of the three exit stairwells (A, B, and C), has a diameter of about 21 feet (6 m) and an area of 360 sq feet (33 sq m); the larger circle encompasses all three stairwells and has a diameter of about 66 feet (20 m) and an area of about 3,400 sq ft (316 sq m). In other words, an event impacting as little as a 360 sq ft (33 sq m) circular area could damage a portion of the shaft walls of all three exit stairwells while an event destroying as little as a 3,400 sq ft (316 sq m) circular area could eliminate all three exit stairwells—essentially what happened on 9/11. Relative to the overall floor area, these circular areas are respectively only about 1 percent and 8 percent of the floor area. Note that the core area, within the major interior columns, measured about 86 feet by 137 feet (26 m by 42 m), making an area of about 11,800 sq ft. (1,100 sq m) or about 26 percent of the floor area overall. Thus an event devastating as little as one-third of the core area could (and did) destroy all three exit stairwells.

Surely it cannot be reasonably argued that the exits, especially on upper floors such as floor 96, were as far apart as was practicable nor that reasonable redundancy was provided. Moreover, contributing to my professional opinion that NIST is unreasonably de-emphasizing the role of exit remoteness, is its flawed assessment of the degree with which the WTC towers complied with the NYC building code at the time of its design. Specifically, as discussed above in relation to my Figure 1, the three exits in the impact zone of WTC1 complied with neither the spirit nor the letter of the NYC building code of 1968. Yet NIST NCSTAR 1, on page 58, asserts the following.

> The 1968 NYC Building Code contained a requirement that the stairwells be "as far apart as practicable." Since the stairwells on the impact floors of WTC 1 were substantially closer together than those on the impact floors of WTC 2, it certainly was possible to have designed a greater separation in WTC 1. Local Law 16 (1984) added a quantitative requirement that the separation between exit door openings be at least one-third of the maximum travel distance of the floor. For the WTC towers, this maximum distance was 180 ft, and the smallest separation of stairwell doors was 70 ft. The towers were consistent with this requirement.

Again, my reading of the NYC building code is that the maximum travel distance was 200 feet (61 m), not 180 feet (55 m). Furthermore, my estimate of the *largest* (not the "smallest") travel distance between exit entry doors was only about 60 feet (18 m)—measured per NFPA 101 requirements. Thus, by my assessment, the towers were ***not*** consistent with the NYC requirements in either letter or spirit.

Evidence of Benefit of Increased Remoteness of Exit Stairwells. It is well documented that, due to an unusual, more-remote positioning of exit stairwell A in WTC 2—in the vicinity of its impact zone, several people were able to descend through the impact zone shortly after impact (e.g., see page 156 of NIST NCSTAR 1).

> Eighteen people in or above the impact zone when the plane struck are known to have found the one passable stairway and escaped. It is not known how many others from the impact floors or above found their way to the passable stairway and did not make it out or how many could have been saved had the building not collapsed. A delayed or avoided collapse could have provided the additional time for more people to learn about and use the passable stairway.

There is a possibility that, later, exit stairwell A was once again usable because evacuees were reported coming down—*below the impact zone of WTC 1*—just prior to collapse.

> Stairwell A in WTC 2 remained passable for at least some period of time after the aircraft impact because (1) only the end of the left wing, empty of jet fuel, was in line with the stairwell; (2) Stairwell A was behind the structural/architectural core in the area of impact; and (3) the aircraft debris had to travel through the longer dimension of the core and thus was slowed by a greater number of columns, shafts, walls, and mechanical equipment, and (4) Stairwell A was widely separated from Stairwells B and C.
>
> Eighteen people successfully used the debris-cluttered Stairwell A in WTC 2 to leave the building after being on or above the 78th floor when United Airlines Flight 175 hit the building. It is possible that additional occupants from above the impact floors were making their way down the stairwell some minutes before building collapse.

Page 188 refers to situation awareness about Stairwell A.

> Some occupants did not get information that potentially could have saved their lives, such as notification that Stairwell A was passable from above the impact zone.

Even more detail is provided on page xxxiv of NIST NCSTAR 1-7.

> Minutes prior to the collapse of WTC 2, an NYPD Emergency Services Unit (ESU) officer radioed from a floor in the 20s to the outside that he was having trouble ascending the stairwell due to the large number of occupants descending (Interview 24 NYPD [NIST 2004]). As only seven occupants who started evacuating below the impact region were known not to have survived, among several possibilities, a large group of occupants from above the impact floors may have identified the passable stairwell (Stairwell A) and may have been making their way out of the building as it collapsed.

Thus the largest "what if" question about 9/11 (at least for me) is about the possibility of fewer trapped occupants if the exits had been located for greater redundancy—even if still located in the core column area, let alone outside the core area. During NIST's investigation/study, it certainly appeared to me that the remoteness issue was being given short shrift by NIST staff. The draft final reports seem to confirm that impression and worse.

What the NIST Reports Say and Do Not Say Generally about Exit Remoteness. Looking at NIST NCSTAR 1, specifically the PDF file of the report, remoteness of exit stairs is referred to only five times with the term "remote." The first of these occurs on page 168 in a section titled, "7.3 FACTORS THAT CONTRIBUTED TO ENHANCED LIFE SAFETY." It refers to exit stairwell A in WTC 2. All of the other uses of "remote," in relation to location of exit stairwells, occur in the recommendations section.

specifically on pages 212 and 213, for Recommendation 18 with its wordy, but not very helpful or definitive discussion. A second word search of NIST NCSTAR 1 used the term "separation." This search identified 18 occurrences related to exit remoteness, on pages xiv, 57, 58, 151, 173, 194 and 212.

Balancing (partly) the section titled,"7.3 FACTORS THAT CONTRIBUTED TO ENHANCED LIFE SAFETY" (as described above), was section 8.6, on page 194, "FUTURE FACTORS THAT COULD HAVE IMPROVED LIFE SAFETY." However, nowhere is there any mention in this section of improved remoteness of exits even though it refers to "capabilities that could have increased the survival rate of those in the WTC towers, had they been in place on September 11, 2001." In my professional opinion, greater—*more effective*—remoteness of exits, combined with more-robust construction around the exit stairwells, could have made a major difference with life loss in both towers on 9/11.

Page 173 of NIST NCSTAR 1, while addressing the issue of a fourth exit stairwell possibly being required to serve the top-level assembly occupancy, made the following comment that reinforces the potential value of better distribution of the three provided exit stairwells.

> It is conceivable that such a fourth stairwell, depending on its location and the effects of aircraft impact on its functional integrity, could have remained passable, allowing evacuation by an unknown number of additional occupants from above the floors of impact.

Summing Up. Regarding NIST's treatment of exit remoteness, improvements are recommended to more consistently—and forcefully—describe the benefits of more effective exit remoteness than was provided in the WTC towers. Also, NIST staff should check the accuracy of the 180-foot (55 m) travel distance limit they assert—when my information is that it is 200 feet (61 m). NIST staff should also reconsider their contention that the travel distance between the doors of stairwells A and B was 70 feet (21 m) versus the 60 feet (18 m) I found. Finally, I would hope that NIST would reconsider the weight it gives to the remoteness issue and treats it with the same degree of attention given to some of the structural and collapse mechanism issues. The fact that all three closely-spaced exits were destroyed in WTC 1 and mostly destroyed in WTC 2—and thus trapped many people who might, otherwise, been able to escape—should be dealt with much more seriously in NIST's final report issued after public comment.

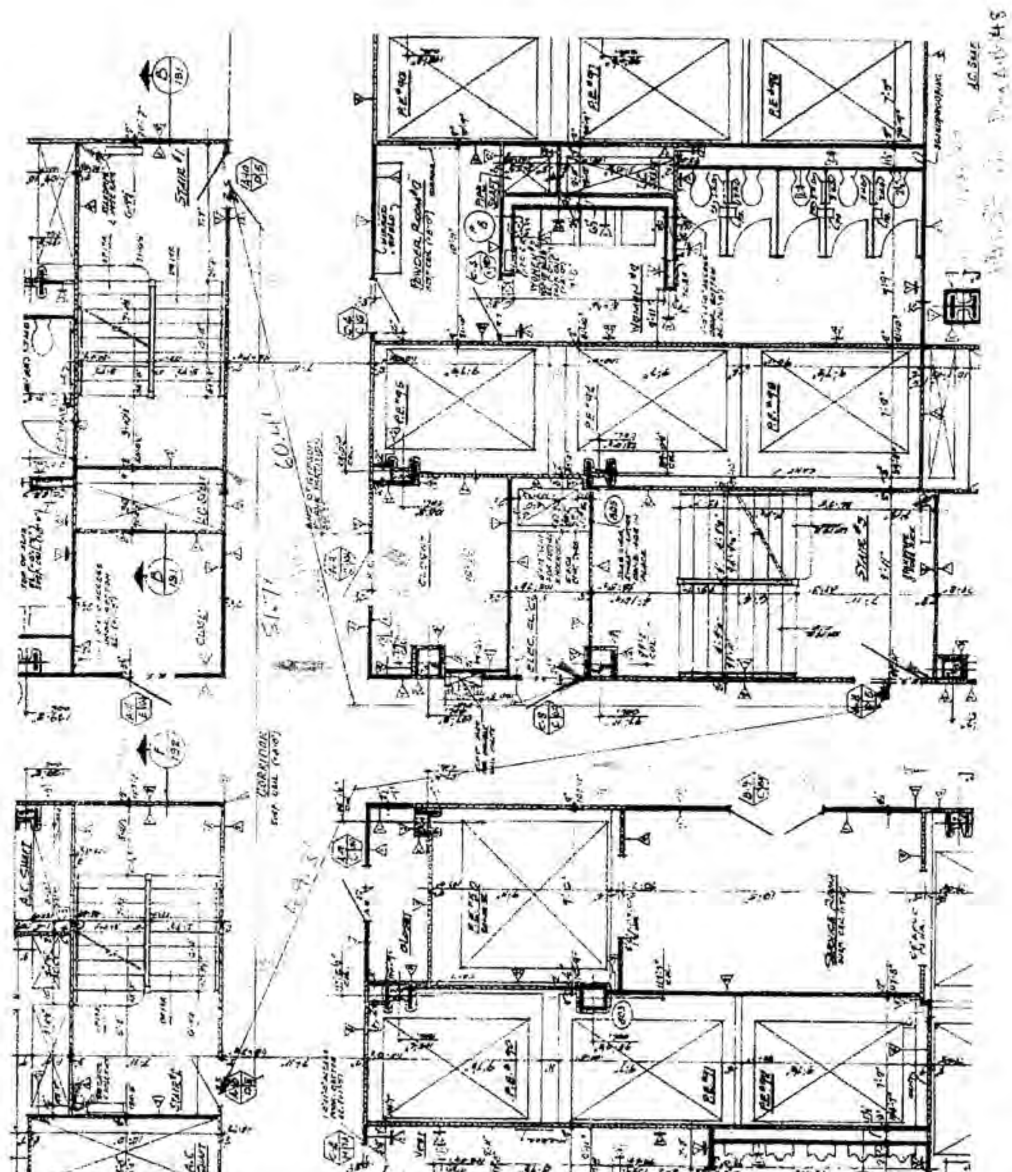
The other major topic dealt with in my comments—the criticism of NIST's relative lack of attention to what was happening in those portions of the exit stairwells that were usable—likely cannot be fixed in the final report. An opportunity to deal with an important aspect of tall building evacuation was missed, apparently because the investigation/study team was more intellectually excited about pre-evacuation behavior. The only fix for this, that I can see, is to make survey data available to other researchers who can still glean, from the survey records, a clearer picture of what happened in the exit stairwells and why it differed so substantially from prevailing expectations about evacuation speed and flow for example. In my opinion NIST has a major problem here, particularly with two predictions that have gotten much media attention. Flawed assumptions about egress performance in the exit stairwells directly affect the prediction that a total evacuation with a full occupancy would have entailed a time of 4 hours. Related to this is the estimate of how many people would have died (the 14,000-fatality figure)—especially due to inadequate exit capacity—had the population been higher. These are based on a highly questionable analysis—based on skimpy data—of what happened in the exit stairwells on 9/11.

Moreover, the six-week public comment period has not permitted thoroughly and critically going through even the small number of reports bearing on human behavior and egress. Had this been possible, I am sure that there would have been many more comments. Among such comments would be a plea to clean up the terminology used to describe people with disabilities. Thankfully, I recognize that a colleague, Edwina Juillet, has communicated with leaders of the NIST WTC study to suggest better, more-standard terminology to replace "mobility challenged" for example. For persons not having permanent physical disabilities, could I suggest (in addition to what Edwina Juillet recommends) that NIST use more-specific terminology such as, perhaps, "fatigue-reduced" egress speed and flow. This could be used with terminology such as "congestion-reduced" egress speed and flow.

Fortunately, my review activity of at least NIST NCSTAR 1 will continue in a number of ways. First, as a member of NFPA's High Rise Building Safety Committee and as a member of several NFPA technical committees and technical correlating committees, much effort will be given to NIST's reports and, especially, the 30 recommendations. Second, as a member of the Professional Advisory Panel of the Skyscraper Safety Campaign, NIST's work will be closely and critically monitored. Third, over coming months, in giving several presentations in the US and Europe based partly on what NIST has learned and how it has treated the findings, there will be significant references to the reports. (Relative to this activity, I hope that NIST permits my presentation at its conference in September.) Fourth, as part of the public discourse in the trade press as well as mass media, I will continue to be open to extensive contact with journalists. Relative to this, as the second appendix to these comments, I am attaching my early reaction to some of the recommendations made by NIST; these were provided to *Engineering News Record* some weeks ago.

Finally, as one involved as a long-time researcher and consultant in the field of human factors in building safety, I was hoping that the WTC study by NIST would help build a set of capabilities, tools and procedures that could be employed—in a future disaster or other emergency event—much more expeditiously than occurred with the WTC disaster. With the limited staff, time and financial resources apparently available at NIST, this appears to have not happened. For one thing, something needs to be done to reduce—if not eliminate—the delay due to IRB approval of surveys of people directly impacted by an emergency. This will be further taken up with the NCSTAC, I hope.

APPENDIX 1. PLAN OF WTC FLOORS 84-86 (DESIGN DWG. A-B-148) SHOWING REMOTENESS ANALYSIS BY JAKE PAULS



APPENDIX 2. COMMENTS SUBMITTED BY J. PAULS TO *ENGINEERING NEWS RECORD* ON NIST WTC REPORT RECOMMENDATIONS

Rec. 4. NIST is correct in noting that time needed for total evacuation should be taken into account when determining appropriate construction of tall buildings. See also Recommendation 17.

Rec. 15. Black boxes have been a standard feature of passenger aircraft for a long time and have been extremely valuable when a mishap occurs to determine exactly what happened. Very large buildings expose many times more people to potential danger yet few have the means to record, reliably, for subsequent analysis, what happened in an emergency. In making Recommendation 15, I would have been more specific than NIST was; I recommend that all exit stairs be equipped with video cameras capturing egress movement and ingress (by emergency responders for example) on the discharge flight of the stairs. Real-time data are needed on exactly how many people evacuate via each stair, what counterflow they encounter and how this occurs over an accurately recorded time scale. As well as being valuable for real-time situation awareness of emergency responders and building management, the video information should be preserved, by means of the building's black box, for post-incident analysis.

Rec. 17. Two very important recommendations are made here. First, even very tall buildings should be designed to facilitate total evacuation, even if such evacuations will take a substantial time that has to be reconciled with hazards occupants will face. As a last resort, total evacuation cannot be ignored. It happens more often than many in the building industry want to admit and, for any one building, there is a high probability of a total evacuation occurring at least once in a tall building's life. Recall that the World Trade Center had at least three in its relatively short life.

Second, my 38 years of research and other work on evacuation of large buildings, especially by stairs, has underlined serious errors in the technology assumed for building regulation and the resulting design and construction of large buildings. After being critical of NIST and NBS (the old organization name) for some three decades, it is heartening to see that NIST finally recognizes the need for exit stair design to be based on what actually happens in 44-inch wide stairs traditionally assumed to facilitate two-abreast crowd flow but actually too narrow, by 12 inches or more, to facilitate such flow. Emergency responder counterflow, especially with firefighters laden with bulky clothing and other gear, also requires that stairs be much wider. Here it might be appropriate to ask the few organizations in the building industry (e.g. BOMA and GSA) who oppose making exit stairs of tall buildings, even relatively heavily populated tall buildings, wider by 12 inches (as being done in NFPA 101 and NFPA 5000 currently), are they planning to participate in the international conference in Vienna this September, on Pedestrian and Evacuation Dynamics, where a scientific paper on the topic of appropriate minimum stair width is being presented? (The conference is PED2005, www.ped2005.com.)

Rec. 18. I believe that the remoteness of the three exit stairs in the WTC towers did not meet the letter or the spirit of the 1968 NYC building code. Generally, remoteness of the

WTC exits could have been a factor in the large life loss, especially in the south tower where one stair was available for a time after impact and could have been available longer—permitting more people above the impact area to evacuate. In this regard, I believe NIST is incorrect in asserting that nothing in the design would have changed the outcome. Perhaps related to NIST not sufficiently recognizing the importance of exit remoteness in its draft final report is its failure to even address the topic until I kept pointing out its relevance during the study period. As one of the earliest topics I addressed in my research on large building safety during the late 1960s and early 1970s, exit remoteness and appropriate travel distance should be more scientifically addressed instead of utilizing the relatively crude criteria currently in the codes and standards.

Rec. 20. Within the recommendations chapter, NIST does not adequately address the current significant progress being made in relation to standards and codes addressing elevator use for both fire services and occupant evacuation. In all of my 38 years in the building use and safety field, the change in thinking observed in the last year and a half on use of elevators is a true paradigm shift. A smaller development is occurring with certain evacuation devices, specifically "stair descent devices"—not "stairwell navigation devices" as confusingly described by NIST—which are being addressed with substantial guidance information in the editions of NFPA 101 and NFPA 5000 being approved this summer.

Generally, underlying many of the recommendations is an implicit set of assumptions about risk and risk acceptance plus management. Risks of dying due to a fire in a single-family home cannot be used as a basis for assessing the acceptable risk of dying in a tall building. The research literature on risk has dealt with the influence of the degree of control an individual perceives relative to a risk. Thus safety in tall buildings is more like safety of commercial air travel than it is, for example, like safety of private automobile use or home safety. The risks for tall buildings have to be very low—and they are not as low as some reports like to make out. Consider, for example, the six deaths in the Cook County Administration building in Chicago in 2003. There is an inadequate appreciation of how public perception, and acceptance, of tall building safety risk changed over recent years. One indication of these changes is the extra attention -- going well beyond minimum code requirements—in some iconic tall buildings recently, including the replacement Building 7 at Ground Zero. Getting tenants into such buildings is another, albeit mixed indicator. This topic cries out for longitudinal research.

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Corpus Christi, TX 78475
jmorey@interconnect.net
July 20, 2005

WTC Technical Information Repository
Attn. Mr. Stephen Cauffman
National Institute of Standards and Technology
Stop 8610
Gaithersburg, MD 20899-8610

Re: Report# NCSTAR 1-Draft WTC Investigation

REFERENCE: P.# 218: Recommendations 29[B] and 30. ". . . NIST recommends that continuing education curricula should be developed and programs should be implemented for training . . . architects and fire protection engineers in modern fire protection principles and technologies, including fire-resistant design of structures." [and] "academic, professional short-course, and web-based training materials . . . To strengthen the base of of available technical capabilities and human resources. . . *Affected Organizations* . . ."

SUGGESTED REVISION: ". . . .NIST recommends that a program of dialogue and advocacy between the fire protection engineering community and the architectural community begin, which will culminate in both academic and continuing education curricula and training for architects ...." [for both recommendations] "*Affected Organizations* ... AIA, at the national, regional, and chapter levels, NCARB (National Council of Architectural Registration Boards), and NAAB (National Architectural Accrediting Board), and ICC (the International Code Council)...."

REASONS: I have spent much of the last ten years trying to do advocacy for fire safe design at the local level and have uncovered some of the difficulties. I have read much of the fire protection engineering material, talked with other architects, helped prepare and support the presentation of a rudimentary fire protection engineering program (along with a building code education program) to our local architects. Along the way, I found it necessary to photograph and share "horror stories" of buildings that may kill; file complaints with the City and our licensing board because the affected architects didn't believe me; researched building code enforcement and A-E liability law; and written many letters to our state licensing professionals, architects, and some affected client representatives. When we planned our C.E. program, I heard lots of excuses from my fellow professionals as to why they did not want to come to this kind of program, and have answered these with reasons why they need to. I have done my homework very thoroughly re code interpretations & fire protection engineering principles (including several SFPE C.E. programs.) I have enlisted the support of both building officials, a few architect leaders who want to be responsible, and attorneys both in private practice, with ICC, and with the City - to make some progress. As our leadership committee planned our program, many architects complained about how long the program was and what days they had to attend; we believed the scope was minimal, compared to the need. Last month, 60 people attended the two + day C.E. program co-sponsored by the City of Corpus Christi and AIA Corpus Christi, and all reports we received from participants indicated that it was a great success. As we planned it, national leaders told us both architects and code officials need to learn the same things at the same time, and in this respect also it was a qualified success. But in terms of needed subject matter, we barely taught some basics. And that success was for a Corpus Christi program where most of the participants did not travel overnight and for which the price was less than half that of all known commercial programs; if it had been given in Houston or even Austin, I might have been one of only two or three from here to attend. Only 8 to 10 chapter members usually attend our state convention or a continuing ed. program on South Padre Island. Another tool we used to get our local leaders to sell the program was to set it up so that our AIA Chapter could financially benefit. The leadership committee received the early registration list, and those firms did not plan to attend were asked to reconsider by committee architects who knew them best.

Based on my experience, I believe we must start with analyzing the fire safety mistakes that get built, share these horrors of potential as well as historical losses with our leaders, in order to get our profession ready to learn. We need to give them some inkling of how widespread these dangers are, and also to identify exactly what the needs are. While systematic national research based on random sampling would be very desirable, at least we should begin with some spot audits which include recording photos and/or drawings of architect-designed buildings being wrongly built, in several US cities. When we have done this and shared them with an analysis with our leaders, I believe my fellow professionals will be more ready to learn. When we have convinced the leaders, they and not someone like me can sell it. At some point, it needs to be a part of our mandatory continuing ed. for licensure. When we have analyzed what the failings of architects are, we will also be better able to tailor the program content to exactly what principles we are missing and to when we need the services of a FPE. Very likely, many architects will need an FPE not only for Alternate Means and Methods, but also for recognizing how much renovation is needed when we do substantial renovations of exiting buildings.

In terms of professional goals, I believe architects in many locations are now getting most of our professional goals of openness and beauty met; but we are not getting the safety we need, because neither code officials nor architects know enough. A second part of the problem is that we architects want beauty and not safety because that is what our profession primarily rewards, and the sanctions for safety are very ineffective. So we don't want to spend more construction dollars on fire protection and we don't want to spend more of our fees. So to simply try to sell us on wonderful benefits of FPE, or to invite us to attend one national program, I believe will be of extremely limited success. Some changes should be made to our Design Awards and our Design education grading criteria. Altogether, it is a program of Systemic Social Change. But if architects don't change our values, our knowledge, and our behavior, we will sooner or later experience a great disaster and we will find more and more of our area of practice taken over by Architectural Engineers. None of us want that!

So, if you are going to recommend this, which organization(s) will take a management/leadership role and who will be the advocate in charge? Without an action plan, not much will happen!

Yours truly,

Jeri L. S. Morey, AIA
afl. m. SFPE
prof. m. ICC

c: Morgan J. Hurley, SFPE Technical Director

In

From: "Jeri L. S. Morey" <jmorey@interconnect.net>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/8/2005.

Name : Jeri L. S. Morey
Affiliation : Jeri L. S. Morey, Architect
Email Address : jmorey@interconnect.net
Phone : 361-866-8923
Report Number : NCSTAR 1
Page Number : 217
Paragraph : Recommendation 26: ". . . . Further , occupancy requirements should be modified where needed (such as when there are assembly use spaces within an office building) to meet the requirements of the model codes."
Comment : I think this is a little bid confusing. Your comments following this are good, but maybe not sufficient to say what needs to be said. What is needed is that all buildings should be evaluated and designed for all building uses, and when additional non-accessory uses are added to a building, all them need to be evaluated, either as separated or non-separated uses, and all egress routes and fire protections upgraded when they no longer meet the codes under which they were built, altered, and expanded.
Comment Reason : See above.

Revision Suggestion : Whenever new uses are added to a building, whether as tenant finish-out, or as an alteration of addition, or simply in the way the building is used for a portion of the time, the building must be re-designed for the egress and fire protection requirements for the complete set of non-accessory uses, per then current model code.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

WTC PUBLIC COMMENTS

PART # 2

From: Charles Jennings <cjenning@jjay.cuny.edu>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/5/2005.

Name : Charles Jennings
Affiliation : John Jay College
Email Address : cjenning@jjay.cuny.edu
Phone : 9144226400
Report Number : NCSTAR 1
Page Number : 19
Paragraph : paragraph 4
Comment : Tone alert capability could be useful for distress signalling, but alternate technologies including using MDC1200 identifiers with a distress button or a seprate digital communications network for accontability could be more effective given the limittaions on frequencies during a major incident.
Comment Reason : NIST, as a technology agency, should identify alternative means for improving accountability and ability to signal emergencies on such incidents.

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Charles Jennings <cjenning@jjay.cuny.edu>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-8

Information Submitted on: 8/5/2005.

Name : Charles Jennings
Affiliation : John Jay College
Email Address : cjenning@jjay.cuny.edu
Phone : 914-422-6400
Report Number : NCSTAR1-8
Page Number : 1
Paragraph : bullet points after first paragraph
Comment : NIST needs to identify minimum needs for technology infrastructure and information to manage complex incidents of this type. The basic deision support infrastructure in place at FDNY was essentially unchaged from 1993 despite lessons learned at the first event and massive technological change in the industry.
Comment Reason : self evident. Needs for lessons learned nationally for policy formation.

Revision Suggestion :

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Cc: dlowe@nist.gov
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Information Submitted on: 8/5/2005.

Name : Charles Jennings
Affiliation : John Jay College
Email Address : cjenning@jjay.cuny.edu
Phone : 914-422-6400
Report Number : NCSTAR1-8
Page Number : xlix
Paragraph : paragraph 3
Comment : The inability to establish a unified command was a major failure, and the rationale for explaining this should be elaborated as a matter of policy, discipline, or envirnmental factors.
Comment Reason : self evident. Unified command is a major objective of NIMS and federal efforts to promote incident management.

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-8

Information Submitted on: 8/5/2005.

Name : Charles Jennings
Affiliation : John Jay College
Email Address : cjenning@jjay.cuny.edu
Phone : 914-422-6400
Report Number : NCSTAR1-8
Page Number : xlviii
Paragraph : Paragraph 6, first sentance.
Comment : NIST set out to interview 100 firefighters. Acording to the report, only 68 were interviewed, and of those, only a handful appeared to have operated inside the towers above grade level.
Comment Reason : Methodological validity of firefighter comments and experience hinge on wide and representative participation in interviews.

Revision Suggestion : Indicate mor precisely the assignment of personnel interviewed from the FDNY and if cooperation was received. If not, were barriers presented by City Attroney, FDNY leadership, or organized labor?

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Email Address : cjenning@jjay.cuny.edu
Phone : 914-422-6400
Report Number : NCSTAR1-8
Page Number : xlix
Paragraph : paragraph 2, last sentance
Comment : The lack of liaison officers at each command post jeopardized incident outcome and was a violation of procedure.
Comment Reason : self evident. If existing practices were not applied, they should be reinforced as lessons for future repsonders and policy makers.

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

X-Sieve: CMU Sieve 2.2
From: Charles Jennings <cjenning@jjay.cuny.edu>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-8
Date: Fri, 05 Aug 2005 17:15:02 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: cjenning@jjay.cuny.edu

Information Submitted on: 8/5/2005.

Name : Charles Jennings
Affiliation : John Jay College
Email Address : cjenning@jjay.cuny.edu
Phone : 914-422-6400
Report Number : NCSTAR1-8
Page Number : xlii
Paragraph : Last paragraph, next to last sentance.
Comment : While principals interviewed indicated that they thought that firefighting on upper floors was not a reasonable option, there was no indication that this belief was translated into a strategic or tactical incident objective, nor that it was communicated to firefighters operating at the scene.
Comment Reason : self evident.

Revision Suggestion : Please elaborate on if these priorities were communicated to responders.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

X-Sieve: CMU Sieve 2.2
From: Charles R Jennings <cjenning@jjay.cuny.edu>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-8
Date: Fri, 05 Aug 2005 15:06:40 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: cjenning@jjay.cuny.edu

Information Submitted on: 8/5/2005.

Name : Charles R Jennings
Affiliation : John Jay College
Email Address : cjenning@jjay.cuny.edu
Phone : 914-422-6400
Report Number : NCSTAR1-8
Page Number : 24
Paragraph : Paragraph 1, sentance 2.
Comment : Referring media inquiries to an agency during an ongoing emergency, particularly when information will be directed to trapped occupants, is not appropriate. Emergency services should have a means for directly speaking with the press.

At an EOC, or a dedicated location, a "live feed" capability with a dedicated spoeksperson to read instructions to the trapped occupants via the media.
Comment Reason : At mass events such as this, there is a clear need for timely and definitive communication to civilians and responders in an affected area. Using existing measn are ineffective, as we have seen.

Revision Suggestion : Consideration should eb given to setting up a facility for shared "live feeds (audio and video) in the 9-1-1 or EOC of a City to permit real-time provision of information culled from incoming 9-1-1 calls that can identify emergent issues, such as evacuation routes, stairwells obstructed, staying off roof, etc.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/5/2005.

Name : Charles Jennings
Affiliation : John Jay College
Email Address : cjenning@jjay.cuny.edu
Phone : 9144226400
Report Number : NCSTAR 1
Page Number : 19
Paragraph : paragraph 4
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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-8

Information Submitted on: 8/5/2005.

Name : Charles Jennings
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Affiliation : John Jay College
Email Address : cjenning@jjay.cuny.edu
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Page Number : xlix
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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-8
Date: Fri, 05 Aug 2005 17:15:02 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
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X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
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Comment : Referring media inquiries to an agency during an ongoing emergency, particularly when information will be directed to trapped occupants, is not appropriate. Emergency services should have a means for directly speaking with the press.

At an EOC, or a dedicated location, a "live feed" capability with a dedicated spoeksperson to read instructions to the trapped occupants via the media.
Comment Reason : At mass events such as this, there is a clear need for timely and definitive communication to civilians and responders in an affected area. Using existing measn are ineffective, as we have seen.

Revision Suggestion : Consideration should eb given to setting up a facility for shared "live feeds (audio and video) in the 9-1-1 or EOC of a City to permit real-time provision of information culled from incoming 9-1-1 calls that can identify emergent issues, such as evacuation routes, stairwells obstructed, staying off roof, etc.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

Comments on NIST Recommendations
June 23, 2005

by Jon Magnusson, PE, SE, Hon. AIA
Chairman/CEO – Magnusson Klemencic Associates – Structural/Civil Engineers
206-292-1200
jmagnusson@mka.com

Member – American Society of Civil Engineers / FEMA WTC Building Performance Assessment Team
Member - National Fire Protection Association Highrise Building Safety Advisory Committee

Recommendation 1 – Progressive Collapse

NIST has provided absolutely no data showing there has been even a single death as a result of progressive collapse anywhere in this country. How do you "improve" public safety from a record of no deaths?

The consequences of the WTC attack did not constitute a case of progressive collapse. This was confirmed by experts at the 2002 NIST Progressive Collapse Workshop in Chicago. The WTC design met and bettered all currently proposed progressive collapse standards and code provisions.

Additionally, progressive collapse standards are ineffective against large scale attacks like those at Oklahoma City, the Pentagon, and the WTC. Shankar Nair, a prominent structural engineer in Chicago, recently published findings of a study showing that the outcome in Oklahoma City would have been the same even if the building had been designed to proposed progressive collapse standards.

Recommendation 2 – Wind Tunnel Testing

Wind tunnel results had absolutely no bearing on the outcome of the WTC attack.

The safety record of buildings designed by wind tunnel testing is 100%...absolutely no deaths due to wind tunnel testing problems.

Recommendation 3 – Building Sway

Building sway standards had absolutely no bearing on the outcome of the WTC attack.

Standards already exist for building sway in wind and earthquake and have proven to result in good building performance.

Recommendation 4 – Fire Issues

Actual fire safety records prove that buildings already achieve the performance objective of reaching "burn out" of the contents with structural collapse.

Records by the National Fire Protection Association show that in the 14-year period of 1985-1998 there were only 7 deaths due to fires in highrise office buildings.

If creating "compartments" in open space offices is required for safety, is NIST recommending that all buildings be retrofitted with these fire walls? The NIST findings talked about 5,000 square feet compartments, why have they increased this to 12,000 square feet?

Where is the actual fire data showing that existing fire codes do not provide safety?

Recommendation 5 – Fire Resistance Testing

Yes, current fire resistance testing methods have been used for a century…with excellent safety results. More sophisticated testing methods result in <u>less fireproofing</u> than current testing methods.

Recommendation 6 – Sprayed Fire Resistive Material

The key question is what standard would be applied? Is it that the fireproofing must resist the impact of an airplane attack? That is not possible; therefore, fireproofing standards had absolutely no bearing on the outcome of the WTC attack.

Recommendation 7 – "Structural Frame" Approach

NIST has provided no scientific data showing that the structural frame approach has any better safety record than the current code approach. The use of the structural frame approach would have had absolutely no bearing on the outcome of the WTC attack.

Recommendation 8 – Burn Out

This is a good objective.

Recommendation 9 – Performance Based Design

This is a good recommendation.

Recommendation 10 – New Fire Coatings

This is a good recommendation.

Recommendation 11 – Advanced Materials

This is a good recommendation.

Recommendation 12 – Sprinklers for Taller Buildings

Sprinkler design already considers fires in highrise buildings. Their fire safety record is excellent. NIST has provided no data to demonstrate a need for change in the current standards.

Since all the sprinkler main and branch lines were destroyed by the impact of the airplane, these proposals would have had absolutely no bearing on the outcome of the WTC attack.

Recommendation 13 – First Responder Communications

This is a good recommendation.

Recommendation 14 – Command Station Data

This is a good recommendation.

Recommendation 15 – Off-site / "Black box" Data Gathering

This is a good recommendation.

Recommendation 16 – Public Education

This is a good recommendation.

Recommendation 17 – Fast Full Building Evacuation

Exits are already provided for full building evacuation…the only question is how long it takes. Under the most common hazard scenarios it is safer not to evacuate the whole building, but rather, to evacuate those people closest to the hazard. If stairwells are filled by people who were not in the hazard area, they will impede the progress of those that are in danger.

NIST did not provide any historical safety data showing the stairwells are not wide enough. To design a tall building for "fast" total evacuation would require the entire lower floors to be nothing but stairs!

The width of the stairwells had absolutely no bearing on the outcome of the WTC attack.

Recommendation 18 - Egress Components

Intuitive and obvious signage is a good recommendation.

It is not possible to maximize remoteness without negatively impacting travel distance. This would reduce safety in fires. Maximum remoteness could also make a building more vulnerable to certain kinds of terrorist attacks.

The locations of stairwells in the WTC were determined in accordance with fire safety and building code standards, not some undefined terrorism standard.

The historical safety record for the integrity and survivability is excellent. Logic dictates that stairwell walls would not need to be "hardened" unless the design hazard is big enough to destroy all the stairwells in a building. Any hazard this large would destroy the entire building. Therefore, it would be irrelevant what the walls were made of. If the NIST recommended "hardening" of the walls is implemented, it could actually make the building more vulnerable to certain kinds of terrorist attacks.

The structural integrity provisions of stairwells in the WTC were designed in accordance with fire safety and building code standards, not some undefined terrorism standard.

Recommendation 19 – Emergency Information

This is a good recommendation.

Recommendation 20 – New Evacuation Technologies

This is a good recommendation.

Recommendation 21 – Fire Protected and Structurally Hardened Elevators

NIST is incorrect to say that first responders do not currently use elevators. They are used all the time in emergency situations. National building already require elevators to return to the lobby during a fire alarm for use by emergency responders.

Elevators are already in fire-protected enclosures.

If you decide to "structurally harden" elevators, the key question is how "hard"? What is the design hazard in an attack on the elevators?

Recommendation 22 – Communication Systems

This is a good recommendation.

Recommendation 23 – Situational Intelligence

This is a good recommendation.

Recommendation 24 – Command and Control Systems

From a building design standpoint, there is absolutely no way to ensure effective and uninterrupted operation of a building command center. A bomb could be put in the command center itself. However, command centers can be designed for code-basis hazards.

Other protocols are outside of building design.

Recommendation 25 – Code Jurisdiction

The NIST statement that some entities "are not subject to building and fire safety code requirements of any governmental jurisdiction" is not correct. The Port Authority of New York and New Jersey is subject to their own requirements and they are a governmental jurisdiction.

Also, it is a fact is that no federal or state project is required to meet a city building code. This inventory constitutes thousands of buildings.

However, in every case that I know of, the governmental entity simply uses or betters the requirements of the local codes. All agencies have internal reviews of designs performed by architects and engineers and most already use independent third-party technical peer reviews for significant structures.

There are no non-governmental entities exempt from codes (except possibly Disney in Florida and they developed their own code).

Recommendation 26 – Code Enforcement

This is a good recommendation.

Recommendation 27 – Building Documents

Most jurisdictions already keep building plans. It is a good recommendation that building owners keep a set of their building's plans. Calculations are not a part of the design and there is no need to keep them.

It is a good recommendation that emergency responders have access to building plans both before and during emergencies.

Recommendation 28 – Code Mandated Role of Fire Protection and Structural Engineers

NIST conducted no research into relative safety records for building designs that used or didn't use fire protection and/or structural engineers. Any recommendation without this science is inappropriate. The code should not be used to "make work" for any design discipline without a scientific public safety basis.

In the case of fire protection engineers, their involvement traditionally does not increase fireproofing requirements, but rather, reduces them.

Recommendation 29 – Continuing Education

This is a good recommendation.

Recommendation 30 – Additional Education Issues

This is a good recommendation.

X-Sieve: CMU Sieve 2.2
X-Originating-IP: [64.4.56.202]
X-Originating-Email: [amitabha_basak@hotmail.com]
X-Sender: amitabha_basak@hotmail.com
From: "amitabha basak" <amitabha_basak@hotmail.com>
To: wtc@nist.gov
Subject: Re: Public comment on NIST Response to WTC Disaster Fedaral Building dt. June 23

Date: Mon, 04 Jul 2005 18:41:10 +0000
X-OriginalArrivalTime: 04 Jul 2005 18:41:11.0279 (UTC) FILETIME=[F2F30FF0:01C580C7]
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: amitabha_basak@hotmail.com

Dear Sir,
This is in reference to The "NIST Report to WTC Disaster Federal Building & Fire Safety Investigation of WTC Disaster" issued on June 23, 2005 for public opinion.
The report is comprehensive and covers mostly all the aspects need for updating to prevent such occurance in future.
However I feel that some improvements can be made in quick evacuation of the people from the tall rise building in case of fire. Attached please find a brief writ up for our perusal.
I am a Professional Engineer and a Certified Fire Protection Specialist(CFPS) from NFPA. I am working in a Consulting engineering Company, The Kuljian Corporation in Philadelphia,PA.
Will appreciate if I get a feed back on my write up suggesting some improvements on the evacuation system.
The particulars of identification as asked for is as below:

Name: Amitabha Basak, P.E., CFPS
Affiliation: The Kuljian Corporation, 3700 Science Center, Philadelphia, PA-19014.
Contact; amitabha_basak@hotmail.com
Phone: 215-243-1951(Work), 267-252-8053(Cell)

Amitabha Basak
The Kuljian Corporation
3700 Science Center
Philadelphia, PA-19104
Tel: 610-622-4207(H)
215-243-1951(W)

Elevator for WTC.doc

Reference: NIST Report/Recommendation on Tall Rise Building Design after WTC accident and NIST appeal to public for their suggestion for improvement.

Suggestion: Based on the above report of NIST, following is suggested as one of the improvements for consideration.

1. Evacuation after an accident, like fire, in a tall rise building is one of the foremost important criteria. Its proper implementation should be considered as a prime safety factor in the building design. Following steps may be considered to implement effective evacuation from a building:
   a. Elevator is the fastest practical mode of vertical transport of people. Its layout and operation should be carried out in such a way that it will remain in tact and in operation during outbreak fire in the building. Following are proposed for consideration:
      i. Elevators are to be laid outside the building with connecting aisles with the main building at each floor so that any damage in the building will not affect the elevator.
      ii. Elevators should be placed at different levels so that damage of any elevator operating between floors cannot jeopardize the operation of elevator at other levels. For example for a 100 floor rise building, elevator can be placed at four levels like from Ground "Zero" to 25th floor, from 25th floor to 50th Floor, from 50th floor to 75th floor and from 75th floor to 100th floor. In case elevator between 75th floor and 100th floor stopped working due to an accident, elevators operating between other floors will not get affected.
      iii. The elevators should be oriented at four faces of the building, one each towards one face of the building and connected with the main building at different levels with aisles. Purpose of elevator at four levels and at different orientation is that in case an external object hits the top floors of the building, the elevators operating at lower levels will not get affected and be in operation to evacuate the people. To be optimistic, in case the line of action of the hit does not coincide with the orientation of the elevator at that level, elevator at that floor being outside the main building can remain in operation and be a vehicle to transport the people from the top affected floors.
      iv. People below the affected floor can escape through the elevator in the fastest time possible through the elevators at other levels.
   b. Elevator control should be made fire safe enabling its operation during outbreak of fire.
   c. At worst Emergency condition, operation of the elevator from inside the elevator should be made possible. A hybrid of rack and pinion type with regular elevator can be envisaged.

From: "D. Alexander Floum" <afloum@williams-law-firm.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : D. Alexander Floum
Affiliation :
Email Address : afloum@williams-law-firm.com
Phone : 925-818-1702
Report Number : NCSTAR 1
Page Number : ALL
Paragraph : ALL
Comment : NY Fire Department Chief of Safety stated there were "bombs" and "secondary devices", which caused the explosions in the buildings: http://terrorize.dk/911/witnesses/911.wtc.reporter.1.wmv ; high-quality audio here: http://www.whatreallyhappened.com/IMAGES/SecondaryDevices.mp3

NYC firefighters who witnessed attacks stated that it looked like their were detonators : i.e. bombs in the buildings : http://www.letsroll911.org/discussion_in_firehouse.mpg NYC

NYC firefighter stated "On the last trip up a bomb went off. We think there was bombs set in the building" : http://web.archive.org/web/20010914230246/: http://people.aol.com/people/special/0,11859,174592_3,00.html

British newspaper stated some eyewitnesses reported hearing another explosion just before the structure crumbled. Police said that it looked almost like a "planned implosion" : http://www.guardian.co.uk/september11/story/0,11209,600839,00.html

A facilities manager in the north tower "was convinced that there were bombs planted all over the place and someone was sitting at a control panel pushing detonator buttons" : http://www.thememoryhole.org/911/veliz_bombs.htm

Indeed, Larry Silverstein, the leaseholder of the World Trade Center, said in a PBS documentary that Building 7 was "pulled" on September 11th. : http://www.infowars.com/Video/911/wtc7_pbs.WMV "Pulling" is apparently a construction industry term for "intentionally demolishing", as shown in discussing the demolition of world trade center building 6 many weeks after 9/11 : http://thewebfairy.com/911/pullit/pull_it2_lo.wmv.

Moreover, there is evidence that substantial explosions occurred well BELOW the area impacted by the planes, and - in at least one case - they occurred BEFORE the plane had hit:

World trade center employee stated "the bottom of our building was blown out" : http://xrl.us/gsji

Employee of insurance company in south tower heard an explosion from BELOW the

impact of the airplane, an "exploding sound" shook the building, a tornado of hot air, smoke and ceiling tiles and bits of drywall came flying UP the stairwell, and the wall split from the bottom UP:
http://www.csmonitor.com/2001/0917/p1s1_usgn.html

A Port Authority Police Department officer, who was intimately familiar with the World Trade Center from his years of police duties patrolling there, described how the hallway began to shudder as a "terrible deafening roar" swept over him, then a giant fireball exploded in the street seconds before the south tower collapsed: http://www.bowhunter.com/feature_articles/BN_FromTheRubble/

Stationary engineer who worked in world trade center one described more consistent in nature and timing with a bomb than with damage from an airplane :
http://www.chiefengineer.org/article.cfm?seqnum1=1029 tremendous damage in the basement of the building

9/11 hero, last man out of the north tower, said there was a massive explosion in the basement of the North tower BEFORE the plane hit :
http://www.arcticbeacon.com/articles/article/1518131/28031.htm ; and radio interview at
http://radiodialect.net/qcms4/m3u.php?title=William+Rodriguez&mp3path=http://radiodialect.org/archive/2005/06/20050602_william_rc

Janitor who worked in the basement of north tower also witnessed explosion :
http://www.arcticbeacon.com/articles/article/1518131/29079.htm

There is also substantial indirect evidence of explosives in the world trade center:

MSNBC reporter stated "I heard a second explosion ... And then a fire marshal came in and said we had to leave, because if there was a third explosion this building might not last" :
http://www.whatreallyhappened.com/IMAGES/911.wtc.msnbc.2.wmv

Rescue worker discussing "secondary explosions" before the collapse of one of the twin towers : http://www.911blimp.net/videos/FDNY_explosions.mov

Fire chief from a nearby town heard a "high-pitched noise and a popping noise" right before the collapse of the South tower :
http://september11.ceenews.com/ar/electric_broadway_electrical_supplys/

BBC reporter stated "There was a huge bang and the building physically shook . . . Seconds later there were two or three similar huge explosions and the building literally shook again" :
http://news.bbc.co.uk/1/hi/world/americas/1537500.stm

Reputable astrophysicist wrote in an email that, immediately before the collapse of each of the twin towers, he heard explosions and then low-frequency rumbles : http://research.amnh.org/users/tyson/essays/TheHorrorTheHorror.html

Comment Reason : Omissions in Reports.

Revision Suggestion : Conduct a new investigation.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Rand Fanshier <rand@fanshier.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-3

Information Submitted on: 7/15/2005.

Name : Rand Fanshier
Affiliation : libertyforum.org
Email Address : rand@fanshier.com
Phone : 303-670-8563
Report Number : NCSTAR1-3
Page Number : General
Paragraph : General
Comment : No physical evidence to support the official hypothesis for initiation of collapse.

Link to my digest of report 3 here:

http://www.libertyforum.org/showflat.php?Number=293727256
Comment Reason : I'd like to see some proof about why the towers fell as they did.

What's interesting here is that NIST could have faked it, if they wanted to. But they didn't. It's clear to me that the actual scientists and engineers there were simply not willing to lie.

All they did was to describe the testing they performed on the limited evidence they found, and left it at that. The entire metallurgical analysis report I read came to no conclusions at all as to cause of initiation of collapse!

Revision Suggestion : The official explanation, including the entirety of the NIST report of the (three!) global collapses in no manner considers nor addresses (they aren't discussed at all) the following contradictions of conclusions in the twin tower collapses:

A) Time to the ground less than 13 seconds
B) Enormous size of pyroclastic cloud
C) Zero Core columns tested had been above 250 degrees C
D) Buildings didn't topple over, dropped straight down.

I would like these urgent matters addressed.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

Subject:
From: "rgmorse" <rgmorse@mzaconsulting.com>
To: <wtc@nist.gov>

We checked our inspection records and found the fireproofing thickness on the joists in the WTC to be substantially thinner than the ¾" indicated in the report. Please see attached report and photographs.

Roger G. Morse AIA
Morse Zehnter Associates
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(518) 283-7671
Fax: (518) 283-9855
email: rgmorse@mzaconsulting.com

fireproofing thickness report 050406.pdf

Fireproofing Thickness Evaluation
World Trade Center Towers 1 & 2

New York, N.Y

By:

Roger G. Morse and

Dominique R. Washock

April 2005

Morse Zehnter Associates
Architecture, Planning and Environmental Consulting
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Table of Contents

Summary:

World Trade Centers One and Two (WTC1 & WTC2) were high rise office towers located on West Street in Lower Manhattan, NYC. WTC1 & WTC2 were 1,368 feet and 1,362 feet respectively. Each tower had 110 floors and approximately 4.7 million square feet of gross floor area. WTC1 & WTC2 were constructed in 1969 using structural steel framing, structural joists and non-composite steel deck with poured, lightweight concrete floors. The exterior, perimeter walls were load bearing, built-up box columns. Dryspray fireproofing was applied to the structural steel and joists as well as the underside of the metal decking throughout each of the towers. The purpose of this evaluation was to determine the thickness of the fireproofing on the joists.

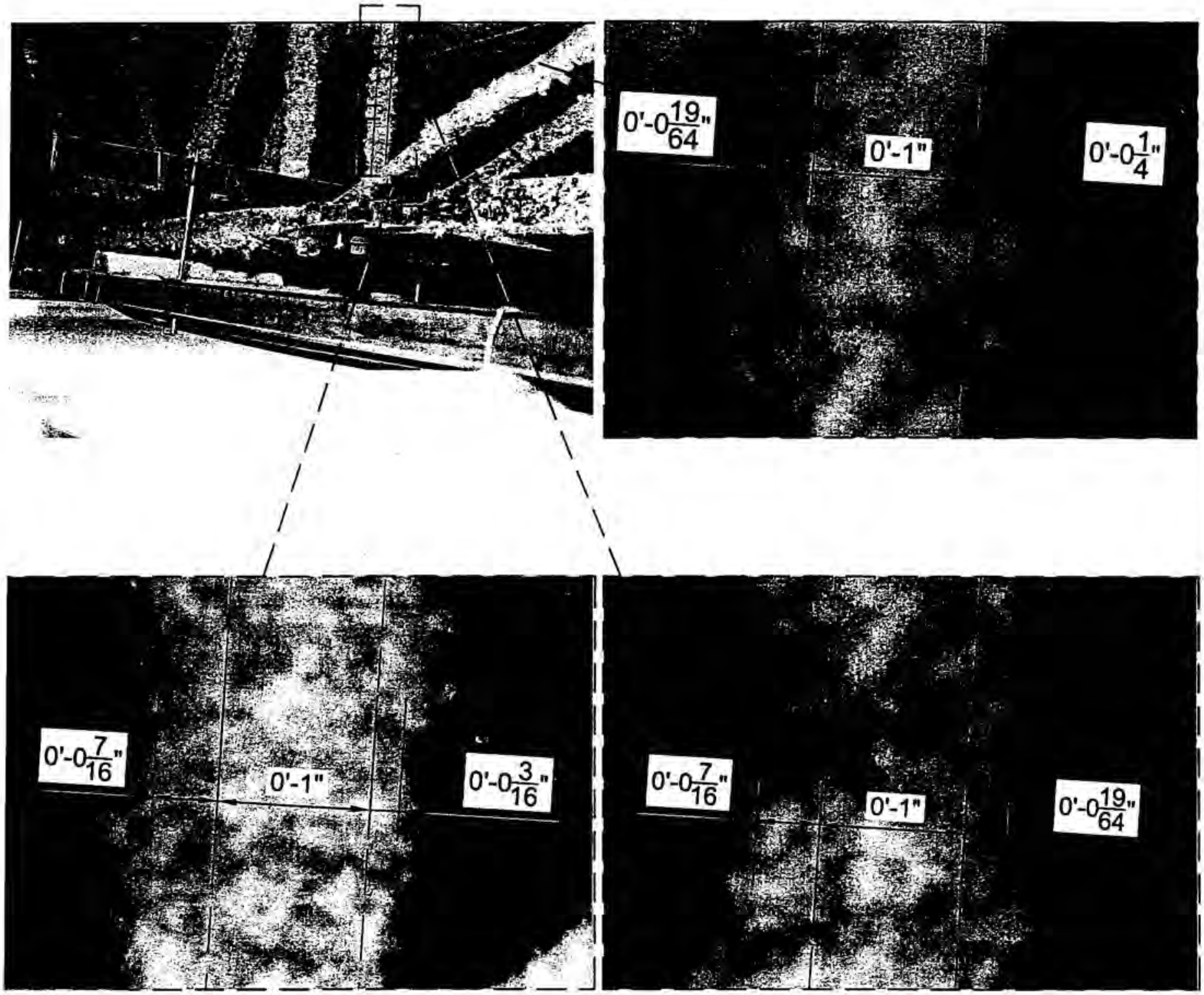
Photos used in this evaluation were obtained during a series of site inspections performed between August 1990 and July 1993. Examination of the site inspection records produced eighty (80) photographs of joists located in WTC1 and WTC2. Joists were categorized as being parallel or perpendicular to the decking. A third category labeled "miscellaneous" was used for members that were photographed at a range too close to allow for identification as either parallel or perpendicular. Assessment of these photos showed that, exposed metal was found on 47% of the joists parallel to the decking, 50% of the joists perpendicular to the decking, and 86% of the miscellaneous joists (see Table – 1).

Close review of the site inspection photos reveal areas of missing or thin dryspray fireproofing coverage on the structural steel joists (see Photos 1 through 10). These photos were chosen because they show enough exposed webbing to allow for an accurate measurement of the one-inch diameter web members. Using the one-inch dimension as a reference, it was possible to determine the thickness of the fireproofing adjacent to the bare metal area on the web members as well as on web members shown in the same plane within the photo. Fireproofing thicknesses ranged from 0" (Photo 7) to 0.55" (35/64" Photo 3), with an average thickness of 0.30" (see Table – 2). Photo 6 includes a web located in the foreground that was not included in the evaluation. This particular web is atypical in that it is almost entirely exposed and if included in the evaluation it would have skewed the resulting average.

Evaluation of dryspray fireproofing located on structural joists in WTC1 & WTC2, through existing site inspection photos, reveals many areas of thin or non-existent fireproofing.

Photos

Fireproofing Thickness



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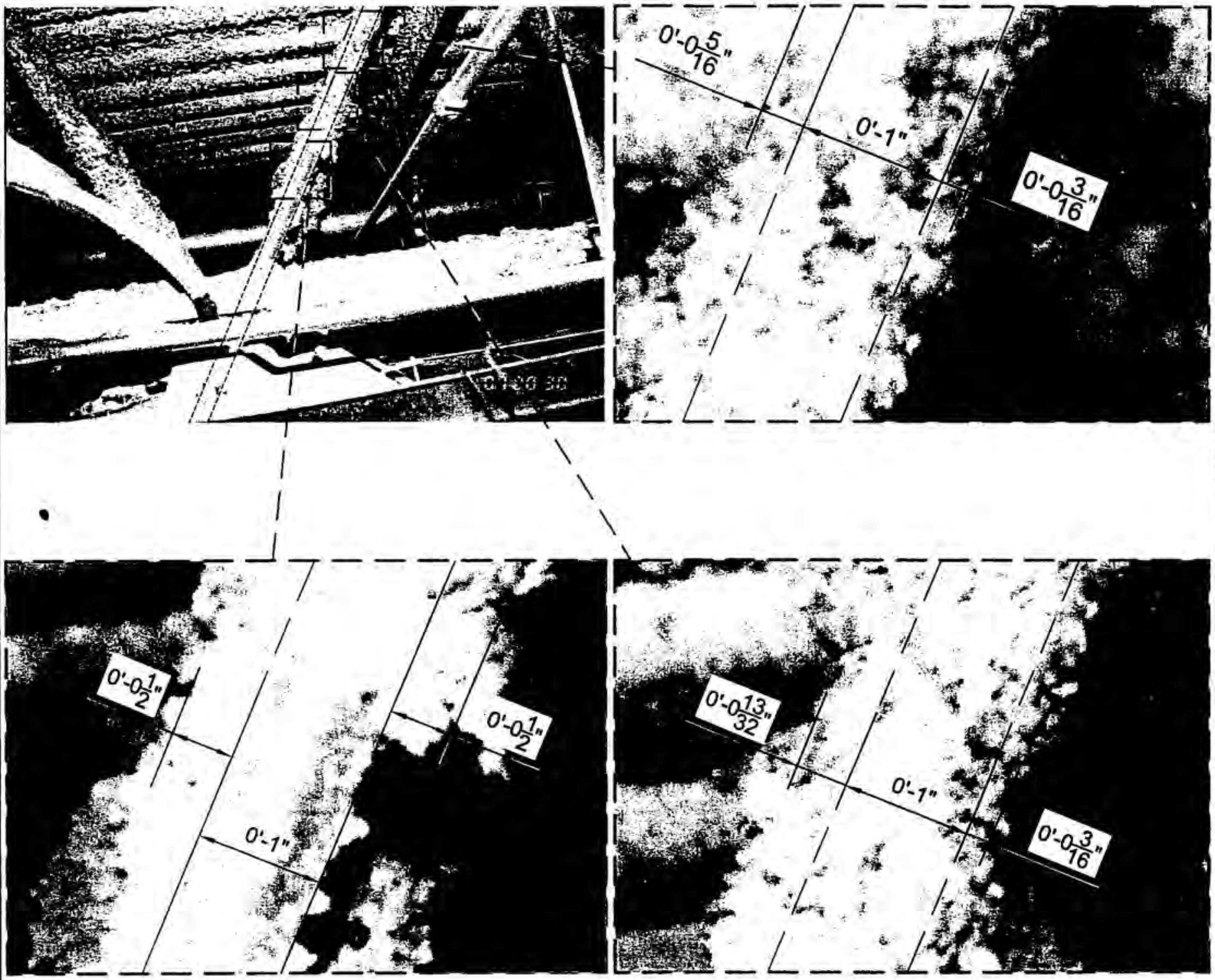
WORLD TRADE CENTER

NEW YORK, NY

FIREPROOFING THICKNESS
WTC1-FLR.23-TRUSS 1-WEB 1

DATE:	DEC. 30, 2004
SCALE:	NTS
DRAWN BY:	DRW
APPV'D. BY:	RGM

1 OF 10



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WORLD TRADE CENTER

NEW YORK, NY

FIREPROOFING THICKNESS

WTC1-FLR.27-TRUSS 1-WEB 1

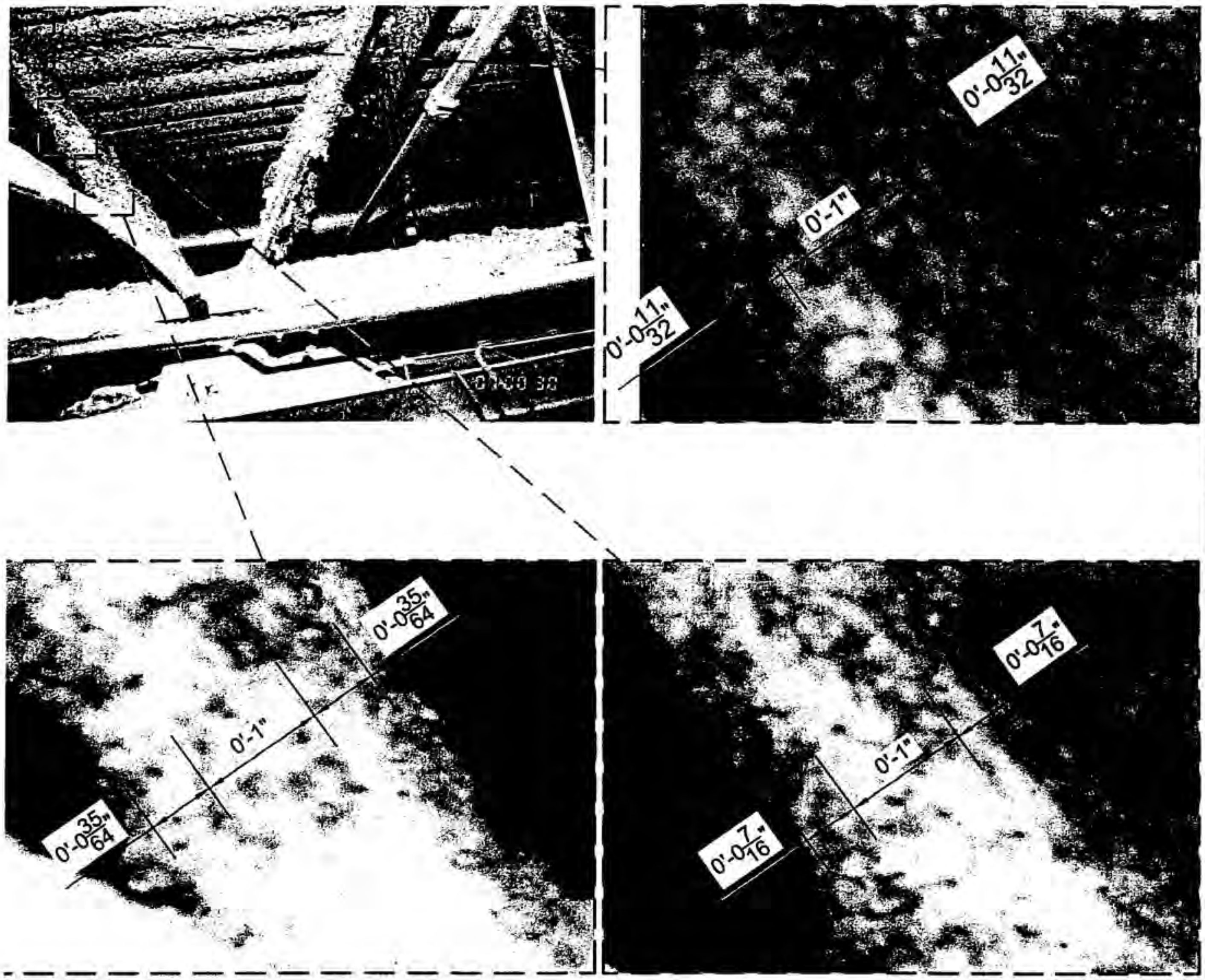
DATE: DEC. 30, 2004

SCALE: NTS

DRAWN BY: DRW

APPV'D. BY: RGM

2 OF 10



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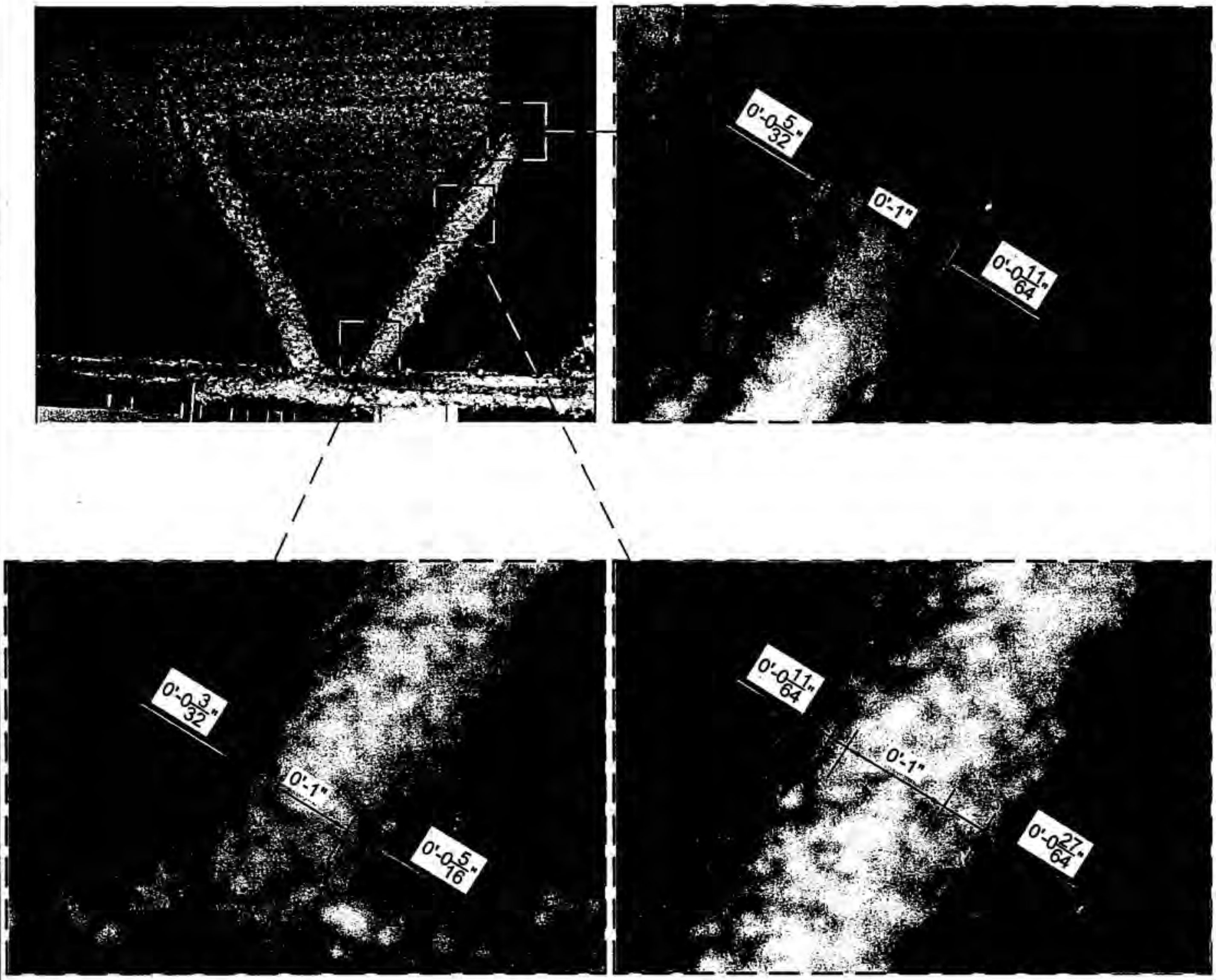
WORLD TRADE CENTER

NEW YORK, NY

FIREPROOFING THICKNESS
WTC1-FLR.27-TRUSS 1-WEB 2

DATE: DEC. 30, 2004
SCALE: NTS
DRAWN BY: DRW
APPV'D. BY: RGM

3 OF 10



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FIREPROOFING THICKNESS
WTC1-FLR.27-TRUSS 2-WEB 1

DATE: DEC. 30, 2004
SCALE: NTS
DRAWN BY: DRW
APPV'D. BY: RGM

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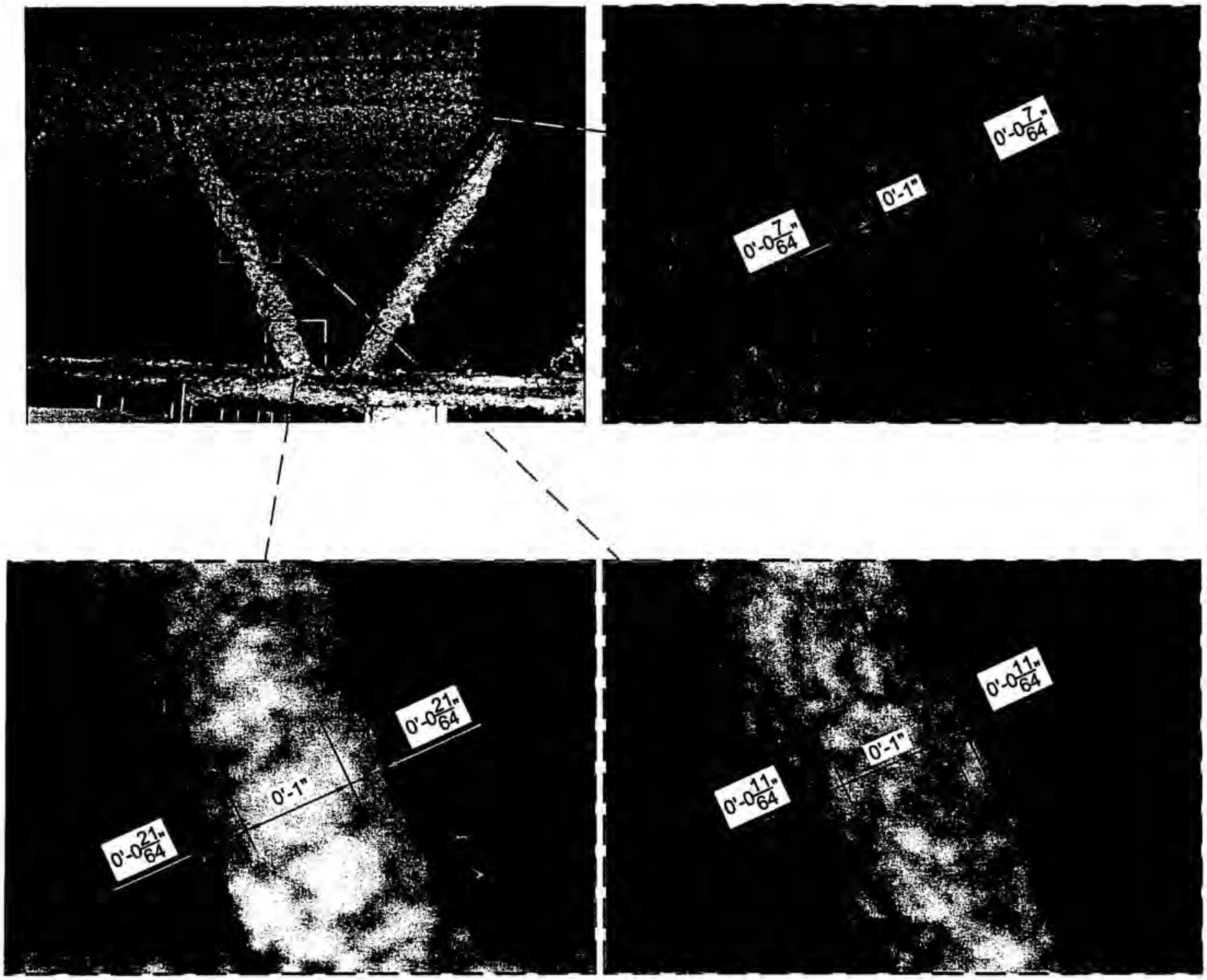

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FIREPROOFING THICKNESS
WTC1-FLR.27-TRUSS 2-WEB 2

DATE: DEC. 30, 2004
SCALE: NTS
DRAWN BY: DRW
APPV'D. BY: RGM

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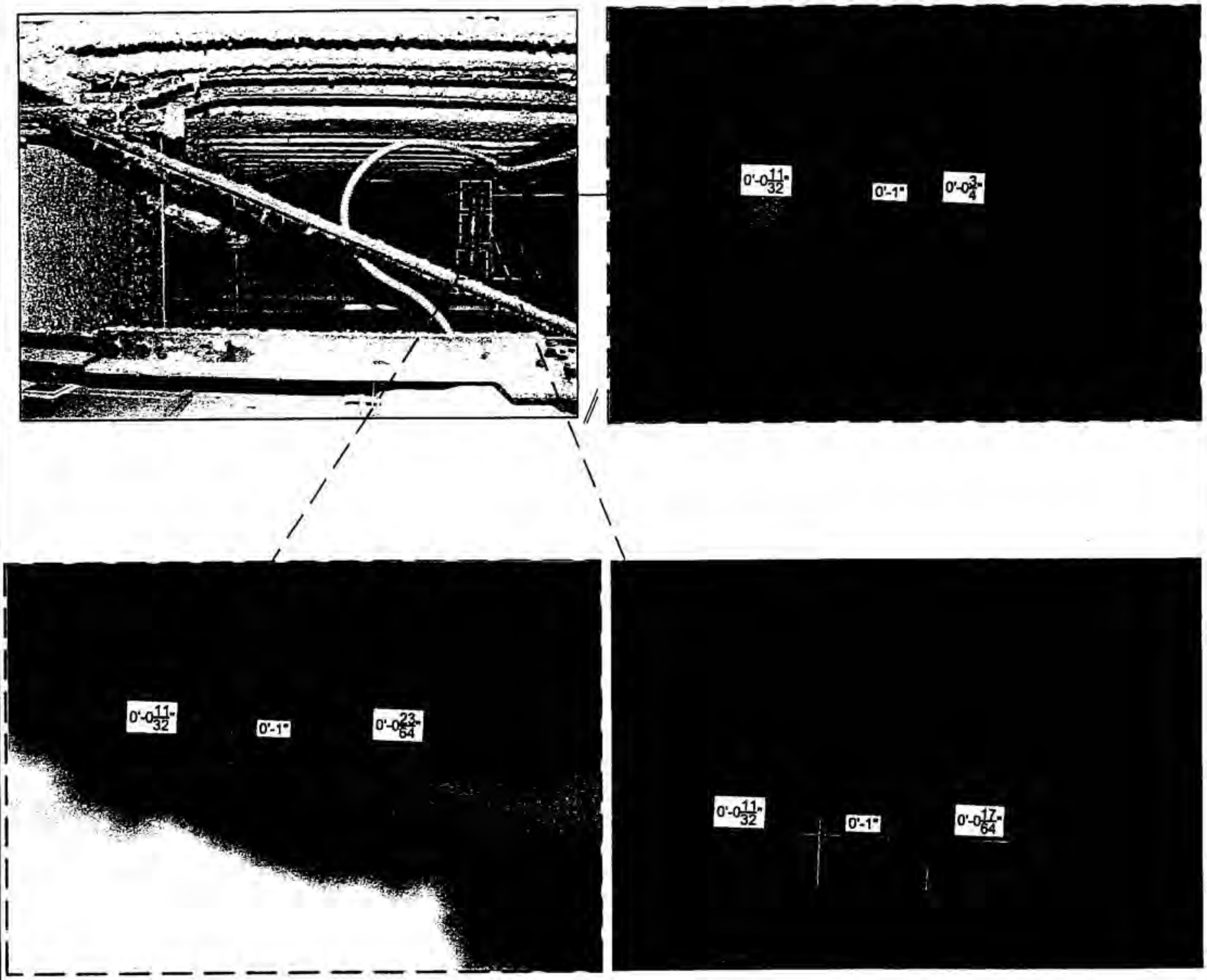

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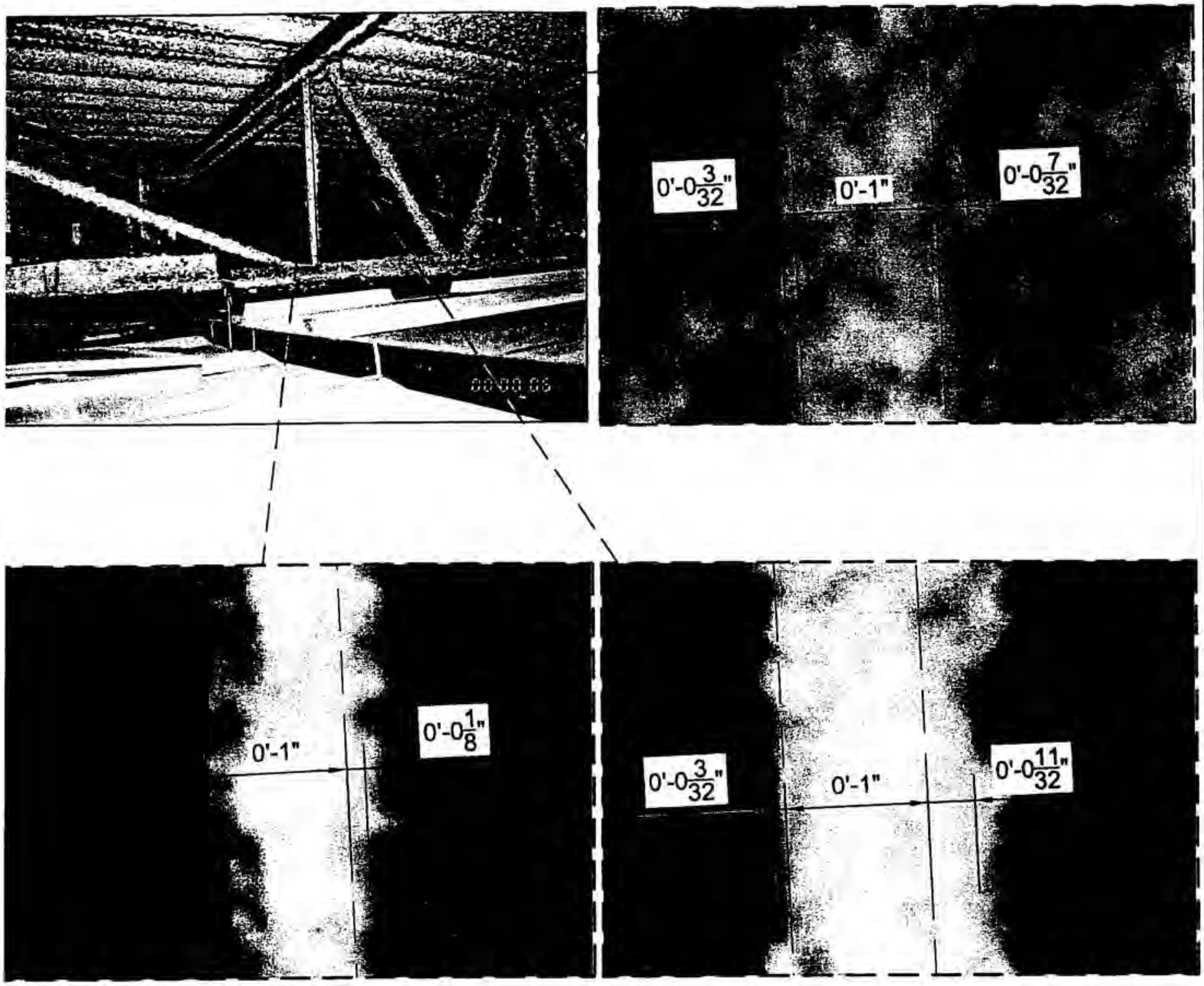
WORLD TRADE CENTER

NEW YORK, NY

FIREPROOFING THICKNESS
WTC1-FLR.27-TRUSS 3-WEB 1

DATE: DEC. 30, 2004
SCALE: NTS
DRAWN BY: DRW
APPV'D. BY: RGM

6 OF 10



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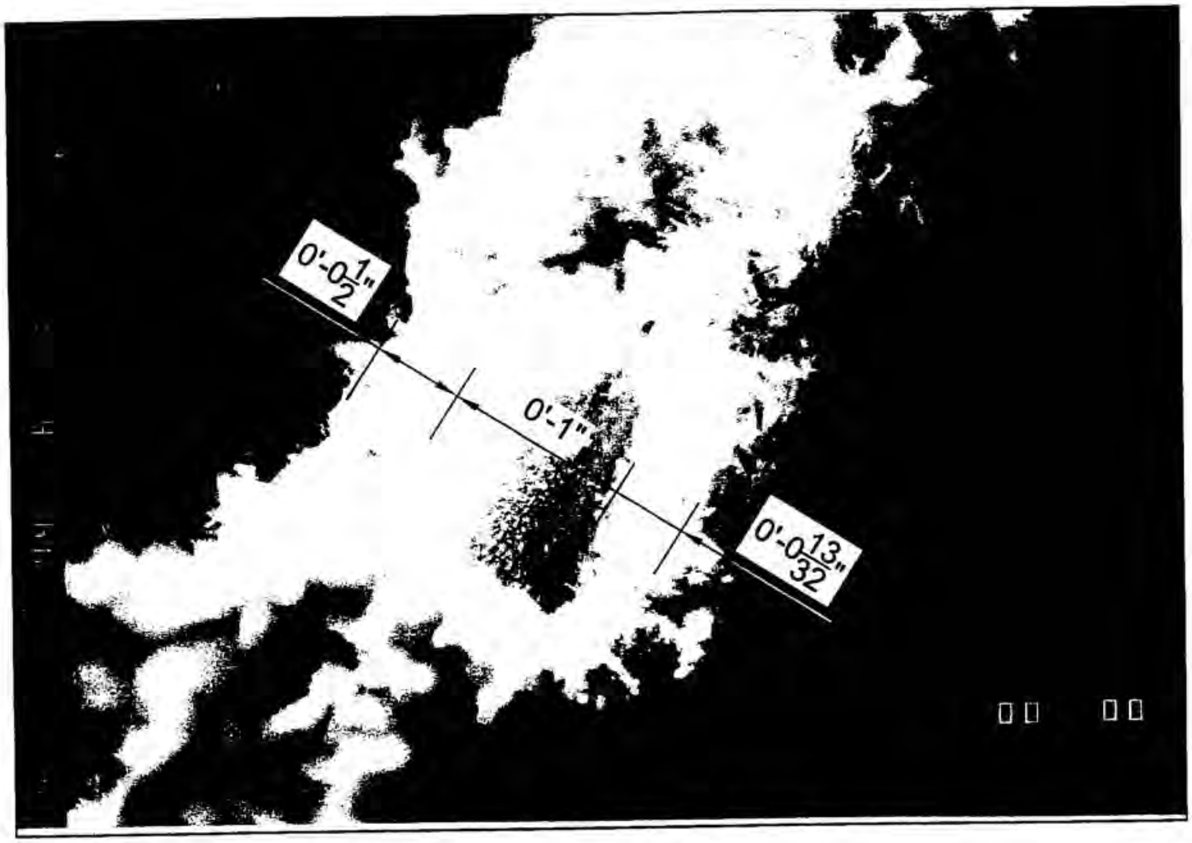
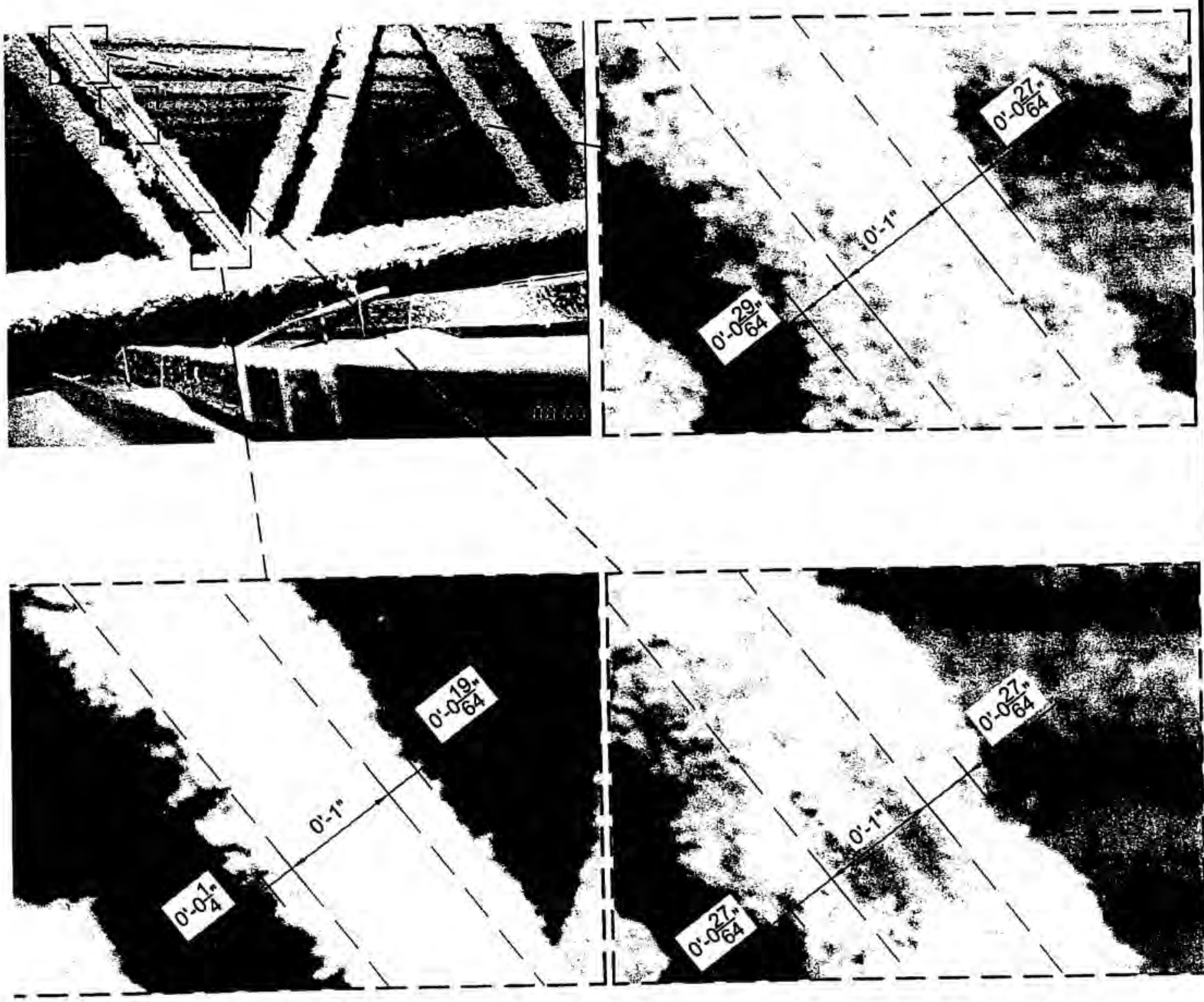
FIREPROOFING THICKNESS
WTC1-FLR.27-TRUSS 4-WEB 1

DATE: DEC. 30, 2004	
SCALE: NTS	
DRAWN BY: DRW	
APPV'D. BY: RGM	
7 OF 10	



MORSE ZEHNTER ASSOCIATES 504 SNAKE HILL ROAD POESTENKILL, NY 12140 PH: (518) 283-7671 FAX: (518) 283-9855	**WORLD TRADE CENTER** NEW YORK, NY	DATE: DEC. 30, 2004 SCALE: NTS DRAWN BY: DRW APPV'D. BY: RGM
	FIREPROOFING THICKNESS WTC1-FLR.27-TRUSS 5-WEB 1	8 OF 10



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WORLD TRADE CENTER

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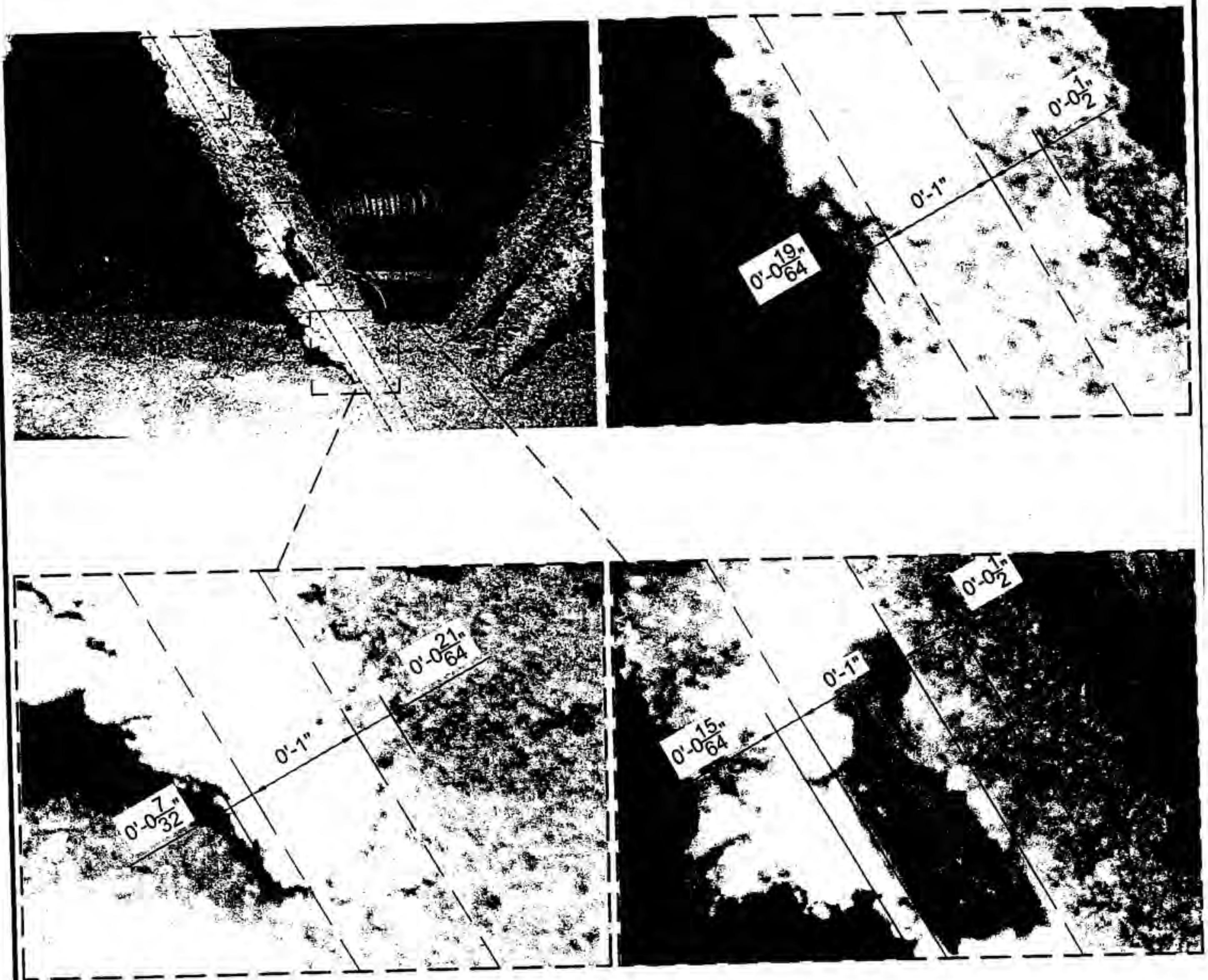
FIREPROOFING THICKNESS
WTC 2-FLR.26-TRUSS 1-WEB 1

DATE:	DEC. 30, 2004
SCALE:	NTS
DRAWN BY:	DRW
APPV'D. BY:	RGM

9 OF 10



MORSE ZEHNTER ASSOCIATES
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WORLD TRADE CENTER

NEW YORK, NY

FIREPROOFING THICKNESS

WTC2-FLR.26-TRUSS 2-WEB 1

DATE: DEC. 30, 2004

SCALE: NTS

DRAWN BY: DRW

APPV'D. BY: RGM

10 OF 10

Table - 1

WTC 1&2-Fireproofing Thickness Evaluation

Table -1

WORLD TRADE CENTER 1 & 2 FIREPROOFING COVERAGE

Photo No.	Photo Date	Location	Number of Visible Joists Parallel to Decking	Number of Visible Joists Parallel to Decking With Exposed Metal	Number of Visible Joists Perpendicular to Decking	Number of Visible Joists Perpendicular to Decking With Exposed Metal	Number of Misc. Visible Joists	Number of Misc. Visible Joists With Exposed Metal
48	8/8/1990	WTC1, Flr-12	1	0				
49	8/8/1990	WTC1, Flr-12	1	1	1	0		
50	8/8/1990	WTC1, Flr-12					1	0
51	8/8/1990	WTC1, Flr-12	2	0	1	1		
52	8/8/1990	WTC1, Flr-12	3	2				
59	8/8/1990	WTC1, Flr-12	2	1	1	1		
201	7/7/1993	WTC1, Flr-22	1	0	1			
202	7/7/1993	WTC1, Flr-22	1	0	1	0		
203	7/7/1993	WTC1, Flr-22	2	1				
204	7/7/1993	WTC1, Flr-22	1	0	1	1		
205	7/7/1993	WTC1, Flr-22	2	0	1	0		
206	7/7/1993	WTC1, Flr-17	2	2	1	0		
207	7/7/1993	WTC1, Flr-17	2	1	1	1		
208	7/7/1993	WTC1, Flr-17	1	1	1	0		
212	7/7/1993	WTC1, Flr-17	1	1	1	1		
213	7/7/1993	WTC1, Flr-17	1	0				
214	7/7/1993	WTC1, Flr-17	1	1	1	1		
101	7/7/1993	WTC1, Flr-22					1	1
107	7/7/1993	WTC1, Flr-22			1	0		
109	7/7/1993	WTC1, Flr-22	1	1				
111	7/7/1993	WTC1, Flr-22	1	1	1	1		
112	7/7/1993	WTC1, Flr-22	1	1	1	0		
118	7/7/1993	WTC1, Flr-22	1	0				
120	7/7/1993	WTC1, Flr-22	2	0	1	0		
121	7/7/1993	WTC1, Flr-22	2	1				
122	7/7/1993	WTC1, Flr-22	1	0	1	0		
123	7/7/1993	WTC1, Flr-22	2	1				
1	8/8/1990	WTC1, Flr-23	1	1	1	1		

WORLD TRADE CENTER 1 & 2 FIREPROOFING COVERAGE

Photo No.	Photo Date	Location	Number of Visible Joists Parallel to Decking	Number of Visible Joists Parallel to Decking With Exposed Metal	Number of Visible Joists Perpendicular to Decking	Number of Visible Joists Perpendicular to Decking With Exposed Metal	Number of Misc. Visible Joists	Number of Misc. Visible Joists With Exposed Metal
2	8/8/1990	WTC1, Flr-23	1	1				
3	8/8/1990	WTC1, Flr-23	1	0				
4	8/8/1990	WTC1, Flr-23	1	0				
7	8/8/1990	WTC1, Flr-23	1	1	1	0		
8	8/8/1990	WTC1, Flr-23	1	1	1	0		
9	8/8/1990	WTC1, Flr-23	2	0	1	1		
10	8/8/1990	WTC1, Flr-23	3	3				
11	8/8/1990	WTC1, Flr-23			1	1		
15	8/8/1990	WTC1, Flr-23	1	1	1	1		
16	8/8/1990	WTC1, Flr-23	1	1	1	0		
20	8/8/1990	WTC1, Flr-23			1	1		
22	8/8/1990	WTC1, Flr-23	1	1				
23	8/8/1990	WTC1, Flr-23					1	1
24	8/8/1990	WTC1, Flr-23					1	1
25	8/8/1990	WTC1, Flr-23	1		1	1		
26	8/8/1990	WTC1, Flr-23	2	2				
27	8/8/1990	WTC1, Flr-23	1	1	1			
28	8/8/1990	WTC1, Flr-23	3	1				
3	1/9/1995	WTC1, Flr-27	2		1	1		
4	1/9/1995	WTC1, Flr-27	2	2				
6	1/9/1995	WTC1, Flr-27	1	1	1	1		
7	1/9/1995	WTC1, Flr-27	2	0	1	1		
10	1/9/1995	WTC1, Flr-27	2	1				
15	1/9/1995	WTC1, Flr-27	3	2				
16	1/9/1995	WTC1, Flr-27	2	1	1	1		
17	1/9/1995	WTC1, Flr-27	1	1	1	1		
18	1/9/1995	WTC1, Flr-27	1	1				
28	1/9/1995	WTC1, Flr-27	1	0	1	1		
29	1/9/1995	WTC1, Flr-27	2	1				

WORLD TRADE CENTER 1 & 2 FIREPROOFING COVERAGE

Photo No.	Photo Date	Location	Number of Visible Joists Parallel to Decking	Number of Visible Joists Parallel to Decking With Exposed Metal	Number of Visible Joists Perpendicular to Decking	Number of Visible Joists Perpendicular to Decking With Exposed Metal	Number of Misc. Visible Joists	Number of Misc. Visible Joists With Exposed Metal
33	1/9/1995	WTC1, Flr-27	1	1	1	0	1	1
42	1/9/1995	WTC1, Flr-27					1	1
47	6/20/1994	WTC2, Flr-26						
102	12/9/1991	WTC2, Flr-26	1	1				
103	12/9/1991	WTC2, Flr-26	2	2				
104	12/9/1991	WTC2, Flr-26	1	0				
105	12/9/1991	WTC2, Flr-26	1	0	1	1		
106	12/9/1991	WTC2, Flr-26	2	1				
107	12/9/1991	WTC2, Flr-26	2		1			
108	12/9/1991	WTC2, Flr-26	2	0				
110	12/9/1991	WTC2, Flr-26	2	0	1	0		
113	12/9/1991	WTC2, Flr-26	2	1				
115	12/9/1991	WTC2, Flr-26	2	1				
116	12/9/1991	WTC2, Flr-26	1	0	1	0	1	1
118	12/9/1991	WTC2, Flr-26						
120	12/9/1991	WTC2, Flr-26	2	1	1	0		
122	12/9/1991	WTC2, Flr-26	1	0				
201	12/9/1991	WTC2, Flr-26	1	0				
202	12/9/1991	WTC2, Flr-26	1	0				
203	12/9/1991	WTC2, Flr-26	1	0				
205	12/9/1991	WTC2, Flr-26	1	0				
206	12/9/1991	WTC2, Flr-26	1	0	1	0		
207	12/9/1991	WTC2, Flr-26	1	0				
Total Number of Visible Joists			103		40		7	
Total Number of Visible Joists With Exposed Metal				48		20		6
Percentage With Exposed Metal			47%		50%		86%	

Table - 2

WTC 1&2 Fireproofing Coverage

Table - 2

WORLD TRADE CENTER 1 & 2 - FIREPROOFING THICKNESS EVALUATION

Photo/File Name	Drawing Description	Thickness (in)	Thickness (in)	Thickness (in)	Thickness (in)	Thickness (in)	Thickness (in)	Average Thickness (in)	Average Thickness (in)
900808 - 08	WTC1-FLR.23-TRUSS 1-WEB 1	19/64	1/4	7/16	3/16	7/16	19/64	27/85	0.32
950109 - 30	WTC1-FLR.27-TRUSS 1-WEB 1	5/16	3/16	1/2	1/2	13/32	3/16	15/43	0.35
950109 - 30	WTC1-FLR.27-TRUSS 1-WEB 2	11/32	11/32	35/64	35/64	7/16	7/16	27/61	0.44
950109 - 10	WTC1-FLR.27-TRUSS 2-WEB 1	5/32	11/64	3/32	5/16	11/64	27/64	2/9	0.22
950109 - 10	WTC1-FLR.27-TRUSS 2-WEB 2	7/64	7/64	21/64	21/64	11/64	11/64	13/64	0.20
950109 - 15	WTC1-FLR.27-TRUSS 3-WEB 1	11/32	3/4	11/32	23/64	11/32	17/64	2/5	0.40
950109 - 06	WTC1-FLR.27-TRUSS 4-WEB 1	3/32	7/32	0	1/8	3/32	11/32	7/48	0.15
940620 - 53	WTC1-FLR.27-TRUSS 5-WEB 1	1/2	13/32					8/53	0.15
911209 - 103	WTC2-FLR.26-TRUSS 1-WEB 1	29/64	27/64	1/4	19/64	27/64	27/64	37/98	0.38
911209 - 106	WTC2-FLR.26-TRUSS 1-WEB 2	19/64	1/2	7/32	21/64	15/64	1/2	9/26	0.35

AVERAGE FIREPROOFING THICKNESS **0.30**

From: shawn bliss <smbliss@email.msn.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-1A

Information Submitted on: 8/3/2005.

Name : shawn bliss
Affiliation : NA
Email Address : smbliss@email.msn.com
Phone : 206 910 9680
Report Number : NCSTAR1-1A
Page Number : na
Paragraph : na
Comment : How will any recommendations make it into the codes?
Comment Reason : The National Construction Safety Team does not appear to have clout over the ICC. Other countries have building codes/standards written by the government. There is a 'knowledge to practice' gap that needs to be addressed in the Building Safety arena in this country in order to achieve a life safety standard that as Americans we assume we have.

Revision Suggestion : Have NIST take over the writing of the Building and Fire Codes. (Possibly model/incorportate to British Standards) Move towards ISO standards. Mandatory Building Safety course required as part of any architectural degree or Building Official placement.

I realize this is not directly relevant to the comments requested, but don't know where else to write.

kind regards,
shawn bliss

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: "Frederick Sweeney" <fsweeney@firemarshals.org>
To: <wtc@nist.gov>
Cc: <mklein@firemarshals.org>
Subject:

Mr. Cauffman:

I am submitting the attached document (NIST WTC Comments Final 8.4.05) on behalf of the National Association of State Fire Marshals. It summarizes our comments/recommendations pertaining to NIST's reports on the Federal Building and Fire Safety Investigation of the World Trade Center Disaster. This e-mail also includes two attachments (503 and Attachment to 503) mentioned in our public comment.

Thank You,

Ray Sweeney
Government Relations
National Association of State Fire Marshals
1319 F Street, NW Ste. 301
Washington, DC 20004
Tel: (202) 737-1226 ext. 21
Fax: (202) 393-1296
Email: fsweeney@firemarshals.org

NIST WTC Comments Final 8.4.05.pdf

503.pdf

Attachment to 503.pdf

NFPA RESPONSE TO
NIST WTC STUDY

NFPA is pleased with both the content and direction that the WTC Study has taken in the past 3 years. It has been no easy task to reconstruct the complex sequence of events that caused the loss of multiple structures at the WTC site on September 11, 2001. While it is easy to over simplify the events of that day (aircraft impact → initial structural damage → dislodged fire proofing → thermal degradation/failure → progressive collapse), it simply isn't good enough to "Monday morning quarterback" such a loss based on intuition and pictures from the media.

The wide range of recommendations, while somewhat daunting, are appropriate for the design, engineering and construction communities to look at. NFPA may not agree with all of the recommendations, (for example…), but we are committed none-the-less to review, study and provide meaningful comments back to NIST. We truly believe that the majority of these recommendations are appropriate, one way or another, in the NFPA Codes and Standards.

The recommendations from NIST are likely to have some level of impact on numerous NFPA Codes and Standards including:

NFPA 1, *Uniform Fire Code*

NFPA 13, *Installation of Sprinkler Systems*

NFPA 14, *Standard for the Installation of Standpipe and Hose Systems*

NFPA 20, *Standard for the Installation of Stationary Fire Pumps for Fire Protection*

NFPA 30, *Flammable & Combustible Liquids Code*

NFPA 37, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines*

NFPA 70, *National Electrical Code*

NFPA 72, *National Fire Alarm Code*

NFPA 101, *Life Safety Code*

NFPA 110, *Standard for Emergency and Standby Power Systems*

NFPA 220, *Standard on Types of Building Construction*

NFPA 221, *Standard for Fire Walls and Fire Barrier Walls*

NFPA 251, *Standard Methods of Tests of Fire Endurance of Building Construction and Materials*

NFPA 5000, *Building Construction and Safety Code*

While the recommendations are fairly definitive, some will require further study; some will require additional research; and some are already at various stages of completion by NFPA. Among those changes are:

COMPLETED: **NFPA 5000**, *Building Construction and Safety Code* already contains a requirement for 4 hour protection of key structural components for buildings in excess of 420 feet in height. This change, made and accepted in the first edition of the Code in 2002 is providing an additional robustness to structural members in certain categories of tall buildings – that is, those in excess of 40 stories.

NEAR TERM COMPLETION: (2-6 Months)

- New Minimum Stair/Door Widths. The 2006 editions of **NFPA 101,** *Life Safety Code* and **NFPA 5000,** *Building Construction and Safety Code* have been revised to require wider stair widths under select conditions. Stair widths that serve an accumulated population of 2000 or more occupants will be required to be a minimum of 56 inches in width. The current minimum is 44 inches. This change will reduce stair congestion and its related slowing of evacuation speed and will improve counter flow issues between building occupants and first responders. A related change will also require that exit discharge doors serving such stairs be sized at 2/3rds of the nominal width of the stair (i.e. 37(+) inches).

- Establish Performance Requirements for Emergency Escape Devices.

  The 2006 editions of NFPA 101 and NFPA 5000 have been revised to establish a recognition of those devices. The Codes will NOT mandate the use of such devices nor will the codes give any credit to the installation of such devices. We have seen an increase in the awareness (and use) of this equipment in the last few years. At present, there is absolutely no regulation of these systems. The basic first step in the process is to at least establish some level of performance under various use conditions.

- Stair Descent Device – NFPA 101 and NFPA 5000 will mandate placement of stair descent devices for buildings designed with 44 inch wide stairs. One chair per floor will be required with another device required at a rate of 1 per every 200 occupants.

Long Term Completion (12-19 Months)

- **NFPA 557,** *Standard on Fire Exposure for Engineering Design of Structural Fire Resistance in Buildings.*

  This proposed new document will allow for fuller evaluation and analysis of building performance under fire conditions – especially as it relates to performance – based design.

- Emergency Evacuation Elevator Systems (EEES)

  This effort is well underway in multiple areas. NFPA staff have been active with both the NIST/ASME activity in this area as well as with the CTBUH project in this area.

- Evaluation of Fire Test Protocols

  While the testing procedures for determining hourly fire resistance ratings of structural members has largely remained unchanged for decades, those test procedures continue to serve the design and construction industry very well. That is not to say, however, that there isn't a need to review the procedures, and look at items such as restrained and unrestrained connections.

National Association of State Fire Marshals (NASFM)

Response to Request for Comments
From the National Institute of Standards and Technology (NIST)
On National Construction Safety Team (NCST) draft report
August 4, 2005

The membership of the National Association of State Fire Marshals (NASFM) comprises senior state-level public safety officials, with many directly accountable for the safety of buildings in their jurisdictions. All of these individuals are responsible for the safety of emergency responders at incidents involving buildings. In general, NASFM regards the National Construction Safety Team's (NCST) final report as an exceptionally thorough, balanced and actionable work, which must now serve as a blueprint for those with the legal authority and moral obligation to ensure that all buildings are constructed in ways that do not unnecessarily or unfairly imperil civilians or responders.

On a personal note, I serve as the New York State Fire Administrator and was at the scene of the World Trade Center towers shortly after the terrorist attacks of September 11, 2001. The NCST has worked hard to understand how and why the towers collapsed. The clear intent and value of the NCST's work, however, has nothing to do with protecting buildings from jet airliners. Significant fires from everyday causes too often result in collapsed buildings. We can and must do better. The NCST report tells us how and it urges us to proceed now. NASFM accepts that challenge.

NASFM respectfully makes the following recommendations to clarify and, in some instances, correct language in the report. Because our members are among those who must implement the NCST recommendations, we have made some additional comments about how we are now moving forward.

NASFM Recommendation 1

Chapter 9, section 9.2 on p.199, states that, "*Immediate and serious consideration be given to these recommendations by the building and fire safety communities – especially ... codes and standards development organizations, regulators, fire safety professionals and emergency responders.*"

NASFM recommends adding the following language: "The model codes and code enforcement officials should act with special urgency and place a higher standard of care to prevent building collapse where rescue operations are inevitable, such as health care facilities, certain places of public assembly, schools and day-care centers."

Rationale

The lives of rescuers and those who need to be rescued are especially at risk when building collapse may occur in hospitals, extended care facilities, elementary schools and senior and child day-care centers. Especially with fire department staffing levels unacceptably low, firefighters often must postpone suppression until rescues are complete.

NASFM Actions

At the annual meeting of the International Code Council in Detroit, Michigan, from September 28-October 2, 2005, NASFM will request immediate adoption of amendments that will restore proven levels of fire protection previously used with the three legacy codes for certain public assembly, educational and institutional occupancies. The current edition of the International Building Code (IBC) permits these structures to be constructed significantly larger than in the past, and without appropriate levels of active or passive fire protection. In these high-priority occupancies, some reasonable level of safety redundancy is critical given the necessity of rescues.

Longer range, NASFM is pleased to work with other stakeholders in examining these issues as they pertain to commercial and other occupancies.

NASFM Recommendation 2

Section 9.2, p. 201, under bullet entitled *"Affected Population of Buildings,"* NASFM recommends replacing the word "tall" with "high-rise" and eliminating the reference to buildings over 20 stories in height. Also, eliminate the 20 story reference in "Selected other buildings," and from Footnote #21 (p. 204), remove the inappropriate view that elevators are to be used by building occupants during an emergency evacuation.

In addition, NASFM recommends revising Footnote #16 by striking the words "20 or more stories" and inserting "high-rise buildings" and by removing the words "without functioning elevators."

Rationale

- Current codes already define "high-rise" as seven stories, a height at which fire departments may no longer use ladders for rescue purposes. This is also, historically, the building height at which firefighters begin experiencing an overwhelming physiological burden during response and operations.

- NASFM urges the re-write of Footnote #21 on p. 204, as follows: "The construction classification and fire rating requirements should be *risk-consistent* with respect to the *design-basis hazards* and the *consequences* of those hazards. The fire rating requirements, which were originally developed based on experience, have generally decreased over the past 80 years since historical fire data for buildings suggests considerable conservatism in those requirements. As buildings increase in height and area, the likely consequences of a given threat to an occupant on the upper floors become increasingly more severe than the consequences to an occupant on the first floor or the lower floors. For example, the time requirements are much greater for both full building evacuations from upper floors and emergency responder access to those floors. It is not clear how the current height and area tables in building codes consider the technical basis for the progressively increasing risk to an occupant as buildings become larger in area and complexity and increase in height."

- Use of the "20-story" reference may be used by some to suggest that the NCST's recommendations pertain to less than 0.2 percent of all commercial buildings in the United States. According to the most recent accounting of the heights of buildings by the U.S. Census in 1999, there were 4.7 million commercial buildings, just 11,000 of which had 10 or more floors. That ratio is unlikely to have changed appreciably in recent years. The State of New Jersey, for example, conservatively contains 60,000 buildings that are not one- or two-family homes. Of that number, only 1,130 are classified as high-rise and only 12 percent of those high-rise buildings, or a total of 136, are 20 or more stories in height.

- The NCST makes reference (Footnote #16) to the concern that above 20 stories, firefighters are physiologically less able to perform their duties. In practice, firefighters individually carry upwards of 100 pounds of equipment into fires and may need to carry humans out of fires. Even with the most physically fit firefighter, physiological stress may begin to occur at ground level and routinely increases floor by floor. Absent the most modern elevator technology, firefighters have been trained to not use elevators to ascend to the fire floor. This causes fatigue far before the 20th floor. Incident commanders are trained to deploy substantially more manpower when entering elevated floors, but budget reductions in most communities deny them that margin of safety.

NASFM Action

The Occupational Safety and Health Administration has warned fire departments to take special care protecting firefighters from building collapse. This fall, NASFM will seek funding from the Department of Homeland Security to begin development of an analytical tool for incident commanders to estimate the probability of building collapse at the scene of incidents, based on type of construction, findings from recent inspections, conditions at the scene of the incident, known contents, etc.

NASFM Recommendation 3

NIST Recommendation #4, p. 204, states, "*NIST recommends evaluating, and where needed improving, the technical basis for determining appropriate construction classification and fire rating requirements (especially for tall buildings greater than 20 stories in height)—and making related code changes now as much as possible—by explicitly considering factors including ...*"

NASFM recommends removing the parenthetical reference to 20 stories (See NASFM Recommendation #2).

NASFM also recommends inserting the following bullet between bullets 5 and 6:

- Ensuring that, when applying the allowable increases provided by the height and area modification sections of the model building codes, the prescribed heights and areas for certain high-risk occupancies DO NOT allow construction of buildings far exceeding the overall size of those encountered in the past, and that the prescribed heights and areas for certain high-risk occupancies DO NOT place occupants and first responders at greater risk.

NASFM also recommends revising the next to last bullet point to more clearly address the anticipated problem, as follows:
"the impact on the design characteristics of active and passive fire protection of incremental increases in combustible contents, or of the addition of unusually large fuel concentrations in some building spaces, that change the nature, over time, of the expected occupancy of the building; and"

Rationale

- Current height and area increases prescribed under the model building codes allow for significantly greater tabular heights and areas than those prescribed under any of the previous model building codes. NASFM has proposed to revise the height and area requirements in the IBC for certain occupancies in order to ensure that occupants and first responders do not encounter an unacceptable risk. A copy of NASFM's proposal is attached to this comment.

- NCST's Recommendation #12, p. 209, recognizes the "greater risks associated with increasing building height" and use of open spaces and high-risk activities. IBC's "Height and Area" tables are the cornerstone of the process that defines fire protection in all but one- and two-family residential occupancies. This reference will tie the NCST recommendation to the real world of code development and enforcement.

- As was found in NCST's assessments of the fires that followed the aircraft assaults on the World Trade Center towers, the fuel load in a typical office cubicle far exceeds the assumptions we have traditionally used to determine the adequacy of fire protection in commercial occupancies. Authorities Having Jurisdiction must have the ability to restrict contents, and the codes should provide limits, not just considerations, for each use group.

NASFM Recommendation 4

On NIST Recommendation #6, p. 206, concerning *"Spray-applied fire resistant material,"* section 703.1 of the 2004 supplement of the International Fire Code (IFC), at NASFM's suggestion, was amended to address this concern.[1] The NCST report should be amended accordingly.

NASFM recommends amending as follows:
"NIST recommends the development of criteria, test methods, and standards in conjunction, and consistent with, the requirements of Section 703.1 of the 2004 IFC."

"703.1 Maintenance. The required fire-resistance rating of fire resistance-rated construction (including walls, fire stops, shaft enclosures, partitions, smoke barriers, floors, fire resistive coatings and sprayed fire-resistant materials applied to structural members, and fire resistive joint systems) shall be maintained. Such elements shall be properly repaired, restored or replaced when damaged, altered, breached or penetrated. Openings made therein for the passage of pipes, electrical conduit, wires, ducts, air transfer openings, and holes made for any reason shall be protected with approved methods capable of resisting the passage of smoke and fire. Openings through fire-resistance-rated assemblies shall be protected by self-closing or automatic-closing doors of approved construction meeting the fire protection requirements for the assembly."

Rationale

The NASFM-sponsored Partnership for Safer Buildings has conducted a number of case studies of existing buildings to identify, among other things, fire safety problems that might best be addressed through changes to building and fire codes. During a number of these inspections, lightweight sprayed fire-resistive materials were found to be severely degraded such that material fell off of protected building members when casually brushed by hand. In other instances, large chunks of these coatings were found to have already fallen off of the building members, leaving them virtually unprotected (See *"Report of the Partnership for Safer Buildings' On-Site Inspections Subcommittee"* available at: http://www.firemarshals.org/issues/catastrophic/onsiteinspection.html). With the exception of these materials, fire protection technologies, e.g., sprinklers, alarm systems, standpipes, etc., are expected to remain in working condition as long as the systems are in place (even if the building is vacant).

[1] At the 2004 Final Action Hearings of the International Code Council's International Fire Code, NASFM's proposal to amend section 703.1 was accepted. A copy of the proposals and revised language can be found at http://www.firemarshals.org/mission/catastrophic/docs/ICC_Code_resub.pdf.

National Construction Safety Team
August 4, 2005
Page 6

NASFM Recommendation 5

On NIST Recommendation #27, p. 217, pertaining to document retention, NASFM recommends the NCST report be amended to note the fact that such document retention reinforces and is a natural extension of the current requirements found in the IBC, National Fire Protection Association (NFPA) 25, NFPA 72 and other NFPA standards.[2]

Rationale

As building occupancies change and structures are remodeled, it becomes difficult, if not impossible, to determine some of the design and construction characteristics of a building. This knowledge is necessary for code enforcement officials to adequately and appropriately assess the acceptable use groups for any given building.

Respectfully submitted,

James A Burns

James A. Burns, President

Attachment

cc: Membership, NASFM
International Code Council
National Fire Protection Association

[2] NASFM is currently proposing the following changes to Section 901 of the International Fire Code: Section 901.6.2 - Records: Records of all system inspections, tests, and maintenance required by the referenced standards shall be maintained on the premises for a minimum of 3 years and available to the Fire Code Official upon request.

901.6.2.1 - Initial records shall include the name of the installation contractor, type of components installed, manufacturer of the components, location and number of components installed per floor. Records shall also include *"Manufacturers' Operation and Maintenance Instruction Manuals."* Such records shall be maintained on premises.

For office use only:
CD#: ____ Date Rec'd. ____ Log No. ____ Comment No. ____

INTERNATIONAL CODE COUNCIL®

ICC CODES - PUBLIC COMMENT FORM

FOR PUBLIC COMMENTS ON THE 2004/2005 "REPORT OF THE PUBLIC HEARINGS"

PLEASE SEE BACK OF FORM FOR PROCEDURES ON SUBMITTING PUBLIC COMMENTS. ALL SUBMITTALS MUST COMPLY WITH THESE PROCEDURES.

CLOSING DATE: All Comments Must Be Received by June 16, 2005
The 2005 Final Action Hearings will be held September 28 – October 2, 2005 in Detroit, Michigan

1) **Indicate the format in which you would like to receive your Final Action Agenda (FAA)**

☐ **Paper** ☐ **Electronic** ☐ ***Download**

(*Note: A paper copy will not be sent to you if you have chosen to download the FAA from the ICC Web Site.)

2) **PLEASE TYPE OR PRINT CLEARLY: FORMS WILL BE RETURNED if they contain unreadable information.**

Name:	James A. Burns			Date:	June 16, 2005
Jurisdiction/Company:	National Association of State Fire Marshals				
Submitted on Behalf of:	National Association of State Fire Marshals				
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3) ***Signature:** ____________ ☐ **Signature on file (see over)**

**I hereby grant and assign to ICC all rights in copyright I may have in any authorship contributions I make to ICC in connection with this public comment. I understand that I will have no rights in any ICC publications that use such contributions in the form submitted by me or another similar form and certify that such contributions are not protected by the copyright of any other person or entity.*

4) Indicate the Code Change Proposal # that is being addressed by this Public Comment: G92-04/05

5) **I (we)** ☐ **do** ☒ **do not** agree with the action of the Code Committee

6) **COMMENT – The Final Action I (we) request on the indicated Code Change Proposal is: (check BOX):**

☐ **Approved as Submitted (AS):** ☒ **Approved as Modified** by this Public Comment (AMPC): ☐ **Approved as Modified** by the Code Committee as Published in the ROH (AM): ☐ **Approved as Modified** by Assembly Floor Action as Published in the ROH (AMF): ☐ **Disapproved (D):**

7) **Proposed Modification:**

Revise the values in Table 503 for Groups A-1, A-2, E, I-1, I-4
See attached Table for proposed revised table entries.

☐ Modification Continued (Attach additional sheets as necessary)

8) **REASON (State reason and provide substantiation to support the Comment):**

This proposal intends to modify certain sections of Table 503 based on the Committee comment and certain criteria.

The National Association of State Fire Marshals (NASFM) commends the International Code Council (ICC) for committing to "use its code development process to address building safety and fire prevention code issues raised in the National Institute of Standards and Technology (NIST) findings."[1] NASFM believes that this proposal is an opportunity for the ICC to initiate the first of these important steps.

The Committee disapproved the original proposal because it felt that any changes to Table 503 would need to be the result of a comprehensive "review of the code, comparing the impact on whole systems (e.g. means of egress, opening protectives, sprinkler thresholds) and not just the height and area tables alone."[2]

In considering this revision, NASFM conducted a comparative analysis of all three legacy codes: Building Officials and Code Administrators International (BOCA), Uniform Building Code (UBC) and Standard Building Code (SBC). The Committee noted that the current table was developed by using the maximum allowances from the three legacy codes. However, NASFM's analysis shows that some of the height and area increases prescribed in Table 503, as currently written, allow for significantly greater tabular heights and areas than those prescribed under *any* of the previous model building codes. In addition to this comparison, research and recommendations from NIST and data published by the National Institute of Occupational Safety and Health (NIOSH) regarding firefighter death and injuries were used to determine the sections of Table 503 that required revision.

When applying the allowable increases provided by the height and area modification sections, the prescribed heights and areas for certain high risk occupancies allow construction of buildings far exceeding the overall size of those encountered in the past, and thus may place occupants and first responders at greater risk. Both NIST[3] and NIOSH[4] are on record recommending the importance of redundancy in fire protection both from a life safety perspective and from a firefighter safety perspective.

The issue of increased height and area limitations has received a great deal of attention in the building community and among first responders. A recent NIOSH publication, *Preventing Injuries and Deaths of Fire Fighters due to Truss System Failures*[5] discusses the issue in great detail. NIOSH points to the significant increase in engineered buildings because of economic considerations. These dangerous structures, with lighter weight materials to span larger areas, are allowed only because of the increased area limitations. "Engineered building components," NIOSH concludes, "may provide adequate strength under normal loading, but under fire conditions, these truss systems can become weakened and fail, leading to the collapse of floors, roofs and possibly the entire structure," posing serious consequences to firefighters and rescue personnel. NIOSH identified at least 20 fatalities and 12 injuries that have occurred from 1998-2003 during firefighting operations in buildings containing truss systems.

Again, this study supports that the net effect of increasing height and area limitations for certain occupancies is that firefighters may be at greater risk of death or injury from structural collapse. Search and rescue operations require more time in larger buildings. As the NIOSH study highlights, a fire has the opportunity to attack structural elements while rescue operations are underway in engineered buildings. Firefighters, as well as building occupants, find themselves farther from an exit, and at increasingly higher building levels. Where fire departments are understaffed – a situation well documented in the congressionally mandated report, *Needs Assessment of the U.S. Fire Service*[6] – the risk to firefighters is even greater when the structural elements may be unable to withstand elevated temperatures. Rescue operations proceed even when there are clearly insufficient numbers of firefighters to conduct operations according to national standards, (i.e., National Fire Protection Association (NFPA) 1500). The failure of a community to adequately fund a fire department is not the ICC's responsibility, but it is a common factor in many communities that should not be ignored.

From a careful review of published national data related to firefighter casualties on the fireground, NASFM notes that from 1979-2002, more than 180 firefighter fatalities occurred due to structural collapse, not including the World Trade Center (WTC) firefighter deaths on September 11, 2001.[7] From 1992-2002, the number of firefighter fatalities attributed to this cause was 68, according to the NIST report. In addition, during the period from 1989-1997, an average of 735 firefighters were injured every year on the fireground by collapsing roofs, walls, floors or ceilings.[8]

The proposed revisions to the values in Table 503 --Groups A-1, A-2, I-1, I-4 and E – address NASFM's concerns regarding occupancy groups that represent potentially large life loss to first responders and/or at-risk populations.

Use Groups A-1 and A-2: Members of the public, the occupants of these structures, cannot be expected to be familiar with the interior physical arrangements or emergency exit pathways. This lack of familiarity makes rapid exiting difficult, especially under emergency conditions. This problem is made more acute in restaurants and nightclubs, where the consumption of alcohol has the effect of dulling the senses and interfering with appropriate decision-making during an emergency. The most aggressive fire code enforcement has yet to put an end to the dangerous practices of blocked or locked exits in some of these occupancies. As building heights and areas increase, greater occupant numbers are a given, which further interferes with rapid evacuation. In the case of nightclubs, where higher occupant density is anticipated and permitted by the code, entertainment has the added effect of drawing the occupants' attention away from dangerous conditions that may develop within the structure.

NASFM compliments the IBC committees that combined the previously separated restaurant and nightclub categories into the current A-2 Use Group. The distinctions between the two are frequently blurred in the real world, where operators of businesses normally considered restaurants add various levels of entertainment for after-dinner patrons to increase their successful hours of operation. NASFM also recognizes the life safety value of including all of these assembly uses in this A-2 category, resulting in automatic fire sprinkler protection for previously unprotected restaurant uses. In construction Type II-A, which is the first type in which all previous codes limited area, the range of allowable aggregate area was 72,000-173,250 square feet. The current IBC Table 53 allows a total aggregate area of 174,375 square feet.

Use Groups I-1 and I-4: The occupants of buildings in these use groups, while they may be physically capable of reacting to emergencies, often are developmentally or otherwise impaired and insufficiently cognizant of the dangers presented by those emergencies. Occupants of I-1 uses, in particular, are at greater risk from the consequences of fire since they are recognized by the fire service community as including individuals who in less socially-enlightened times were residents of State-run residential institutions. While such persons can recognize audible and visual clues of an impending emergency, and are physically capable of initiating appropriate defensive strategies, they may not perceive the need to act without encouragement. Similarly, the primary occupants of daycare facilities of Use Group I-4 will require direction and active adult assistance.

While these buildings require automatic fire suppression systems, evacuation of occupants in a fire situation is essential to ensure their safety. Even with automatic suppression, the fuel loads present in these occupancies often are formidable and not easily or quickly controlled. Partial or complete evacuation cannot be assured without the active rescue efforts of staff, caregivers and responding firefighters, who are needed to encourage appropriate escape behavior. As building height and areas grow, larger numbers of clients within each building can be anticipated, thereby taxing the ability of first responders to effect the necessary evacuation prior to engaging in fire suppression activities. In construction Type II-A, which is the first type in which all previous codes limited area, the range of allowable aggregate area was 54,400-210,00 square feet. The current IBC Table 53 allows a total aggregate area of 213,750 square feet.

Use Group E: These structures contain a multitude of hazards, including but not limited to laboratories, workshops, storage, and assembly areas. In addition, educational occupancies increasingly are being utilized after regular school hours as community centers, as public meeting halls, for religious gatherings, and for other public assemblies and functions. Increasing the heights and areas of these structures, while decreasing other passive fire protection requirements, diminishes the overall protective package that existed in previous model building codes. As is the case with the assembly uses they are beginning to resemble, many occupants of these facilities are not regular students, teachers or administrative staff, thus are unfamiliar with the physical layout. This lack of familiarity, coupled with the increased populations permitted and encouraged by increased heights and areas, will increase the required evacuation time during emergency conditions. Based on recent directives from the Department of Homeland Security (DHS), schools are considered soft targets for potential terrorist activity. Due to this heightened awareness, educational systems are being asked to "harden" their schools so as to provide the greatest levels of safety possible. In construction Type II-A, which is the first type in which all previous codes limited area, the range of allowable aggregate area was 108,000-297,000 square feet. The current IBC Table 53 allows a total aggregate area of 298,125 square feet.

Conclusion:

NASFM seeks to amend certain sections of Table 503. In light of the most recent government studies, safety must be placed above economic considerations. The current values in conjunction with the reduction of other protective requirements present a risk that is unacceptable. The Committee noted that the original table was supposed to be based on maximum allowances from the three legacy codes. However, there are instances where the table goes beyond those values, and this proposal intends to correct those instances. The cost impact would not be dramatic, as the table would simply be restoring previous values. There would be no additional burden since construction under these requirements has already taken place.

☐ REASON Continued (Attach additional sheets as necessary)

PLEASE USE SEPARATE FORM FOR EACH PUBLIC COMMENT
SUBMITTAL AS A DOCUMENT ATTACHED TO AN EMAIL IS PREFERRED
SEE BACK OF FORM FOR DIRECTIONS ON WHERE TO SEND PUBLIC COMMENTS

PUBLIC COMMENTS SHOULD BE SENT TO THE FOLLOWING OFFICES VIA REGULAR MAIL OR EMAIL. AN EMAIL SUBMITTAL IS PREFERRED, INCLUDING AN ELECTRONIC VERSION, IN EITHER WORD PERFECT OR WORD. THE ONLY FORMATTING THAT IS NEEDED IS BOLDING, ~~STRIKEOUT~~ OR UNDERLINING. PLEASE DO NOT PROVIDE ADDITIONAL FORMATTING SUCH AS TABS, COLUMNS, ETC. AS THIS WILL BE DONE BY ICC. ALL PUBLIC COMMENTS RECEIVED WILL RECEIVE AN ACKNOWLEDGEMENT. IF YOU DO NOT RECEIVE AN ACKNOWLEDGEMENT BY JULY 11, 2005, PLEASE CONTACT MANAGER OF CODES AT 888-ICC-SAFE, EXTENSION 4323 OR STAFF ADMINISTRATIVE ASSISTANT AT 4340.

Signature on File: When submitting public comments electronically, to complete the submittal process, print a copy of the ICC Electronic Copyright Release form found at www.iccsafe.org, fill in the requested information, send to ICC.

Code	Send to:
IBC ICCEC IEBC IFC IFGC ICCPC IPC IPSDC IPMC IUWIC IZC	International Code Council Chicago District Office Attn: Diane Schoonover 4051 West Flossmoor Road Country Club Hills, IL 60478-5795 Fax: 708/799-0320 publiccomments@iccsafe.org
IECC IMC IRC	International Code Council Birmingham District Office Attn: Annette Sundberg 900 Montclair Road Birmingham, AL 35213-1206 Fax: 205/592-7001 publiccommentsbhm@iccsafe.org

Acronym	ICC Code Name
IBC	International Building Code
ICCEC	ICC Electrical Code – Administrative Provisions
IECC	International Energy Conservation Code
IEBC	International Existing Building Code
IFC	International Fire Code
IFGC	International Fuel Gas Code
IMC	International Mechanical Code
ICCPC	ICC Performance Code
IPC	International Plumbing Code
IPMC	International Property Maintenance Code
IPSDC	International Private Sewage Disposal Code
IRC	International Residential Code
IUWIC	International Urban-Wildland Interface Code
IZC	International Zoning Code

The following procedures are excerpts from the *ICC Code Development Process for the International Codes.* The full procedures can be downloaded from the ICC website at www.iccsafe.org.

6.0 Public Comments

6.1 Intent: The public comment process gives attendees at the Final Action Hearing an opportunity to consider specific objections to the results of the public hearing and more thoughtfully prepare for the discussion for Final Action Consideration. The public comment process expedites the Final Action Consideration at the Final Action Hearing by limiting the items discussed to the following:

1. Consideration of items for which a public comment has been submitted; and
2. Consideration of items which received a successful assembly action at the public hearing.

6.2 Deadline: The deadline for receipt of a public comment to the results of the public hearing shall be announced at the public hearing but shall not be less than 30 days from the availability of the report of the results of the public hearing (see Section 5.8).

6.3 Form and Content of Public Comments: Any interested person, persons or group may submit a public comment to the results of the public hearing which will be considered when in conformance to these requirements. Each public comment to a code change proposal shall be submitted separately and shall be complete in itself. Each public comment shall contain the following information:

6.3.1 Public comment: Each public comment shall include the name, title, mailing address and telephone number of the public comment. If a group, organization or committee submits a public comment, an individual with prime responsibility shall be indicated. If a public comment is submitted on behalf of a client, group, organization or committee, the name and mailing address of the client, group, organization or committee shall be indicated.

6.3.2 Code Reference: Each public comment shall include the code change proposal number and the results of the public hearing on the code change proposal to which the public comment is directed.

6.3.3 Desired Final Action: The public comment shall indicate the desired final action as one of the following:

1. Approve the code change proposal (AS), or
2. Approve the code change proposal as modified (AM) by one or more specific modifications published in the Results of the Public Hearing or published in a public comment, or
3. Disapprove the code change proposal (D).

6.3.4 Supporting Information: The public comment shall include a statement containing a reason and justification for the desired final action on the code change proposal. Reasons and justification which are reviewed in accordance with Section 6.4 and determined as not germane to the technical issues addressed in the code change proposal or committee action shall be identified as such. The public commenter shall be notified that the public comment is considered an incomplete public comment in accordance with Section 6.4.1 and the public comment shall be held until the deficiencies are corrected. The public commenter shall have the right to appeal this action in accordance with the policy of the ICC Board. A bibliography of any substantiating material submitted with a public comment shall be published with the public comment.

6.3.5 Number: Two copies of each public comment and two copies of all substantiating information shall be submitted. Additional copies may be requested when determined necessary by the Secretariat. A copy of the public comment in electronic form may be requested.

6.4 Review: The Secretariat shall be responsible for reviewing all submitted public comments from an editorial and technical viewpoint similar to the review of code change proposals (see Section 4.2).

6.4.1 Incomplete Public Comment: When a public comment is submitted with incorrect format, without the required information or judged as not in compliance with these Rules of Procedure, the public comment shall not be processed. The Secretariat shall notify the public commenter of the specific deficiencies and the public comment shall be held until the deficiencies are corrected, or the public comment shall be returned to the public commenter with instructions to correct the deficiencies with a final date set for receipt of the corrected public comment.

6.4.2 Duplications: On receipt of duplicate or parallel public comments, the Secretariat may consolidate such public comments for Final Action Consideration. Each public commenter shall be notified of this action when it occurs.

6.4.3 Deadline: Public comments received by the Secretariat after the deadline set for receipt shall not be published and shall not be considered as part of the Final Action Consideration.

6.5 Publication: The list of public hearing results on code change proposals that have not been public commented and the code change proposals with public commented public hearing results shall constitute the final action agenda. The final action agenda shall be published and made available at least 30 days prior to Final Action Consideration.

The 2004/2005 Final Action Hearings will be held September 28 – October 2, 2005 in Detroit, Michigan

[1] http://www.iccsafe.org/news/nr/2005/0406WTC.html.
[2] http://www.iccsafe.org/cs/codes/2004-05cycle/2005ROH%7EIBC-G.pdf.
[3] Fact Sheet: "Key Findings of NIST's June 2004 Progress Report on the Federal Building and Fire Safety Investigation of the World Trade Center Disaster," Available at http://www.nist.gov/public_affairs/factsheet/wtc_keyfindings.htm.
[4] NIOSH Publication 99-146, "*The Prevention of Injuries and Deaths to Firefighters Due to Structural Collapse,*" See http://www.cdc.gov/niosh/99-146.html.
[5] NIOSH Publication No. 2005-132, "*Preventing Injuries and Deaths of Fire Fighters due to Truss System Failures,*" See http://www.cdc.gov/niosh/docs/2005-132/.
[6] Public Law 106-398, Section 1701, Sec. 33 (b) required that the Director of the Federal Emergency Management Agency (FEMA) conduct a study in conjunction with the National Fire Protection Association (NFPA) to (a) define the current role and activities associated with the fire services; (b) determine the adequacy of current levels of funding; and c) provide a needs assessment to identify shortfalls. This seminal report, "A Needs Assessment of the U.S. Fire Service," found that the vast majority of fire departments cannot respond to emergencies in a timely manner, and when firefighters do reach the scene of an emergency, there are not enough personnel to do the job safely and effectively. The report found that up to 75 percent of our nation's fire departments have too few fire stations to meet response time guidelines. In fire departments that protect communities with a population of less than a million, it is common to respond to emergencies with an insufficient number of fire fighters. Further, the report found that only 11 percent of our nation's fire departments could handle structural collapse involving rescue and EMS operations for over 50 people. The report can be found in its entirety at: http://www.nfpa.org/assets/files/PDF/needsassessment.pdf.
[7] *Trends in Firefighter Fatalities Due to Structural Collapse, 1979-2002*. Bureau of Fire Research Laboratory, NIST; November 2003.
[8] *Patterns of Firefighter Fireground Injuries*, NFPA, January 1998.

Table 503

Proponent: James A. Burns, National Association of State Fire Marshals, Washington, D.C.

Revise table entries as follows:

TABLE 503 (Supp)
ALLOWABLE HEIGHT AND BUILDING AREAS
Height limitations shown as stories and feet above grade plane.
Area limitations as determined by the definition of "Area, building", per floor.

		TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
Group	Hst(S)	UL	160	65	55	65	55	65	50	40
A-1	S A	UL UL	5 ~~UL~~ 29,900	3 ~~15,500~~ 13,500	~~2~~ NP ~~8,500~~ NP	3 ~~14,000~~ 13,500	~~2~~ NP ~~8,500~~ NP	3 ~~15,000~~ 13,500	2 ~~11,500~~ 10,500	~~1~~ NP ~~5,500~~ NP
A-2	S A	UL UL	11 ~~UL~~ 29,900	3 ~~15,500~~ 13,500	2 ~~9,500~~ 9,100	3 ~~14,000~~ 13,500	2 ~~9,500~~ 9,100	3 ~~15,000~~ 13,500	2 ~~11,500~~ 10,500	1 6,000
A-3	S A	UL UL	11 UL	3 15,500	2 9,500	3 14,000	2 9,500	3 15,000	2 11,500	1 6,000
A-4	S A	UL UL	11 UL	3 15,500	2 9,500	3 14,000	2 9,500	3 15,000	2 11,500	1 6,000
A-5	S A	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL	UL UL
B	S A	UL UL	11 UL	5 37,500	4 23,000	5 28,500	4 19,000	5 36,000	3 14,000	2 9,000
E	S A	UL UL	5 ~~UL~~ 45,200	3 ~~26,500~~ 20,200	2 ~~14,500~~ 13,500	3 ~~23,500~~ 20,200	2 ~~14,500~~ 13,500	3 ~~25,500~~ 20,200	1 ~~18,500~~ 15,700	1 ~~9,500~~ 9,100
F-1	S A	UL UL	11 UL	4 25,000	2 15,500	3 19,000	2 12,000	4 33,500	2 14,000	1 8,500
F-2	S A	UL UL	11 UL	5 37,500	3 23,000	4 28,500	3 18,000	5 50,500	3 21,000	2 12,000
H-1	S A	1 21,000	1 16,500	1 11,000	1 7,000	1 9,500	1 7,000	1 10,500	1 7,500	NP NP
H-2	S A	UL 21,000	3 16,500	2 11,000	1 7,000	2 9,500	1 7,000	2 10,500	1 7,500	1 3000
H-3	S A	UL UL	6 60,000	4 26,500	2 14,000	4 17,500	2 13,000	4 25,500	2 10,000	1 5,000
H-4	S A	UL UL	7 UL	5 37,500	3 17,500	5 28,500	3 17,500	5 36,000	3 18,000	2 6,500
H- 5	S A	3 UL	4 UL	3 37,500	3 23,000	3 28,500	3 19,000	3 36,000	3 18,000	2 9,000
I-1	S A	UL UL	9 ~~55,000~~ 15,100	4 ~~19,000~~ 6,800	~~3~~ NP ~~10,000~~ NP	4 ~~16,500~~ 6,800	~~3~~ NP ~~10,000~~ NP	4 ~~18,000~~ 6,800	3 ~~10,500~~ 5,200	~~2~~ NP ~~4,500~~ NP
I-2	S A	UL UL	4 UL	2 15,000	1 11,000	1 12,000	NP NP	1 12,000	1 9,500	NP NP
I-3	S A	UL UL	4 UL	2 15,000	1 11,000	2 10,500	1 7,500	2 12,000	2 7,500	1 5,000
I-4	S A	UL UL	5 ~~60,500~~ 45,200	3 ~~26,500~~ 20,200	2 ~~13,000~~ 13,500	3 ~~23,500~~ 20,200	2 ~~13,000~~ 13,500	3 ~~25,500~~ 20,200	1 ~~18,500~~ 15,700	1 ~~9,000~~ 9,100
M	S A	UL UL	11 UL	4 21,500	4 12,500	4 18,500	4 12,500	4 20,500	3 14000	1 9000

R-1	S A	UL UL	11 UL	4 24,000	4 16,000	4 24,000	4 16,000	4 20,500	3 12,000	2 6000
R-2[a]	S A	UL UL	11 UL	4 24,000	4 16,000	4 24,000	4 16,000	4 20,500	3 10,500	2 7,000
R-3[a]	S A	UL UL	11 UL	4 UL	4 UL	4 UL	4 UL	4 UL	3 UL	3 UL
R-4	S A	UL UL	11 UL	4 24,000	4 16,000	4 24,000	4 16,000	4 20,500	3 12,000	2 7000
S-1	S A	UL UL	11 48,000	4 26,000	3 17,500	3 26,000	3 17,500	4 25,500	3 14,000	1 9,000
S-2[b, c]	S A	UL UL	11 79,000	5 39,000	4 26,000	4 39,000	4 26,000	5 38,500	4 21,000	2 13,500
U[c]	S A	UL UL	5 35,500	4 19,000	2 8,500	3 14,000	2 8,500	4 18,000	2 9,000	1 5,500

For SI: 1 foot = 304.8 mm, 1 square foot = 0.0929 m^2.
UL = Unlimited, NP = Not permitted.
a. As applicable in Section 101.2.
b. For open parking structures, see Section 406.3.
c. For private garages, see Section406.1.

NCS BCS
National Conference of States on Building Codes & Standards

August 3, 2005

Dr. Shyam Sunder
Acting Assistant Director, Building & Fire Research Laboratory
Lead Investigator, World Trade Center Disaster
100 Bureau Drive, Mail Stop 8610
Gaithersburg, MD 20899-8600

Dear Dr. Sunder:

On behalf of our President Cynthia Wilk, the Board of Directors, and members of the National Conference of States on Building Codes and Standards (NCSBCS), I am pleased to forward for NIST's review and consideration our association's attached response to the Final Report and Recommendations of the National Construction Safety Team on the Collapses of the World Trade Center Towers.

In preparing our response, President Wilk appointed a work group comprised of building officials representing a cross-section of our members whose jurisdictions are the site of many high-rise structures. Serving on that work group were California Acting State Architect, Richard Conrad; Illinois Building Commission Director, Jerry Crabtree; State of New Jersey Building Official, Amy Frank; and Miami-Dade County Building Commissioner, Charles Danger. In addition, the NCSBCS submission was circulated for review and input by our Board of Directors and state Delegates and members from major cities and counties across the United States.

NCSBCS appreciates NIST's review and consideration of our comments regarding your June 23, 2005, report. We wish to congratulate the members of the National Construction Safety Team, you and your colleagues at NIST for your detailed work in preparing your series of reports on the World Trade Center disaster.

NCSBCS, under the terms of our agreements with the National Governors Association and the Council of State Governments, is forwarding a copy of this submission for the consideration of their respective members.

In our submission we note several areas where NCSBCS is prepared to work cooperatively with NIST in seeking the implementation of your recommendations. In that regard, NCSBCS looks forward to participating in your upcoming September 13-15 Workshop on the World Trade Center Report and to holding follow-up discussions with NIST regarding areas of possible future cooperation.

Should you have any questions concerning our submission, please do not hesitate to contact me at 703 481-2035.

Sincerely,

Robert C. Wible
Executive Director

Cc: Raymond Scheppach, Executive Director, National Governors Association
Dan Spague, Executive Director, Council of State Governments
NCSBCS President Cynthia Wilk & Members of the NCSBCS Board of Directors

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National Conference of States on Building Codes & Standards

NCSBCS RESPONSE TO THE FINAL REPORT AND RECOMMENDATIONS OF THE NATIONAL CONSTRUCTION SAFETY TEAM ON THE COLLAPSES OF THE WORLD TRADE CENTER TOWERS

August 4, 2005

The members of the National Conference of States on Building Codes and Standards thank the National Institute of Standards and Technology (NIST) for inviting comments on the draft final report of the National Construction Safety Team on the World Trade Center Collapse.

Representing the building code and public safety interests of the state building officials, NCSBCS has reviewed the draft report and offers for NIST's consideration several general recommendations and specific comments concerning the report's 30 recommendations.

In particular, NCSBCS wants to stress the following points concerning implementation, enforceability, affordability, and demographics.

NCSBCS GENERAL OVERARCHING COMMENTS ON THE REPORT

- Overall, NCSBCS endorses the 30 recommendations within the Final Report and urges NIST to work with the construction industry, codes and standards community, other federal agencies and with state and local governments in their implementation.

- Secondly, while the follow-up research and potential changes in the codes and standards based upon NIST's findings are of major importance, it is critical that state and local governments adopt and enforce such changes. This means that elected officials must assure that building departments are adequately funded and staffed by qualified personnel to assure that new high-rise structures and those undergoing retrofits indeed are built to conform to the upgraded codes and standards. The recent history of building safety is replete with examples of where the laws (codes) were on the books but there was inadequate enforcement of those codes.

- Thirdly, the majority of the report's recommendations are directed towards new construction. NCSBCS urges NIST and other Federal agencies to work closely with the construction community and with state and local governments to research affordable and practical application of the NIST recommendations in retrofit situations. Care must be taken not to make the retrofit of high-rise construction so expensive as to reduce the value and usability of the nation's existing stock of such structures. Such an approach must also take into account helping building owners and building departments accurately assess the risk and vulnerability of existing high-rise buildings and iconic structures and then apply appropriate enhanced safety features. The livability and viability of our urban areas depends upon the continued use of our high-rise building stock.

- Lastly, NCSBCS wishes to note that the research described in Recommendation #17 regarding determining building evacuations, needs to include addressing the special evacuation needs of high-rise residential structures, especially those that are the homes of a large number of elderly citizens. That research may result in recommendations that some of the NIST recommendations be applied to high-rise residential buildings of less than 20 stories.

NCSBCS SPECIFIC COMMENTS ON NIST RECOMMENDATIONS

- **GROUP 1 - Increased Structural Integrity (Recommendations Nos. 1 – 3)**

  NCSBCS supports the implementation of all three of these increased structural integrity recommendations but wishes to stress that there is an immediate need especially for national uniformity in wind tunnel testing. A number of high-rise structures are currently under design that would benefit from such uniform testing (Recommendations #2 & #3).

- **GROUP 2 - Enhanced Fire Resistance of Structures (Recommendations Nos. 4 – 7)**

  NCSBCS supports all four of these recommendations regarding enhanced fire resistance of structures.

- **GROUP 3 - New Methods of Fire Resistance Design of Structures (Recommendations Nos. 8 – 11)**

  NCSBCS supports each of these four recommendations on fire resistance design. These recommendations need further study to look at their application in retrofit situations to make sure the most affordable approaches and applications are found. The federal government together with the insurance industry should consider funding such research.

- **GROUP 4 - Improved Active Fire Protection (Recommendations Nos. 12 – 15)**

  NCSBCS encourages the development of these active fire protection systems and their implementation to support safer building operations. NCSBCS also endorses the incorporation of these recommendations noting that Recommendation #12 will involve changes in the nation's model codes.

- **GROUP 5 - Improved Building Evacuation (Recommendations Nos. 16 – 20)**

  NCSBCS also endorses these improved building evacuation recommendations and specifically wants to stress the importance of testing different types of occupancies for evacuation speed and capabilities of their occupants. Special attention should be paid to high-rise structures housing the elderly and their special evacuation needs. Moreover, NCSBCS believes that Recommendations #18, 19 & 20 are critical.

  NCSBCS wishes to acknowledge that NIST in their report has listed NCSBCS as one of the national organizations that should be involved in the implementation of Recommendation #16. NCSBCS will study ways in which it can work with other associations and organizations in developing and carrying out such a public education program.

- **GROUP 6 - Improved Emergency Response (Recommendations Nos. 21 – 24)**

  NCSBCS supports each of the improved emergency response recommendations and adds that in many disaster situations, the building official may be on the scene making evaluations of the structural soundness of buildings after/during a disaster event. Among the information that is critical to be available to first responders are current as-built plans for the building, emergency contact information to the architect and engineers who designed or retrofitted the building.

  NCSBCS has recommended to NIST and the Department of Homeland Security that a secure database of such designs and other critical technical information on the building (including fire rating of the structure) should be developed.

- **GROUP 7 - Improved Procedures and Practices (Recommendations Nos. 25 – 28)**

  NCSBCS supports all four of the improved procedures and practices recommendations and adds that it is critical at this juncture in our nation's history for all jurisdictions and all government entities to have their buildings constructed and inspected in conformance with adopted modern building codes and standards.

  This group of recommendations also can only be carried out if building departments are adequately funded and staffed and effective enforcement action is taken where warranted. In the past too many building departments had building permit and other funds taken from them to support other government functions, leaving the building department inadequately staffed with qualified professionals to carry out codes administration and enforcement functions that are necessary to protect citizens in the built environment. In this regard, NCSBCS is prepared to share with other jurisdictions across this nation samples of effective codes administration and enforcement legislation and codes funding programs that meet the above needs.

- **GROUP 8 - Education and Training (Recommendations Nos. 29 & 30)**

  NCSBCS believes that education and training is another critical area that cannot be ignored. Life long learning is essential if we are to assure the public's health and life safety in our buildings.

NCSBCS CLOSING COMMENT

The Board of Directors and members of the National Conference of States on Building Codes and Standards wish to thank NIST for this opportunity to comment on the draft report and recommendations. In addition, NCSBCS wishes to note that under the terms of our cooperative agreements with the National Governors Association and the Council of State Governments, we are forwarding these comments to both organizations.

NCSBCS is available to answer any questions NIST may have regarding our comments. These may be directed to the NCSBCS Executive Director, Robert Wible, at 703 481-2035 or rwible@ncsbcs.org.

National Conference of States on Building Codes and Standards, Inc.

August 3, 2005

Dr. Shyam Sunder
Acting Assistant Director, Building & Fire Research Laboratory
Lead Investigator, World Trade Center Disaster
100 Bureau Drive, Mail Stop 8610
Gaithersburg, MD 20899-8600

Dear Dr. Sunder:

On behalf of our President Cynthia Wilk, the Board of Directors, and members of the National Conference of States on Building Codes and Standards (NCSBCS), I am pleased to forward for NIST's review and consideration our association's attached response to the Final Report and Recommendations of the National Construction Safety Team on the Collapses of the World Trade Center Towers.

In preparing our response, President Wilk appointed a work group comprised of building officials representing a cross-section of our members whose jurisdictions are the site of many high-rise structures. Serving on that work group were California Acting State Architect, Richard Conrad; Illinois Building Commission Director, Jerry Crabtree; State of New Jersey Building Official, Amy Frank; and Miami-Dade County Building Commissioner, Charles Danger. In addition, the NCSBCS submission was circulated for review and input by our Board of Directors and state Delegates and members from major cities and counties across the United States.

NCSBCS appreciates NIST's review and consideration of our comments regarding your June 23, 2005, report. We wish to congratulate the members of the National Construction Safety Team, you and your colleagues at NIST for your detailed work in preparing your series of reports on the World Trade Center disaster.

NCSBCS, under the terms of our agreements with the National Governors Association and the Council of State Governments, is forwarding a copy of this submission for the consideration of their respective members.

In our submission we note several areas where NCSBCS is prepared to work cooperatively with NIST in seeking the implementation of your recommendations. In that regard, NCSBCS looks forward to participating in your upcoming September 13-15 Workshop on the World Trade Center Report and to holding follow-up discussions with NIST regarding areas of possible future cooperation.

Should you have any questions concerning our submission, please do not hesitate to contact me at 703 481-2035.

Sincerely,

Robert C. Wible

Robert C. Wible
Executive Director

Cc: Raymond Scheppach, Executive Director, National Governors Association
Dan Spague, Executive Director, Council of State Governments
NCSBCS President Cynthia Wilk & Members of the NCSBCS Board of Directors

NCSBCS RESPONSE
TO THE
FINAL REPORT AND RECOMMENDATIONS OF THE
NATIONAL CONSTRUCTION SAFETY TEAM ON THE
COLLAPSES OF THE WORLD TRADE CENTER TOWERS
August 4, 2005

The members of the National Conference of States on Building Codes and Standards thank the National Institute of Standards and Technology (NIST) for inviting comments on the draft final report of the National Construction Safety Team on the World Trade Center Collapse.

Representing the building code and public safety interests of the state building officials, NCSBCS has reviewed the draft report and offers for NIST's consideration several general recommendations and specific comments concerning the report's 30 recommendations.

In particular, NCSBCS wants to stress the following points concerning implementation, enforceability, affordability, and demographics.

NCSBCS GENERAL OVERARCHING COMMENTS ON THE REPORT

- Overall, NCSBCS endorses the 30 recommendations within the Final Report and urges NIST to work with the construction industry, codes and standards community, other federal agencies and with state and local governments in their implementation.

- Secondly, while the follow-up research and potential changes in the codes and standards based upon NIST's findings are of major importance, it is critical that state and local governments adopt and enforce such changes. This means that elected officials must assure that building departments are adequately funded and staffed by qualified personnel to assure that new high-rise structures and those undergoing retrofits indeed are built to conform to the upgraded codes and standards. The recent history of building safety is replete with examples of where the laws (codes) were on the books but there was inadequate enforcement of those codes.

- Thirdly, the majority of the report's recommendations are directed towards new construction. NCSBCS urges NIST and other Federal agencies to work closely with the construction community and with state and local governments to research affordable and practical application of the NIST recommendations in retrofit situations. Care must be taken not to make the retrofit of high-rise construction so expensive as to reduce the value and usability of the nation's existing stock of such structures. Such an approach must also take into account helping building owners and building departments accurately assess the risk and vulnerability of existing high-rise buildings and iconic structures and then apply appropriate enhanced safety features. The livability and viability of our urban areas depends upon the continued use of our high-rise building stock.

- Lastly, NCSBCS wishes to note that the research described in Recommendation #17 regarding determining building evacuations, needs to include addressing the special evacuation needs of high-rise residential structures, especially those that are the homes of a large number of elderly citizens. That research may result in recommendations that some of the NIST recommendations be applied to high-rise residential buildings of less than 20 stories.

NCSBCS SPECIFIC COMMENTS ON NIST RECOMMENDATIONS

- **GROUP 1 - Increased Structural Integrity (Recommendations Nos. 1 – 3)**

  NCSBCS supports the implementation of all three of these increased structural integrity recommendations but wishes to stress that there is an immediate need especially for national uniformity in wind tunnel testing. A number of high-rise structures are currently under design that would benefit from such uniform testing (Recommendations #2 & #3).

- **GROUP 2 - Enhanced Fire Resistance of Structures (Recommendations Nos. 4 – 7)**

  NCSBCS supports all four of these recommendations regarding enhanced fire resistance of structures.

- **GROUP 3 - New Methods of Fire Resistance Design of Structures (Recommendations Nos. 8 – 11)**

  NCSBCS supports each of these four recommendations on fire resistance design. These recommendations need further study to look at their application in retrofit situations to make sure the most affordable approaches and applications are found. The federal government together with the insurance industry should consider funding such research.

- **GROUP 4 - Improved Active Fire Protection (Recommendations Nos. 12 – 15)**

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NCSBCS wishes to acknowledge that NIST in their report has listed NCSBCS as one of the national organizations that should be involved in the implementation of Recommendation #16. NCSBCS will study ways in which it can work with other associations and organizations in developing and carrying out such a public education program.

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NCSBCS has recommended to NIST and the Department of Homeland Security that a secure database of such designs and other critical technical information on the building (including fire rating of the structure) should be developed.

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NCSBCS believes that education and training is another critical area that cannot be ignored. Life long learning is essential if we are to assure the public's health and life safety in our buildings.

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The Board of Directors and members of the National Conference of States on Building Codes and Standards wish to thank NIST for this opportunity to comment on the draft report and recommendations. In addition, NCSBCS wishes to note that under the terms of our cooperative agreements with the National Governors Association and the Council of State Governments, we are forwarding these comments to both organizations.

NCSBCS is available to answer any questions NIST may have regarding our comments. These may be directed to the NCSBCS Executive Director, Robert Wible, at 703 481-2035 or rwible@ncsbcs.org.

From: Edwin Huston <huston@smithhustoninc.com>
To: wtc@nist.gov
Subject: Public Comments to the NIST WTC Recommendations

Attached are Public Comments to the NIST WTC Recommendations being made by The National Council of Structural Engineering Associations (NCSEA) and correlated by Edwin T. Huston, PE, SE, Chair of the Code Advisory Committee, General Engineering Subcommittee. I may be reached by email at huston@smithhustoninc.com or by phone 206-448-8448.

Best Regards
Ed Huston

NCSEA Response to NIST Recommendations.doc

huston.vcf

Response made by The National Council of Structural Engineering Associations (NCSEA)
Submitted by Edwin Huston, PE, SE, Chair of the Code Advisory Committee, General Engineering Subcommittee
Contact Information: huston@smithhustoninc.com or Phone 206-448-8448
Report Number: NCSTAR 1 Chapter 9 - Recommendations

Recommendation 1. NIST recommends that: (1) progressive collapse should be prevented in buildings through the development and nationwide adoption of consensus standards and code provisions, along with the tools and guidelines needed for their use in practice; and (2) a standard methodology should be developed—supported by analytical design tools and practical design guidance—to reliably predict the potential for complex failures in structural systems subjected to multiple hazards.

NCSEA Response:

1. The suggested methodology discusses the design for the removal of a single column or transfer beam. In the WTC collapse, more than 30 adjacent columns were removed. In the Oklahoma City Murrah Federal Building, four adjacent columns and the transfer beams above them were taken out. No design methodology can accommodate this level of destruction and result in useful buildings. This recommendation would not have changed the outcome of either of these events.
2. This recommendation calls for a building code change for all buildings. It would be prohibitively expensive and take huge amounts of time, effectively slowing down construction to a point that nothing could be built. If such standards are to be incorporated they should be tied to some high target classification of buildings, such as federal buildings, trade centers, or other iconic buildings. Otherwise this would be applied to two-story strip malls.
3. Developing such design protocols is more difficult for certain types of buildings. In a masonry or concrete building with long walls on all four sides, it is difficult to define what constitutes an element. Is it a 40-foot long wall that is one or more stories tall? What is an element in a wood framed building? The British experience has shown that enforcement for these classes of buildings has been problematic, and they have been working with it since 1970.
4. Some have suggested that tying a building together could lead to worse performance in a disaster. The loss of a critical element could cause connected elements, which otherwise would not have been affected, to be pulled into the failure. In fact, at the Pentagon, the presence of a building separation joint prevented the collapse of additional sections of the structure.

Recommendation 2. NIST recommends that nationally accepted performance standards be developed for: (1) conducting wind tunnel testing of prototype structures based on sound technical methods that result in repeatable and reproducible results among testing laboratories; and (2) estimating wind loads and their effects on tall buildings for use in design, based on wind tunnel testing data and directional wind speed data.

NCSEA Response: The effectiveness and reproduceability of wind tunnel tests is unrelated to the collapse of the WTC, or any other known terrorist attack. This recommendation would not fix any of the problems which occurred in this or other attacks, or problems that would occur under different attack scenarios

Recommendation 3. NIST recommends that an appropriate criterion should be developed and implemented to enhance the performance of tall buildings by limiting how much they sway under lateral load design conditions (e.g., winds and earthquakes).

NCSEA Response: Building sway is, in part, a function of the stiffness of the lateral force resisting system. The stiffness of the lateral force resisting system of the WTC is unrelated to the collapse of the WTC or to the loss of life of the WTC. The Pentagon and the Oklahoma City Murrah Federal Building did not have undesirable sway characteristics; in fact the Pentagon given its height and overall size would have been a very stiff building. This stiffness of these latter two buildings did not result in preventing collapse or lessening the loss of life in their partial collapses.

While building codes do not have specific limits for the sway of tall buildings under wind load design conditions, tall buildings are typically designed to meet relatively stringent sway criteria which have been developed based on occupant comfort. The existing criteria, which has been based in part on review of less than optimal performance of a few notable tall buildings, results in acceptable building performance.

This recommendation would not have changed the outcome of the WTC or other terrorist attacks and does nothing to prevent future building collapses and is therefore outside the scope of this investigation.

Recommendation 9. NIST recommends the development of: (1) performance-based standards and code provisions, as an alternative to current prescriptive design methods, to enable the design and retrofit of structures to resist real building fire conditions, including their ability to achieve the performance objective of burnout without structural or local floor collapse: and (2) the tools, guidelines, and test methods necessary to evaluate the fire performance of the structure as a whole system.

NCSEA Response: This appears to be a good objective. Should it be applied universally to all buildings, regardless of height, or should it be required for certain classes of buildings, such as federal buildings, trade centers, or other iconic buildings, or buildings over a certain height? Buildings with built-in "areas of refuge" should meet this performance objective.

For retrofit situations, with the retrofit the mandatory or would the retrofit be required if the building were being retrofitted for a change of occupancy? Would this requirement be triggered for retrofit of a percentage of the building's value? For example would it be required for the seismic retrofit of a tilt-up warehouse? The retrofit issue needs to be carefully considered. Past building code regulations regarding retrofits have proven to be barriers to improve building safety rather than promoting improved building safety. For example, if the owner wishes to seismically upgrade a building and at the same time must upgrade the mechanical and electrical systems, due to the code regulations triggered by the cost of the upgrade, the result in many cases is that nothing is upgraded.

As part of the development, there needs to be validation that the models actually predict "real" behavior.

Recommendation 11. NIST recommends that the performance and suitability of advanced structural steel, reinforced and pre-stressed concrete, and other high-performance material systems should be evaluated for use under conditions expected in building fires.

NCSEA Response: This appears to be a good objective. It is already a requirement of all building codes.

Recommendation 18. NIST recommends that egress systems should be designed: (1) to maximize remoteness of egress components (i.e., stairs, elevators, exits) without negatively impacting the average travel distance; (2) to maintain their functional integrity and survivability under foreseeable building-specific or large-scale emergencies; and (3) with consistent layouts, standard signage, and guidance so that systems become intuitive and obvious to building occupants during evacuations.

NCSEA Response: Prior to the adoption of the IBC or NFPA codes the three legacy codes had different requirements for remoteness of egress components. The effectiveness and safety record of the three legacy code requirements for remoteness should be evaluated. In different emergencies, different outcomes can occur. In some cases remoteness can be beneficial, in other cases the increased travel distance can be a hindrance.

Hardening of egress components could have significant and substantial impacts on building design. Hardening of these components will increase their stiffness and attract additional force to them if concrete or masonry enclosures are employed. This becomes a circular problem. As more force is attracted, more stiffness is required. It is also unclear just how "hard" these components should be. After the first WTC bomb attack, people were able to exit elevators by cutting through gypsum wallboard enclosures with penknives. This would not be possible if the enclosure had been "hardened". Finally, hardening of exit components could create new terrorist opportunities. A secondary bomb placed in a hardened stairwell could kill a tremendous number of people.

Standardized signage, which is intuitive and obvious, is an excellent recommendation. At the same time standardization of elevator buttons should be considered. The "open door", "close door", and "alarm" buttons should always be in the same location and in the same order on all elevators.

Recommendation 21. NIST recommends the installation of fire-protected and structurally hardened elevators to improve emergency response activities in tall buildings by providing timely emergency access to responders and allowing evacuation of mobility-impaired building occupants. Such elevators should be installed for exclusive use by emergency responders during emergencies. In tall buildings, consideration also should be given to installing such elevators for use by all occupants.

NCSEA Response: Currently, building codes already require elevators to return to the lobby during fire alarm so that emergency responders can use them. Elevator use by building occupants during a fire has not been shown to be an effective method of evacuation. If the elevator doors open into a smoke engulfed floor, the elevator occupants can die of smoke inhalation. The elevators, themselves, are already required to be housed within fire-protected enclosures.

Structurally hardening elevators is problematic. In some disasters, people have been able to escape from damaged elevators because they had not been hardened.

Recommendation 25. Nongovernmental and quasi-governmental entities that own or lease buildings and are not subject to building and fire safety code requirements of any governmental jurisdiction are nevertheless concerned about the safety of the building occupants and the responding emergency personnel. NIST recommends that such entities should be encouraged to provide a level of safety that equals or exceeds the level of safety that would be provided by strict compliance with the code requirements of an appropriate governmental jurisdiction. To gain broad public

confidence in the safety of such buildings, NIST further recommends that it is important that as-designed and as-built safety be certified by a qualified third party, independent of the building owner(s). The process should not use self-approval for code enforcement in areas including interpretation of code provisions, design approval, product acceptance, certification of the final construction, and post-occupancy inspections over the life of the buildings.

NCSEA Response: While it is true that many national and local state government buildings are not required to meet local city building codes, current practice is that these structures are designed to requirements that are equal or better than the requirements of the local codes. These agencies also already require internal review of the construction documents prepared by the Registered Design Professionals.

Recommendation 27. NIST recommends that building codes should incorporate a provision that requires building owners to retain documents, including supporting calculations and test data, related to building design, construction, maintenance and modifications over the entire life of the building. Means should be developed for offsite storage and maintenance of the documents. In addition, NIST recommends that relevant building information should be made available in suitably designed hard copy or electronic format for use by emergency responders. Such information should be easily accessible by responders during emergencies.

NCSEA Response: Many Building Departments already retain copies of the building plans. Whether these plans would be accessible during an emergency is another matter. Building Departments are not open 24/7. While it is possible to require building owners to retain copies of the building plans, it may not be possible to guarantee that those plans are accessible during an emergency. The person who knows where the plans are may not be available. If the plans are stored offsite, the storage facility may not be open at the time of the emergency. This would mean that the agencies of the possible first responders would have to have hard copy or electronic format copies of plans for all significant structures within their jurisdiction. This puts a tremendous burden on the agencies that provide the first responders. Finally, plans sets for tall buildings are very large and expertise is required to read and interpret the information. Will the agencies that provide first responders now need to have on staff structural engineers to provide these interpretation capabilities? These problems become even more formidable when the plan sets have to include modifications due to maintenance, alterations or tenant improvements.

This problem is compounded when calculations and test data must be available in addition to the plans sets. Furthermore, calculations become outdated due to building code changes and materials code changes long before the building has reached the end of its useful life. In emergency situation, even the personnel in the offices of the Registered Design Professionals will not have time to refer to and interpret the calculations and test data. This portion of this recommendation adds nothing to the emergency response in the time of a disaster.

Recommendation 28. NIST recommends that the role of the "Design Professional in Responsible Charge" should be clarified to ensure that: (1) all appropriate design professionals (including, e.g., the fire protection engineer) are part of the design team providing the standard of care when designing buildings employing innovative or unusual fire safety systems47, and (2) all appropriate design professionals (including, e.g., the structural engineer and the fire protection engineer) are part of the design team providing the standard of care when designing the structure to resist fires, in buildings that employ innovative or unusual structural and fire safety systems.

NCSEA Response: This calls for a building code change for all buildings. If such standards are to be incorporated they should be tied to some high target classification of buildings, such as federal buildings, trade centers, etc. Otherwise this would be applied to two-story strip malls. In modern building design, the vast majority of buildings constructed do not use the services of fire protection engineers. Requiring them increases the cost of building design without providing an equivalent benefit. Furthermore, when fire protection engineers are used in the design of significant structures, they are typically employed to reduce the cost of the structure and the cost of the fireproofing.

NIST has not shown that the use of fire protection engineers would have changed the outcome at either the WTC or the Pentagon.

Finally, the purpose of defining the Design Professional in Responsible Charge is so that there is one "go-to" person for the discipline in question. It does not preclude teamwork, as NIST seems to imply. This seems to be unnecessary.

Recommendation 29. NIST recommends that continuing education curricula should be developed and programs should be implemented for training fire protection engineers and architects in structural engineering principles and design, and training structural engineers, architects, and fire protection engineers in modern fire protection principles and technologies, including fire-resistance design of structures.

NCSEA Response: This is an excellent recommendation.

Recommendation 30. NIST recommends that academic, professional short-course, and webbased training materials in the use of computational fire dynamics and thermostructural analysis tools should be developed and delivered to strengthen the base of available technical capabilities and human resources.

NCSEA Response: This is an excellent recommendation.

National Elevator Industry, Inc.

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WWW.NEII.ORG • E-Mail: info@neii.org

July 20, 2005

WTC Technical Information Repository,
Stop 8610
100 Bureau Drive
Gaithersburg, MD 20899-8610

Subject: Draft NIST WTC Report

Gentlemen:

National Elevator Industry, Inc. (NEII) has reviewed the draft report including recommendations. NEII is intentionally not commenting in an elaborate way as we are awaiting the final report from ASME A17 Emergency Operations Committee Task Groups on the Use of Elevators in a Fire, which includes representatives from the elevator industry, AHJ's, ICC, NFPA, NIST, fire fighters, fire protection engineers, disability organizations, consultants, etc.

- Recommendation 17 subparagraph (c) needs to be clarified that even when hardened elevators are provided sufficient stairway exiting capacity as specified in Recommendation 17 must be provided.

- Recommendation 21 (a) clarification is needed.

- "Structurally Hardened" as defined in footnote 37 as "to withstand the range of foreseeable building …" is too broad a statement and should be focused in order to be practical.

- Recommendation 26, clarification on the reference to ASME A17.3 is needed.

If I can be of any assistance in further clarifying the above comments, feel free to contact me.

Very truly yours

Edward A. Donoghue

Edward A. Donoghue, CPCA
Code and Safety Consultant to NEII

cc: NEII Board of Directors
NEII Central Code Committee

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CARTER, LEDYARD & MILBURN

MEMORANDUM

2 Wall Street
New York, N.Y. 10005
212.732.3200
Fax: 212.732.3232

To: National Institute of Standards and Technology, 100 Bureau Street, Gaithersburg, MD 20899 Attn: Richard W Bukowski P.E.

W Gene Corley, P.E., Senior VP, Construction Technology Labs, 5420 Old Orchard Rd, Skokie Illinois 60077

From: Robert R. Grew (Retired Partner)

Subject: WTC

Date: July 13, 2005

Cc: Raymond E Grew, P.E., 28124 Hamden Lane, Rancho Hidden Valley, Escondido, CA 92026.

I am pleased to enclose comments dated July 2, 2002 from my brother, Ray Grew, on the article concerning the report by NIST on the World Trade Center which appeared in the *New York Times* on June 24, 2005 at page B-7.

Bob Grew

R.R.G.

Direct Dial No.:	212-238-8803
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July 2, 2005

Rob

Refer to the page numbers on the copy.

1 Under what conditions? Of course he must mean under regular hazards and not fuel all over.

2 The building was a special light weight structure, how does this fit into the code? In this case the Port Authority could just do what they wanted to do not like a city approving the building drawings and specifications. I believe the City Council ruled that asbestos in the fireproofing could not be used.

3 It might be hard to get information on the code from experience on an building that might not have followed the current code in effect at the time.

4 This might bring up good information.

5 Freight or special elevator that the Firemen could take over in case of an emergency?

6 I believe a good part of codes are based on experience rather than research, however surely new methods developed over a period of time would be good. Effective separate exits always was in the code. Still a lightweight building structure that allows a maximum of outside rental space does not go with taking some of that space for non money producing space let alone the possibility of cutting off good outside views.

7 Glow in the dark might work but the normal system is emergency battery lighting that turns on with a power failure. Of course there is the cost and responsibility of maintaining the batteries.

8 It is good that fireproofing be inspected, new construction and some damage could affect the fireproofing after the building has been occupied over a time. Adding a pipe has to have a hanger that can go through the fireproofing. Any connection from a pipe or electric conduit can be a conductor of heat to a structural member, how much? But not restoring the fireproofing after opening it up to mount pipe hanger has to be handled.

9 If sheetrock walls were used more strength in the stairwell walls would help. But normal cinder block walls might not work with the light weight construction except in the center of the building. Rest areas, do not people have to get out of the building as fast as possible? Somehow handle the problem of handicapped people in the fireman's emergency elevator. It might get very involved for the fireman to know where the handicapped people are.

: Changes in the Construction of Tall Buildings? Experts Disagree

owers Should Have Had One More Staircase, Report Finds

By JIM DWYER

its bluntest finding about tcomings of the World Trade ter that may have contributed e deaths on Sept. 11, a federal rt said yesterday that the tow- did not have enough staircases neet New York City's building

ach tower had three staircases, should have had four to meet city's code, the report stated. Port Authority of New York New Jersey, which built and ed the towers, had long said while it was not bound by the , it was committed to "meet or ed" those standards.

Of the six staircases in the two buildings, five were destroyed outright by the impact of the planes. The sixth, in the south tower, survived at least partly intact and at least 18 people from the impact zone used it to escape.

In the north tower, however, no one above the 91st floor was able to get out, even though about 1,000 are likely to have survived the impact of the hijacked airplane.

The fourth staircase — had it been built, as the code required, and if it had been out of the path of destruction — presents the painful, tantalizing prospect that some of those people might have been able to get out.

"If it had survived, at least partially, you might not have had everybody killed," said Richard W. Bukowski, a senior engineer with the National Institute of Standards and Technology. He led the investigation into the Port Authority's assertion that it had complied with building codes.

Mr. Bukowski noted that it was quite possible that a fourth staircase might have had the same immediate fate as most of the others, depending on where it was located.

The Port Authority maintains that the stairway was not required.

"On the issue of the fourth staircase, we will respectfully disagree with the N.I.S.T. findings and maintain that we met the city building codes in this area," said Steve Coleman, an agency spokesman.

The report said the fourth staircase was required because Windows on the World, in the north tower, and the public observatory, in the south tower, had occupancy ratings of 1,000 people or more.

"If the building was built under the New York City building code, it would have required a fourth staircase," said Jennifer Givner, a spokeswoman for the city's Department of Buildings, endorsing the federal finding.

(9)

Matthews Dusha

staircases, a feature of the enter stairs that a number of said had been helpful in their tion, and which the city required for all tall buildings. g where and how much of the ould be applied took nearly rs, Ms. Lancaster said.

Ms. Lancaster said that the city was determined not to let reform efforts fall into a bureaucratic torpor, and that it had already adopted a number of the recommendations called for by the federal inquiry. These include such changes as reinforced walls for staircases and elevators, more sprinklers, smoke control measures, and inspection of fireproofing. The question of expanding the width of staircases continues to be debated in New York because of cost concerns.

(8)

Dr. Corley, Mr. Baker and Dr. Barnett each agreed that many of the recommendations could work their way into model codes adopted by organizations like the National Fire Protection Association and the International Code Council, which local and state governments use as templates for their own codes.

Jack Murphy, an adviser to the National Fire Protection Association on high-rise safety, said that firefighters could provide powerful voices on the need for change, but that they are rarely involved.

The new standards will likely result in an immediate adjustment in the development of certain major skyscrapers, if they have not already been made. Mr. Baker, for example, is working on the structural design for the Trump Tower in Chicago. The Freedom Tower, which is to replace the World Trade Center, is also likely to integrate many of the recommendations, the engineers predicted.

The changes Mr. Baker is incorporating into these kinds of buildings include wider stairwells that have more robust walls, and refuge areas for the disabled to await assistance or for tired tenants to rest during an evacuation. He also is designing these towers with stronger connections between columns and beams, addressing one recommendation in yesterday's report.

"What we might do on a high-profile building or a building with special tenants is one thing," Mr. Baker said. "But if you want to do that in all tall buildings, I am not sure that is appropriate."

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Continued From Page B1

building codes will likely be modest. "I expect it will be more a case of refinements than wholesale changes," Mr. Baker said.

Leaders of the National Institute of Standards and Technology say that they have an ambitious program of meetings with building code experts and industry officials to push for changes that they believe will improve the safety of buildings faced not only with terrorist attacks, but also more routine hazards like earthquakes, fires, and hurricanes. The agency plans to hold a conference in September on how the building industry can reduce the risk.

"We already have begun working with the organizations that will be responsible for turning the recommendations into action," said Hratch Semerjian, the acting director of the institute.

Nationally, between 1989 and 1999, no more than five civilians were killed in 6,900 reported high-rise office building fires, according to statistics compiled by the National Fire Protection Association. Those numbers — which do not include the attacks at the World Trade Center — are not large enough to produce wide-scale change in building codes, several engineers said.

"You can do anything you want, but you can't change a number that is already extremely low," Dr. Corley said.

In presenting the findings yesterday, S. Shyam Sunder, who led the federal investigation, rejected suggestions that the events at the trade center were too rare to provide useful lessons for other skyscrapers. The investigation used two approaches to study risks, he said. One was based on historical records. The second was "scenario driven," an effort to anticipate unusual events that could cause serious injury or death.

Dr. Sunder said that fully equipped firefighters — carrying nearly 100 pounds of gear up stairs — begin to reach their physiological limits about the 15th or 20th floor, and that it takes about two minutes to climb per floor. For people on the 60th floor of a building that has lost power, Dr. Sunder said, "help is actually a few hours away. We did not look at other buildings, but we are very confident in our recommendations."

Historically, major revisions in building codes have often followed catastrophes or spectacular fires, such as the Chicago Iroquois Theater fire in 1903, the Triangle Shirtwaist fire in New York in 1911, two major skyscraper fires in New York City in the early 1970's, and a deadly fire in 1980 at the MGM Grand Hotel in Las Vegas. All told, hundreds of people died in those fires. Even so, the debate over code changes often drags on for years as groups with competing interests attempt to influence the process, debating costs and benefits.

Jonathan Barnett, a professor at the Worcester Polytechnic Institute Center for Fire Safety Studies, said that many recommendations the standards institute has made would require extensive research before code standards could be drafted.

That research would cost tens of millions of dollars, he said, far more than the $16 million that the institute invested in the study. "There will be no significant change unless Congress throws money at this," he said. "It is not going to come from the private sector."

Ms. Lancaster, of the New York Department of Buildings, cited the example of using glow-in-the-dark

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August 3, 2005

WTC Technical Information Repository
ATTN: Mr. Stephen Cauffman
National Institute of Standards and Technology
Stop 8610
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Fax: 301.975.6122
Email: wtc@nist.gov

Dear Mr. Cauffman:

Several members of the NFPA Technical Staff reviewed the draft report relating to the Federal Building and Fire Safety Investigation of the World Trade Center Disaster. First, NFPA wants to thank Dr. Sunder and his team members for producing such a detailed report. We have made every attempt to provide equally detailed comments and recommended changes or clarifications to the report.

Second, for any of our comments that may seem to be overly critical, our purpose was to make sure the public has as much background as possible on the assumptions or approaches made by the team.

I am looking forward to hearing the presentations and discussions at the Technical Conference on the Federal Building and Fire Safety Investigation of the World Trade Center Disaster in September.

Sincerely,

Gary Keith
Vice President
Building Codes & Standards/Regional Operations

GK:RES:jtm

C: Dr. Shyam Sunder
Dr. William Grosshandler
A. Cote

Enclosure: NFPA Comments

NFPA COMMENTS TO NIST ON THE FEDERAL BUILDING AND FIRE SAFETY INVESTIGATION OF THE WORLD TRADE CENTER DISASTER

INTRODUCTION

NFPA is pleased to present comments to NIST on their comprehensive study of the World Trade Center (WTC) disaster. The level of effort, study, analysis and examination of both the known, factual events of September 11, 2001 as well as the circumstances that NIST had to develop a hypothesis for because of a lack of visual or physical evidence, is notable, and unprecedented. The members of the National Construction Safety Team (NCST), the contributing NIST staff, as well as the private contractors and consultants are to be commended for their commitment to this project. Likewise, the public members of the NCST Federal Advisory Committee for their oversight of the project.

The NCST reports will serve as an important framework for the basis of possible changes to many of the NFPA codes and standards in the coming years. Within the 30 recommendations, are issues related to NFPA codes that have either already been revised, are in the process of being revised, or are likely to be revised in some way during future code changes and document revision cycles. It should be noted, however, that it is not only possible, but likely, that after a thorough and detailed analysis of some of the NCST recommendations, there simply may not be enough sufficient detail or compelling evidence to promulgate a change to a particular code or standard. With that said, NFPA is making a commitment to NIST to continue to study, review and evaluate each recommendation before any final decision on a given recommendation is finalized.

The on-going debate about whether building regulations should address events associated with normal building hazards, or more extreme events such as hostile acts and explosions will have to be settled first before consensus is reached on many of the recommendations and findings address in the WTC study. This will be a long term process in most case.

Implementation of many of the recommendations will require significant study and scientific input. NIST is uniquely positioned to help provide this type of information. Much of NIST's effort has focused on the application of computer modeling techniques to mathematically reproduce the events of September 11, 2001. This knowledge and experience should be applied to acquire a greater understanding of the effects of fire.

The comments contained within this document have been prepared by the staff of NFPA and have not been reviewed or endorsed by any of the NFPA Technical Committees or relevant NFPA advisory committees. That process will occur in the future once the final report is issued.

Our comments have been arranged so as to generally follow the major NCSTAR section and chapter headings of the report. When possible, our comments will refer to specific sections of the NIST study to make sure we have correlated our responses to the recommendations, findings or supplemental information contained within the report. In most cases, NFPA's comments may be as simple as agreeing with the recommendation or finding, agreeing with the recommendation or finding in principle or in some cases, disagreeing with the recommendation or finding. Regardless of our comments on the report, NFPA plans to fully consider the depth and breadth of all of the recommendations in future revision cycles of the relevant NFPA codes and standards, research programs or public education programs and instruction efforts.

SUMMARY

NFPA's Initial Reactions and Comments

The draft report by NIST on 23 June 2005 is what NFPA believes is a very thorough, technical, scientific study of any building loss investigation ever conducted. This report, the second issued under the authority of the National Construction Safety Team Act (NCST), shows that NIST takes its responsibility under the NCST seriously and that NIST is committed, not only to providing a high level of scientific data, but also to providing a set of recommendations for future consideration to codes and standards developers as well. Additionally, NFPA is pleased to see the work effort of NIST resulting in positions on many controversial and sometimes, unpopular subjects. The need to conduct more research in numerous areas is quite clear. In addition, the need to parse the recommendations that may only be appropriate for a September 11, 2001 attack (or similar extreme event) versus lower magnitude events that may have severe consequences is an important distinction.

As NFPA noted in our comments for The Station nightclub investigation: *"The quality, quantity, and depth of information provided in this draft report are indicative of the resources, both human and financial, that NIST has committed to this effort. By this example, NIST has also set a high standard of performance for the future of such building loss investigations."* is positively true. The WTC study is unprecedented and shows the scientific resources and talent that NIST has at its disposal.

The reports and recommendations released by NIST represent a great first step in setting an agenda for high-rise building design and construction as well as for other structures that may benefit from such technological changes. The 30 recommendations vary greatly in their complexity, ease of integration into codes and standards, or practice and in some cases, their ability to definitively make a difference in some realm or range of building design hazard. Some of the recommendations should be considered for implementation sooner rather than later; other recommendations will require further study, debate and elaboration; and some others may never realize implementation. In determining what changes go where, and when, consideration should be given to preparing guides or recommended practice documents. Such design options can then be used when deemed necessary by a designer or a government entity on select, but not all projects.

NFPA plans to take full advantage of the effort by NIST. NFPA's efforts will be multi-faceted and will cover many projects, programs and activities within NFPA. In addition, NFPA will also work with collaborators on certain recommendations. In particular, those that may specifically signal the need for more study, more research, or areas where NFPA can interact with some of our allied organizations or constituents. NFPA staff members have already identified areas where our technical committees, membership sections, public education programs, or some combination thereof, can serve as change agents for the subjects determined to be appropriate for change.

Following the release of the final report, NFPA staff will:

a. Review the report recommendations to determine the best course of action for each, within the NFPA codes and standards process or in other research or education areas within NFPA
b. Determine the status of each recommendation within NFPA's activities (Some have already been acted on; some are in process; some are not yet developed where NFPA has a clear position.)
c. Develop a schedule, specifying priorities, for actions on the recommendations

Once the final report is released, a continuing review of the 30 recommendations including the practicality or impracticality of each, the extent to which the recommendation is justified or defined, and the best approach to integrate the recommendation, if feasible, into practice now needs to be the focus of building owners, designers, contractors and code organizations in the coming years.

NFPA's response to this effort to date has primarily been based on NFPA staff input along with some preliminary input from the NFPA High Rise Building Safety Advisory Committee (HRBSAC) and the Disability Access Review and Advisory Committee (DARAC).

NFPA COMMENTS ON THE RECOMMENDATIONS

NFPA has addressed the substance of the NIST report in three ways. First, we have laid out a broad reaction and response to the 30 recommendations. This section provides input and response to NIST and also notes what NFPA committee projects or programs are likely to be asked to look at the details of the related recommendations.

The second part of our response provides comments directly on several of the NCSTAR documents. This portion identifies changes that we believe need to be made to clarify, revise or correct in the final report from NIST.

The third and final section of our comments relates to the methodology used in developing the causal model of the evacuation that is discussed in Appendix C of NCSTAR 1-7.

NFPA'S INITIAL COMMENTS AND REACTIONS

The following are the basic recommendations from NIST and NFPA's initial comment and reaction to the 8 subject groups and 30 recommendations.

Group 1. Increased Structural Integrity

The standards for estimating the load effects of potential hazards (e.g., progressive collapse, wind) and the design of structural systems to mitigate the effects of those hazards should be improved to enhance structural integrity.

Recommendation 1. NIST recommends that: (1) progressive collapse should be prevented in buildings through the development and nationwide adoption of consensus standards and code provisions, along with the tools and guidelines needed for their use in practice; and (2) a standard methodology should be developed—supported by analytical design tools and practical design guidance—to reliably predict the potential for complex failures in structural systems subjected to multiple hazards.

NFPA Comment: This recommendation will need further discussion and debate as it does not stipulate the extent of the multiple hazards to be considered, what load conditions should be assumed, what percentage of load path members would be assumed to be unavailable, and on how many floors those members would be missing.

NFPA believes that progressive collapse should be prevented and that it ultimately should be addressed by building regulations and design methods. However, the concept deserves further study. A clear delineation between what is defined as progressive collapse versus disproportionate collapse must be established and plainly defined.

The degree to which progressive collapse can be addressed is dependent upon the threat/hazard to be considered. Most scenarios would dictate that a progressive collapse of a building would be initiated by a substantial event such as an explosion rather than the type of events considered by current codes. The techniques used to protect against progressive collapse also need to be further analyzed. Mitigation techniques may need to consider more than just the loss of a single column or load path. Additionally, the impact of any potential solutions on other design objectives also needs to be thoroughly considered. This recommendation is of the type that may only be needed to be considered for select icon or symbolic buildings. Any such collapse scenarios, and their associated designs would require a comprehensive risk analysis to better identify the threat/hazard to be protected against. NFPA further believes that the collection of existing data on the hazard level with respect to progressive collapse is needed, and that other kinds of data such as that which shows how many deaths have resulted from disproportionate collapse also needs to be collected. Policy wise, organizations such as the Structural Engineering Institute of ASCE and the National Council of Structural Engineering Associations (NCSEA) should be tasked with development of key guidelines or manuals to address this concept.

NFPA PROJECTS: Technical Committee on Fundamentals (BLD-FUN); Technical Committee on Structures and Construction (BLD-STR); Technical Committee on Building Construction (BLD-BLC).

Recommendation 2. NIST recommends that nationally accepted performance standards be developed for: (1) conducting wind tunnel testing of prototype structures based on sound technical methods that result in repeatable and reproducible results among testing laboratories; and (2) estimating wind loads and their effects on tall buildings for use in design, based on wind tunnel testing data and directional wind speed data.

NFPA Comment: Comparing state of the practice from 1964 to the tools available in 2002 does not seem to be a fair judgment. Such tools are available and have been in use for decades. This recommendation would seem to be asking for refinement of these tools, but not a mandate to use them. Policy wise, organizations such as the Structural Engineering Institute of ASCE and the National Council of Structural Engineering Associations (NCSEA) should be tasked with development of key guidelines or manuals to address this concept.

NFPA PROJECTS: Technical Committee on Structures and Construction (BLD-STR);

Recommendation 3. NIST recommends that an appropriate criterion should be developed and implemented to enhance the performance of tall buildings by limiting how much they sway under lateral load design conditions (e.g., winds and earthquakes).

NFPA Comment: It would appear that the drift limit criteria associated with seismic design already exists to address this recommendation. Serviceability criteria also would seem to drive this limitation more than wind or seismic design. There is no immediate evidence that something is amiss within this area of tall building deign. Policy wise, organizations such as the Structural Engineering Institute of ASCE and the National Council of Structural Engineering Associations (NCSEA) should be tasked with development of key guidelines or manuals to address this concept.

NFPA PROJECTS: Technical Committee on Structures and Construction

Group 2. Enhanced Fire Resistance of Structures

The procedures and practices used to ensure the fire resistance of structures should be enhanced by improving the technical basis for construction classifications and fire resistance ratings, improving the technical basis for standard fire resistance testing methods, use of the "structural frame" approach to fire resistance ratings, and developing

in-service performance requirements and conformance criteria for spray-applied fire resistive materials.

<u>Recommendation 4.</u> NIST recommends evaluating, and where needed improving, the technical basis for determining appropriate construction classification and fire rating requirements (especially for tall buildings greater than 20 stories in height)—and making related code changes now as much as possible—by explicitly considering factors including:
• timely access by emergency responders and full evacuation of occupants, or the time required for burnout without local collapse;
• the extent to which redundancy in active fire protection (sprinkler and standpipe, fire alarm, and smoke management) systems should be credited for occupant life safety;
• the need for redundancy in fire protection systems that are critical to structural integrity;
• the ability of the structure and local floor systems to withstand a maximum credible fire scenario without collapse, recognizing that sprinklers could be compromised, not operational, or non-existent;
• compartmentation requirements (e.g., 12,000 ft^2) to protect the structure, including fire rated doors and automatic enclosures, and limiting air supply (e.g., thermally resistant window assemblies) to retard fire spread in buildings with large, open floor plans;
• the impact of spaces containing unusually large fuel concentrations for the expected occupancy of the building; and
• the extent to which fire control systems, including suppression by automatic or manual means, should be credited as part of the prevention of fire spread.

NFPA Comment: Ideas in this recommendation are continuously under review, scrutiny and debate-and not just for tall buildings. The fact is, we have had excellent performance in high-rise building fires when the combination of passive and active features was present. The recent history of high-rise building fire that included total or near total burnout of significant parts the structure, including Meridian Plaza (1991); Parque Central (2004) Windsor Towers (2005) would suggest that we are doing much of this at present. These buildings sustained long duration fires (18 plus hours) without suffering global collapse. This recommendation can, and should, be used to determine if such sustained burnouts are acceptable, and if demolition of the structure after the event is an acceptable property, financial and economic loss.

NFPA is in general agreement with the recommendation that a more technical basis for the determination and use of construction classifications be pursued, and notes that NFPA has and continues to pursue this overall objective through its codes and standards development process. NFPA understands this comment to mean that NIST has not indicated that there is a problem with the current system of construction classification but that the current system should be based on a more technical and scientific basis.

More specifically, NFPA believes that the ultimate successful implementation of this recommendation is largely dependent upon how some of the other recommendations are addressed. For example, re-considering the determination of construction type, which is dependent upon the test method utilized to arrive at a fire resistance rating, cannot be pursued until the test protocols are evaluated, as suggested by NIST Recommendation #5. With regard to considering specific factors as identified in the bulleted items of Recommendation #4, these also cannot be properly addressed until other recommendations are considered. For instance, the timely evacuation of occupants in bullet item one would be a function of the potential use of new evacuation means such as the use of elevators as noted in recommendation #20. The very complex and interconnected issues raised by Recommendation #4 are in need of further study. Performance and reliability of automatic sprinkler systems in Recommendation 12 seems to be called into question, which will impact any changes derived from Recommendation 4. Automatic sprinkler performance has been , and continues to be excellent. A more specific research agenda and procedure in addressing this very comprehensive recommendation needs to be developed.

With regard to further categorizing tall buildings based upon height, NFPA believes that this subject deserves more immediate attention and should be specifically addressed based upon the current construction classification system, and then re-evaluated if a new approach for construction classification is developed. One suggestion that NFPA will pursue is to look at a segmentation of high rise building levels and determine if a risk indexing system may be implemented based upon a certain height category. All NFPA technical committees responsible for NFPA 101 and NFPA 5000 should provide further input as any such categorization may be occupancy dependent.

NFPA also notes that the basis for requiring a certain type of construction classification is a function of the threats/hazards to be protected against. The types of threats/hazards to be considered by building regulations and building designs need to be better quantified. NFPA's Technical Committee on Fundamentals (BLD-FUN) and NFPA's occupancy committees could provide further input in this regard.

A small, but important point (the sixth bullet) in this recommendation is crucial and does need will require attention as it relates to location and placement of day tanks and routing of the fuel lines to emergency generators and fire pumps in all structures. NFPA agrees that consideration must be given to the impact on a building structure due to the presence of unusually large amounts of hydrocarbon fuel, such as was stored in WTC 7 for the numerous emergency generators located in WTC 7. Continuous discharge of fuel for these generator sets may have contributed to the collapse of WTC 7 once one or more of the fuel lines failed allowing the fuel to be ignited and burn unimpeded.

NFPA requirements for storage of liquid fuel inside a building for the operation of stationary engine-driven or stationary turbine-driven equipment (e.g., fire pumps, electric generators) are contained in Chapters 6, Fuel Supply – Liquid, of NFPA 37-2002, *Standard for the Installation and Use of Stationary Combustion Engines and Gas Turbines.* The requirements are similar but not identical to the requirements in the Building Code of the City of New York (BCNYC).

Several issues identified in Chapter 12 of NCSTAR 1-1 need to be considered and studied by NFPA's Technical Committee on Internal Combustion Engines, including but not limited to the following:

- Maximum fuel storage capacity allowed unenclosed, i.e., not in a dedicated enclosure. This includes so-called base tanks and day tanks.

- Maximum fuel storage capacity allowed in dedicated fire-rated enclosures and the required fire resistance of the enclosure walls, floor, and ceiling.

- Need for active fire suppression systems designed for the quantity of fuel present.

- Need for specific protection requirements for fuel piping leading from lower floor storage tanks to upper floor stationary engines. (NOTE: NFPA 37 simply refers to NFPA 30-2003, *Flammable and Combustible Liquids Code*, for piping design and installation. NFPA 30 does not contain specific requirements that fuel piping in a building be contained within a dedicated shaft.)

- Need for specific piping system components to shut down fuel supply pumps if a break in the piping occurs.

NFPA 37 is currently being revised and the next edition is scheduled for publication in the first Quarter, 2006. The Technical Committee on Internal Combustion Engines will address these issues during the next document revision cycle.

As with other recommendations, NFPA notes that this recommendation and its associated bulleted items calls for the greater use and application of risk and hazard analyses for building design, and that the factors identified by NIST in the recommendation be considered in these analyses. Many of the tools and data needed to properly conduct this risk evaluation might not be available at present thus presenting some unique challenges as this effort moves forward.

NFPA understands that the bulleted items are intended to serve as factors which might or should be considered in the determination and use of construction types, and that the bulleted items are not intended to serve as stand alone recommendations.

NFPA views these recommendations as long term objectives which will result in a more technical and scientific basis for building regulations.

NFPA PROJECTS: All Technical Committees responsible for NFPA 101 and NFPA 5000 (BLD-AAC, SAF-AAC) ;Technical Committee on Flammable and Combustible Liquids (FLC-AAC); Technical Committee on Emergency Power Supplies (EPS-AAA); Technical Committee on Internal Combustion Engines (INT-AAA).

<u>Recommendation 5.</u> NIST recommends that the technical basis for the century-old standard for fire resistance testing of components, assemblies, and systems should be improved through a national effort. Necessary guidance also should be developed for extrapolating the results of tested assemblies to prototypical building systems.

NFPA Comment: While the test protocols have been used for a very long time, there is nothing striking or remarkably wrong with the tests. The third bullet item under Part a. has been a focal point of the AISC Fire Engineering Committee since May of 2001. In other cases, the need to evaluate construction assemblies under simulated load conditions has also been in discussion. A review of the NFPA 251/ASTM E119/ UL 263 time-temperature curve in comparison to the data that has been collected in real world laboratory fires is reasonable to determine if these test protocols should be modified.

NFPA is in agreement with this recommendation for improving the technical basis for determining fire resistance ratings. NFPA notes that pursuing this recommendation might result in less fireproofing in some instances and more fireproofing in other cases as the current test procedure (NFPA 251/ ASTM E119/UL 263) is considered by many to be conservative on a macro scale even though it does not completely address details such as connection methods. The implementation of this recommendation will require further study and additional research. As a part of the evaluation of these test procedures, a joint effort by NFPA, ASTM and UL will be proposed by the Fire Protection Research Foundation (FPRF) to study the issues, the similarities and the differences between the test protocols versus actual fires and relevant ISO standards to determine if the test protocols need to be or should be changed.

NFPA PROJECTS: Technical Committee on Fire Protection Features (BLD-FIR); Technical Committee on Fire Tests (FIR-AAA); Fire Protection Research Foundation.

<u>Recommendation 6.</u> NIST recommends the development of criteria, test methods, and standards: (1) for the in-service performance of spray-applied fire resistive materials (SFRM, also commonly referred to as fireproofing or insulation) used to protect structural components; and (2) to ensure that these materials, as-installed, conform to conditions in tests used to establish the fire resistance rating of components, assemblies, and systems.

NFPA Comment: Quality control associated with field preparation and application of SFRM is a legitimate concern. Firestop Contractors International Association (FCIA) has initiated work on standards and procedures to address this particular need. These standards, once completed, should be recognized and adopted by models codes and standards. The life of use issue associated with SFRM is also critical. Inspection procedures, on site repair and environmental exposure are all key factors in determining the effectiveness of the material.

NFPA is in agreement with this recommendation to improve the overall performance of SFRM. Further, it is noted that in addition to the specific items listed in the recommendation, particular attention should be given to the application of fireproofing on all structural shapes and sizes. Fire service representatives on NFPA's HRBSAC expressed specific concern with regard to small diameter structural elements such as bar joists. SFRM standards from organization such as FCIA and AWCI should be reviewed for reference by NFPA 5000 and NFPA 101. A need to address the appropriate criteria for abrasion, vibration, shock and impact of SFRM under expected service conditions also exists. Enforcement of the integrity of SFRM throughout the life of the building also needs to be addressed by this recommendation.

NFPA PROJECTS: Technical Committee on Fire Protection Features (BLD-FIR); Technical Committee on Fire Tests (FIR-AAA); Technical Committee on Structures and Construction (BLD-STR); Technical Committee on Building Construction (BLD-BLC); Technical Committee on Fire Prevention Code (UFC-AAA).

Recommendation 7. NIST recommends the nationwide adoption and use of the "structural frame" approach to fire resistance ratings.

NFPA Comment: This approach, now recognized in both model building codes, simply addresses the potential for a "weakest link". While the basis of the recommendation is now addressed in the 2006 edition of NFPA 5000, the term "structural frame" should be better defined for future editions of the model codes. For example, is the term to include the full load path of all structural members? Thermal failure of a beam or girder connected to a main support column carrying a gravity load-and that is essential to the stability of the structure-can impact the load path. This recommendation only addresses that particular scenario.

NFPA PROJECTS: Technical Committee on Structures and Construction (BLD-STR); Technical Committee on Building Construction (BLD-BLC); Technical Committee on Fire Tests (FIR-AAA).

Group 3. New Methods for Fire Resistance Design of Structures

The procedures and practices used in the fire resistance design of structures should be enhanced by requiring an objective that uncontrolled fires result in burnout without local or global collapse. Performance-based methods are an alternative to prescriptive design methods. This effort should include the development and evaluation of new fire resistive coating materials and technologies and evaluation of the fire performance of conventional and high-performance structural materials. Technical and standards barriers to the introduction of new materials and technologies should be eliminated.

Recommendation 8. NIST recommends that the fire resistance of structures should be enhanced by requiring a performance objective that uncontrolled building fires result in burnout without local or global collapse.

NFPA Comment: This recommendation lumps two very different outcomes together-that being total burnout without local or global collapse. The fire events noted in Recommendation 4 did result in local, but not global collapse. The design level of preventing local collapse during a total burnout does not appear to be realistic unless the current cadre of expected fire scenarios are enhanced and made substantially more conservative. This would result in system redundancies and robustness that will LIKELY be difficult to justify from an economic and experiential point of view. Global collapse from a typical or anticipated fire event is certainly an unwanted outcome-but such cases simply do not exist for the high-rise building environment. NFPA suggests that this recommendation be parsed to separately address local collapse (which seems more acceptable) from global collapse (which seems wholly unacceptable)

A need exists to better define what is meant by "uncontrolled building fires". Is it intended that this term include only those types of fires already addressed by building and fire regulations, or is it to include other threats/hazards such as hostile acts and explosions? NFPA notes that where building collapses have occurred as a result of fire, the failures were primarily a result of the inadequate application of code mandated provisions and maintenance of fire protection features rather than from any shortcoming associated with building regulations or design methods.

NFPA PROJECTS: Technical Committees on Structures and Construction (BLD-STR), Technical Committees on Building Construction (BLD-BLC); Technical Committee on Fundamentals (BLD-FUN); Technical Committee on Fire Risk Assessment Methods (FIR-AAA)

Recommendation 9. NIST recommends the development of: (1) performance-based standards and code provisions, as an alternative to current prescriptive design methods, to enable the design and retrofit of structures to resist real building fire conditions, including their ability to achieve the performance objective of burnout without structural or local floor collapse: and (2) the tools, guidelines, and test methods necessary to evaluate the fire performance of the structure as a whole system.

NFPA Comment: Performance Based Design (PBD) methods already exist in NFPA 1, NFPA 101 and NFPA 5000. These can be applied equally to new construction or existing buildings. The same discussion with respect to local and global collapse (Recommendation 8) also applies here. PBD will also have to be measured against prescriptive design to assure it is not providing a lower level of performance in any manner.

NFPA believes that ongoing efforts are needed in the development of tools, data and training for the better implementation of performance-based design methods.

NFPA PROJECTS: Technical Committee on Fundamentals (BLD-FUN).

Recommendation 10. NIST recommends the development and evaluation of new fire resistive coating materials, systems, and technologies with significantly enhanced performance and durability to provide protection following major events.

NFPA Comment: This recommendation should not be de-coupled from recommendation No. 6. There are no technical barriers that NFPA is aware of to such systems or materials and NFPA agrees with this recommendation that new building materials be evaluated for their fire resistant characteristics. The testing and listing laboratories such as UL, FM Global, Omega Point and Southwest have the ability to test innovative materials.

NFPA PROJECTS: Technical Committee on Fire Tests (FIZ-AAA); Technical Committee on Building Construction (BLD-BLC).

<u>Recommendation 11.</u> NIST recommends that the performance and suitability of advanced structural steel, reinforced and pre-stressed concrete, and other high-performance material systems should be evaluated for use under conditions expected in building fires.

NFPA Comment: Use of material such as fire resistive steel (FRS), concrete filled tube (CFT) and use of similar existing innovations (water filled tube WFT) have the potential to become more mainstream. Provided any of the materials or composites provides the same or higher level of protection than the current offering of construction materials, such options should be considered and more fully developed. NFPA comments on Recommendation 10 also apply here.

NFPA PROJECTS: Technical Committee on Fire Tests (FIZ-AAA); Technical Committee on Building Construction (BLD-BLC); Fire Protection Research Foundation

Group 4. Improved Active Fire Protection

Active fire protection systems (i.e., sprinklers, standpipes/hoses, fire alarms, and smoke management systems) should be enhanced through improvements to design, performance, reliability, and redundancy of such systems.

<u>Recommendation 12.</u> NIST recommends that the performance and redundancy of active fire protection systems (sprinklers, standpipes/hoses, fire alarms, and smoke management systems) in buildings should be enhanced to accommodate the greater risks associated with increasing building height and population, increased use of open spaces, available compartmentation, high-risk building activities, fire department response limits, transient fuel loads, and higher threat profile.

NFPA Comment: This recommendation should be broken down into a broader category-namely to look at various risks associated with various segments of tall buildings. While the recommendations are appropriate to look at, other parts of the report only seem to focus on a 20 story differentiation. Consideration of a schedule for high rise buildings (perhaps 4 or 5 categories-see NFPA comments on related subject in Recommendation 4) would be more appropriate. The taller the building, i.e. the greater the perceived risk , construction features and systems with added redundancies or robustness of systems could be increased in some manner.

A means for better understanding and quantifying the impact, performance and reliability of fire protection systems should be pursued. A distinction should also be emphasized between enhancing the effectiveness of such systems and evaluating their appropriateness with respect to specific hazards/threats.

One starting point to consider, revolves around the CTBUH *Building Enhancement Guidelines*. These guidelines, released in May of 2002 provide potential augmentation features that could be applied to increase the reliability of certain building systems and features. In this realm, the systems would be enhanced or hardened to be able to manage certain design hazards that are normally not contemplated in codes. The NFPA HRBSAC is considering a concept (modeled on the LEEDS system) that would provide a point score system for certain system features or enhancements that are best described as "code-plus" designs. Work in this area will likely be in collaboration with NIST and CIB.

It should be noted that the Technical Correlating Committee for the National Electrical Code (NEC) has established a task group to specifically look at the hazard scenarios identified by DHS and to determine what (and where) enhancements to building electrical services could be made to increase the reliability/robustness of such systems.

NFPA PROJECTS: Technical Correlating Committee on Automatic Sprinklers (AUT-AAC); Technical Committee on Fire Pumps (FIM-AAA); Technical Committee on Standpipes (SPI-AAA); Technical Correlating Committee on Signaling Systems for the Protection of Life and Property (SIG-AAC); Technical Correlating Committee on National Electrical Code (NEC-AAC); Technical Committee on Emergency Power Supplies (EPS-AAA); Technical Committee on Smoke Management Systems (SMO-AAA).

Recommendation 13. NIST recommends that fire alarm and communications systems in buildings should be developed to provide continuous, reliable, and accurate information on the status of life safety conditions at a level of detail sufficient to manage the evacuation process in building fire emergencies, and that standards for their performance be developed.

NFPA Comment: Timelines of accurate information for the occupants during large scale building emergencies is of crucial importance. The hardware and software necessary to achieve this is available. Knowing when to give direction, and what direction to give is of paramount importance. This recommendation is closely aligned with Recommendation 16 and 19.

NFPA PROJECTS: Technical Correlating Committee on Signaling Systems for the Protection of Life and Property (SIG-AAC).

Recommendation 14. NIST recommends that control panels at fire/emergency command stations in buildings should be adapted to accept and interpret a larger quantity of more reliable information from the active fire protection systems that provide tactical decision aids to fireground commanders, including water flow rates from pressure and flow measurement devices, and that standards for their performance be developed.

NFPA Comment: The benefit of having flow rate data available at the command center is not obvious. What other information was being considered when this recommendation was being drafted?

NFPA PROJECTS: Technical Correlating Committee on Signaling Systems for the Protection of Life and Property (SIG-AAC); Technical Correlating Committee on

Automatic Sprinklers (AUT-AAC); Technical Committee on Fire Service Occupational Safety (FIX-AAA).

<u>Recommendation 15.</u> **NIST recommends that systems should be developed and implemented for: (1) real-time off-site secure transmission of valuable information from fire alarm and other monitored building systems for use by emergency responders, at any location, to enhance situational awareness and response decisions and maintain safe and efficient operations[32]; and (2) preservation of that information either off-site or in a black box that will survive a fire or other building failure for purposes of subsequent investigations and analysis. Standards for the performance of such systems should be developed, and their use should be required.**

NFPA Comment: Alarm transmission information is routinely backed up and available at central station monitoring facilities. If the only purpose for having this is for event reconstruction, such data already exists in most cases. If it is for use during an event, a point of information overload may be reached. Under some circumstances, too much information becomes less than useful. NIST should particularly pay attention to comments from fire department personnel and OEM managers on this recommendation.

NFPA PROJECTS: Technical Correlating Committee on Signaling Systems for the Protection of Life and Property (SIG-AAC); Technical Committee on Fire Service Occupational Safety (FIX-AAA).

<u>Group 5. Improved Building Evacuation</u>

Building evacuation should be improved to include system designs that facilitate safe and rapid egress, methods for ensuring clear and timely emergency communications to occupants, better occupant preparedness for evacuation during emergencies, and incorporation of appropriate egress technologies.

<u>Recommendation 16.</u> **NIST recommends that public agencies, non-profit organizations concerned with building and fire safety, and building owners and managers should develop and carry out public education campaigns, jointly and on a nationwide scale, to improve building occupants' preparedness for evacuation in case of building emergencies.**

NFPA Comment: This type of action should have been standard protocol pre September 11. High rise building evacuation is a complex subject and while partial relocation of occupants is still the preferred method, we now know that:
A. It may not always be the preference of the occupant;
B. Some building events-fire, power failure, bomb threat-require special approaches, and a full building evacuation may be needed.

At present, NFPA does offer guidelines, both in pamphlet form and on the NFPA website concerning evacuation protocols from high rise buildings. NFPA will pursue the development of additional education programs in this regard and establish cooperative agreements with other organization that have similar interests (BOMA, CTBUH, GSA, ULI). In all cases, any such programs or educational initiatives must be inclusive of persons with all manner of disabilities. See related item in Recommendation 20.

NFPA PROJECTS: Technical Correlating Committee on Safety to Life (SAF-AAC); Technical Committee on Fire Prevention Code (UFC-AAA); Public Education Section; DARAC.

Recommendation 17. **NIST recommends that tall buildings should be designed to accommodate timely full building evacuation of occupants due to building-specific or large-scale emergencies such as widespread power outages, major earthquakes, tornadoes, hurricanes without sufficient advanced warning, fires, accidental explosions, and terrorist attack. Building size, population, function, and iconic status should be taken into account in designing the egress system. Stairwell and exit capacity should be adequate to accommodate counter flow due to emergency access by responders.**

NFPA Comment: Full building evacuation concepts are an important consideration, but should not be viewed as the preferred or optimum choice for a tall building. Width of stairs in high rise buildings has been a discussion topic for decades, not years. While the concept of sizing the stairs for the largest floor population is workable for typical or expected scenarios, there are definitive concerns for mass evacuation of the building coupled with issues of counter-flow by first responders. The 2006 editions of NFPA 101 and NFPA 5000 include a new stair width design concept that incorporates cumulative population use of the stairs. An aggregate of the floor populations will trigger an increase in stair width (from 44 inches to 56 inches) where 2000 or more occupants are expected to use a given stair.

NFPA does believe that a better understanding of the evacuation and egress of building occupants is necessary. Data and methods need to be further developed to help understand occupant behavior and to determine the length of time needed to evacuate building occupants. Scenarios should include various types of evacuation such as partial evacuation or relocation concepts, full evacuation, defend in place concepts, use of elevators, escape devices, and other alternate means of escape. Availability and reduction of egress routes should be also considered. NFPA notes that the term "timely" is largely a function of the threat/hazard to be considered and is likely to require risk analysis. Building-specific and large-scale emergencies need to be quantified. It should also be recognized that rapid evacuation of all building occupants could place them in greater danger. The effect of evacuation planning and drills should be quantified, and efforts in limiting the number of trips and falls should also be pursued.

NFPA PROJECTS: Technical Committee on Means of Egress (BLD/SAF-MEA); Technical Correlating Committee on Signaling Systems for the Protection of Life and Property (SIG-AAC); Technical Committee on Fire Service Occupational Safety (FIX-AAA); Research Section; Fire Service Section, Public Education Section.

Recommendation 18. **NIST recommends that egress systems should be designed: (1) to maximize remoteness of egress components (i.e., stairs, elevators, exits) without negatively impacting the average travel distance; (2) to maintain their functional integrity and survivability under foreseeable building-specific or large-scale emergencies; and (3) with**

consistent layouts, standard signage, and guidance so that systems become intuitive and obvious to building occupants during evacuations.

NFPA Comment: This recommendation is disconcerting in that it introduces a major assumption of a 'large scale' emergency, yet states in item b. this is not an aircraft impact. What event(s) would fit into this category? The recommendation also attempts to sweep into it design of other systems and features such as elevators. NFPA recommends that the subject in Recommendation 18 regarding "large scale" emergency be removed from the list and described as a separate point of philosophical discussion. The on-going debate about whether building regulations should address events associated with normal building hazards, or more extreme events such as hostile acts and explosions will have to be settled first before consensus is reached on this subject.

NFPA agrees with that part of the recommendation regarding consistent layout and signage and the use of features that will make the egress system more intuitive. NFPA 72, *National Fire Alarm Code*, has accepted a series of proposals for the 2007 edition that will introduce the concept of *Exit Marking Audible Notification Appliances*. Such components have the ability to direct occupants by sound to the exit locations.

NFPA also agree that remoteness of exits should be studied, as current remoteness provisions might not be adequate for other than fire events. Areas that NFPA Technical Committees will study include concepts of a more robust building core, or more robust stair construction and the reduction of remoteness of exits in sprinklered buildings.

NFPA PROJECTS: Technical Committee on Means of Egress (BLD/SAF-MEA); Technical Correlating Committee on Signaling Systems for the Protection of Life and Property (SIG-AAC).

Recommendation 19. NIST recommends that building owners, managers, and emergency responders develop a joint plan and take steps to ensure that accurate emergency information is communicated in a timely manner to enhance the situational awareness of building occupants and emergency responders affected by an event. This should be accomplished through better coordination of information among different emergency responder groups, efficient sharing of that information among building occupants and emergency responders, more robust design of emergency public address systems, improved emergency responder communication systems, and use of the Emergency Broadcast System (now known as the Integrated Public Alert and Warning System) and Community Emergency Alert Networks.

NFPA Comment: This subject closely aligns with Recommendation 13. Similar technologies are deployed at the US Capitol complex to provide an alert status to the approximately 30,000 staff, occupants and visitors who may be present on a given day. Recent work underway at NFPA, and that was initiated at the request of the US Air Fore on Mass Notification systems will help to codify and standardize some of these protocols.

NFPA PROJECTS: Technical Correlating Committee on Signaling Systems for the Protection of Life and Property (SIG-AAC); Technical Committee on Building Systems (BLD-SYS); Fire Service Section; Public Education Section; Metro Chiefs.

<u>Recommendation 20.</u> NIST recommends that the full range of current and next generation evacuation technologies should be evaluated for future use, including protected/hardened elevators, exterior escape devices, and stairwell navigation devices, which may allow all occupants an equal opportunity for evacuation and facilitate emergency response access.

NFPA Comment: This subject was part of the theme at a NIST sponsored workshop in 2004. Recommendation 21 on elevator use is going to happen sooner rather than later. Last resort escape devices are gaining some recognition and use, but integration of such devices into the built environment must be carefully managed. And there can be no expectation, however, that current technologies will have an impact on September 11 type events.

The term "stairway descent devices" has been used in NFPA 101 and NFPA 5000, and it is recommended that NIST use the same terminology in lieu of stairwell navigation devices.

NFPA PROJECTS: Technical Committee on Means of Egress (BLD/SAF-MEA); Technical Committee on Building Systems (BLD-SYS); DARAC; Public Education Section.

Group 6. Improved Emergency Response

Technologies and procedures for emergency response should be improved to enable better access to buildings, response operations, emergency communications, and command and control in large scale emergencies.

<u>Recommendation 21.</u> NIST recommends the installation of fire-protected and structurally hardened elevators to improve emergency response activities in tall buildings by providing timely emergency access to responders and allowing evacuation of mobility-impaired building occupants. Such elevators should be installed for exclusive use by emergency responders during emergencies. In tall buildings, consideration also should be given to installing such elevators for use by all occupants.

NFPA Comment: Broad use of elevators well into a building fire or other emergency event will offer a means of attaining a more timely evacuation of very tall buildings as noted in Recommendation 17. Work in this particular area is likely within three years of completion and implementation. If possible, NIST and ASME should fast track this particular project so as to allow the hardened elevator concept to be realized sooner if possible.

The effort being organized by NIST and ASME is of crucial importance to ensure that current technology (both hardware and software) can adequately address the associated safety, functional and operational concerns with using the elevators as described. In particular, concerns with elevator shunt trips, the filling of shafts with smoke, the operation of equipment under adverse conditions such as when wet from fire suppression operations or systems and the need to provide direction to the occupants must be addressed.

A dedicated use elevator as described only for the exclusive use of emergency responders, i.e. fire fighters is open to discussion. In some cases, on site fire ground operations in a high-rise building may take 15 to 20 minutes to commence from time of the first alarm. If a goal truly is to strive for timely evacuation, this is a significant portion of time where the elevators may be in recall mode and are not being utilized. Keeping elevators available for use by building occupants, or at least building occupants with mobility impairments, during this time period, vastly improves the chances of meeting Recommendations 17 and 21.

NFPA suggests that the use elevators should be as a minimum, under exclusive authority of the fire service and other first responders such as fire wardens, security personnel and other authorized on site personnel who may be adequately trained to use the elevator. Ideally, use of the elevators by the occupants should be a longer term goal to strive for. In particular, anything that can be done allow mobility impaired occupants access and use of the elevators under emergency conditions should be pursued as quickly as possible.

Structurally hardened (properly protected) elevators also need to be further defined as well as the threats/hazards to be considered. The CTBUH *Emergency Evacuation Elevator Systems Guideline* (September 2004) provides a definitive starting point for elevator evacuation concepts.

NFPA PROJECTS: Technical Committee on Means of Egress (BLD/SAF-MEA); Technical Committee on Building Systems (BLD-SYS); Technical Committee on Uniform Fire Code (UFC-AAA); Technical Committee on Fire Service Occupational Safety (FIX-AAA); DARAC; Public Education Section; Fire Service Section; Metro Chiefs.

<u>Recommendation 22.</u> NIST recommends the installation, inspection, and testing of emergency communications systems, radio communications, and associated operating protocols to ensure that the systems and protocols: (1) are effective for large-scale emergencies in buildings with challenging radio frequency propagation environments; and (2) can be used to identify, locate, and track emergency responders within indoor building environments and in the field.

NFPA Comment: First responder communication systems must be robust enough to allow uninterrupted, reliable communication between fire, police and OEM officials for all building emergencies and not just the large scale event mentioned. The particular problem of needing reliable and dependable communication systems that work from inside of any building environment to both internal and external locations is crucial.

NFPA PROJECTS: Technical Committee on Fire and Emergency Service Organization and Deployment — Career (ESR-AAA); Technical Committee on Fire and Emergency Service Organization and Deployment — Volunteer ;Technical Committee on Fire

Service Occupational Safety (FIX-AAA) ; Technical Correlating Committee on Signaling Systems for the Protection of Life and Property (SIG-AAC); Technical Committee on Public Emergency Service Communication (PUF-AAA); National Electrical Code Committee (NEC-AAC);Fire Service Section; Metro Chiefs.

Recommendation 23. NIST recommends the establishment and implementation of detailed procedures and methods for gathering, processing, and delivering critical information through integration of relevant voice, video, graphical, and written data to enhance the situational awareness of all emergency responders. An information intelligence sector should be established to coordinate the effort for each incident.

NFPA Comment: Related to Recommendations 15, this concept must remain manageable by that individual or sector. One concern may be too much information.

NFPA PROJECTS: Technical Committee on Fire and Emergency Service Organization and Deployment — Career (FAC-AAA); Technical Committee on Fire and Emergency Service Organization and Deployment — Volunteer (FAD-AAA); Technical Committee on Fire Service Occupational Safety (FIX-AAA) ; Technical Correlating Committee on Signaling Systems for the Protection of Life and Property (SIG-AAC); Technical Committee on Public Emergency Service Communication (PUF-AAA); Technical Committee on Pre-Incident Planning (PIP-AAA);Fire Service Section; Metro Chiefs.

Recommendation 24. NIST recommends the establishment and implementation of codes and protocols for ensuring effective and uninterrupted operation of the command and control system for large-scale building emergencies.

NFPA Comment: Circumstances by which a governmental entity establishes a command authority that is event dependent is critical. Smaller jurisdictions may have a one stop procedure-regardless of the event. Larger jurisdictions may have a complex system that has different lead agencies for different events. Such protocols should consider the event, mutual aid from surrounding jurisdictions, and thresholds for assistance from state and federal government agencies.

Jurisdictions at all levels need to develop and implement protocols that clear lines of authority are established in advance of major emergencies. The recommendations made in the report very clearly outline the steps that jurisdictions should take to improve their command and control of large-scale incidents.

NFPA PROJECTS: Technical Committee on Fire and Emergency Service Organization and Deployment — Career (FAC-AAA); Technical Committee on Fire and Emergency Service Organization and Deployment — Volunteer (FAD-AAA); Technical Committee on Fire Service Occupational Safety (FIX-AAA); Technical Committee on Public Emergency Service Communication (PUF-AAA); Technical Committee on Pre-Incident Planning (PIP-AAA); Fire Service Section; Metro Chiefs.

Group 7. Improved Procedures and Practices

The procedures and practices used in the design, construction, maintenance, and operation of buildings should be improved to include encouraging code compliance by nongovernmental and quasi-governmental entities, adoption and application of egress and sprinkler requirements in codes for existing buildings, and retention and availability of building documents over the life of a building.

Recommendation 25. Nongovernmental and quasi-governmental entities that own or lease buildings and are not subject to building and fire safety code requirements of any governmental jurisdiction are nevertheless concerned about the safety of the building occupants and the responding emergency personnel. NIST recommends that such entities should be encouraged to provide a level of safety that equals or exceeds the level of safety that would be provided by strict compliance with the code requirements of an appropriate governmental jurisdiction. To gain broad public confidence in the safety of such buildings, NIST further recommends that it is important that as-designed and as-built safety be certified by a qualified third party, independent of the building owner(s). The process should not use self-approval for code enforcement in areas including interpretation of code provisions, design approval, product acceptance, certification of the final construction, and post-occupancy inspections over the life of the buildings.

NFPA Comment: The recommendation should also extend to federal agencies as well. This recommendation is simply good practice-both business and neighbor. The terms "non-governmental and quasi-governmental" should be deleted. Additionally it should address those situations where no Authority Having Jurisdiction exists, where the local governing building regulations do not need to be adhered to by the party constructing the building, and where self-certification in the private sector occurs.

NFPA PROJECTS: Technical Committee on Fundamentals (BLD/SAF-FUN); Technical Committee on Uniform Fire Code (UFC-AAA); IFMA; AEBO Section

Recommendation 26. NIST recommends that state and local jurisdictions should adopt and aggressively enforce available provisions in building codes to ensure that egress and sprinkler requirements are met by existing buildings. Further, occupancy requirements should be modified where needed (such as when there are assembly use spaces within an office building) to meet the requirements in model building codes.

NFPA Comment: While retroactive imposition of building safety standards can be intrusive, it is none-the-less good practice. Grandfathering concepts that allow other than imminent hazards to remain in place have proven to be problematic. At first pass, this recommendation needs to be modified somewhat to distinguish between removal of grandfathering clauses and complying with requirements for new construction during renovation type projects. The thresholds' for change is quite different in these two concepts.

Certain requirements for existing buildings such as those pertaining to sprinkler protection and fire resistance should meet the same level of safety required for new construction when a renovation in contemplated. Additional regulations for existing buildings, such as those currently found in NFPA 101, should be developed and adopted. NFPA 101 does not recognize the "grandfathering concept"-instead, it mandates a minimum level of safety and performance that applies retroactively to a building. NFPA is strongly in support of the recommendation that high rise buildings be retrofitted with automatic sprinkler systems. This provision is currently a requirement of NFPA 1 and NFPA 101.

NFPA PROJECTS: Technical Committees for the Life Safety Code (SAF-AAC) and Building Code (BLD-AAC); Technical Committee on Uniform Fire Code (UFC-AAA); IFMA; AEBO Section.

Recommendation 27. **NIST recommends that building codes should incorporate a provision that requires building owners to retain documents, including supporting calculations and test data, related to building design, construction, maintenance and modifications over the entire life of the building[45]. Means should be developed for offsite storage and maintenance of the documents. In addition, NIST recommends that relevant building information should be made available in suitably designed hard copy or electronic format for use by emergency responders. Such information should be easily accessible by responders during emergencies.**

NFPA Comment: The retention of documents- including as built drawings, relevant calculations and O&M manuals is important for future modifications or work on the building. What type, and how much information should be available to first responders will be a function of the extent to which government entities adapt to items in Recommendations 15 and 23. Local issues with regard to information required by first responders, the format of the information, and how much information is necessary must also need to be addressed.

NFPA PROJECTS: Technical Committee on Fire and Emergency Service Organization and Deployment — Career (FAC-AAA); Technical Committee on Fire and Emergency Service Organization and Deployment — Volunteer (FAD-AAA); Technical Committee on Fire Service Occupational Safety (FIX-AAA); Technical Committee on Pre-Incident Planning (PIP-AAA); Fire Service Section; Metro Chiefs.

Recommendation 28. **NIST recommend that the role of the "Design Professional in Responsible Charge"[46] should be clarified to ensure that: (1) all appropriate design professionals (including, e.g., the fire protection engineer) are part of the design team providing the standard of care when designing buildings employing innovative or unusual fire safety systems[47], and (2) all appropriate design professionals (including, e.g., the structural engineer and the fire protection engineer) are part of the design team providing the standard of care when designing the structure to resist fires, in buildings that employ innovative or unusual structural and fire safety systems.**

NFPA Comment: Use of all appropriate design professionals should be integrated into this recommendation. Unusual structural design applications must be over seen by a structural engineer; unusual mechanical design applications must be overseen by a mechanical engineer. Codes should continue to advance the concept of *Design Professional in Responsible Charge*, or *Registered Design Professional*, but state licensing boards should be responsible for establishing the areas of practice for a given project.

Recommendation 29. **NIST recommends that continuing education curricula should be developed and programs should be implemented for training fire protection engineers and architects in structural engineering principles and design, and training structural engineers, architects and fire protection engineers in modern fire protection principles and technologies, including fire-resistance design of structures.**

NFPA Comment: This recommendation embraces a concept that is long overdue. In some case, fire safety needs and concerns are addressed almost as an afterthought. Fire protection engineers want to offer solutions to everyday prescriptive-based designs but also to innovative architectural designs. Likewise, it is important for the architectural community to be aware of the limits in fire protection engineering. Work among affiliated groups such as NFPA, SFPE, AIA, NCSEA and ASCE among others would help with the cross knowledge application desired by this recommendation.

NFPA PROJECTS: Professional Development Division.

Recommendation 30. **NIST recommends that academic, professional short-course, and web based training materials in the use of computational fire dynamics and thermo-structural analysis tools should be developed and delivered to strengthen the base of available technical capabilities and human resources.**

NFPA Comment: Such course offering currently exist and broader availability of these programs will help everyone to perform more concise analyses of buildings designs with respect to fire events. Work among affiliated groups such as NFPA, SFPE, AIA, NCSEA and ASCE among others would help with the cross knowledge application desired by this recommendation.

NFPA PROJECTS: Fire Science and Technology Educators Section

Subject: NFPA COMMENTS WTC STUDY
From: "Solomon, Robert" <rsolomon@NFPA.org>
To: <wtc@nist.gov>

WTC Technical Information Repository
Attention: Mr. Stephen Cauffman
National Institute of Standards and Technology
Stop 8610
Gaithersburg, MD 20899-8610

Mr. Cauffman:

Later today, you will be receiving a transmittal letter from NFPA with paper copies of our comments along with a CD. The information was sent for overnight delivery yesterday (3 August 2005). I am also emailing the comments to you as well in the enclosure.

I will also be sending you a supplemental email on two of the recommendations (25 and 26) that I didn't incorporate in the initial submission. I didn't realize that until last night.

Please contact me by email if you have any questions.

Robert Solomon, PE
National Fire Protection Association

NFPA COMMENTS TO NIST ON THE TECHNICAL INVESTIGATION OF THE WTC.doc

NFPA WTC NCSTAR INFO sorted.doc

NIST-Comments on NCSTAR 1-7 Appendix C.doc

NFPA INFO

SPECIFIC COMMENTS ON NCSTAR DOCUMENTS

REF	NCSTAR REPORT #	PAGE	PAR	COMMENT	REASON	REVISION
	1	xlvii	Third Bullet, Last Sentence	Beginning of sentence is truncated	Editorial	"Technical and standards barriers to the introduction…"
	1	8	top line	Incorrect spelling of authors name.		Rita Fahy
	1	57	Last Paragraph, 2nd to Last Sentence	Reference should be "NFPA 5000"	Editorial	"…would have satisfied NFPA 5000 requirements…"
	1	183	3rd Bullet, 2nd Sentence	Beginning of sentence is truncated	Editorial	"2001. The manually operated…"
	1	183	Section 8.4.2, 4th bullet point, 3rd sentence	Not clear	It sounds like only 11 people were below the impact point when WTC 2 collapsed.	"Eleven occupants located below the impact point in WTC 2 prior to the attack on WTC 1 were killed."
	1	184	3rd bullet point, 2nd sentence	Again here is the assumption that the group of people seen in the stairs shortly before WTC 2 collapsed had come down past the 78th floor after WTC2 was hit.	There is no basis for this assumption, and there is actually ample evidence that this is not the case.	Delete the second sentence.
	1	184	8th bullet point	It is not clear from the analysis that people on higher floors encountered more environmental cues because they started their evacuation later. Didn't they encounter more environmental cues because they were closer	The causal model does not contribute much to understanding what influenced people's experiences during the evacuation.	Explain better why experiencing cues before initiating evacuation would cause increased evacuation times. Explain why the interdependence of the variables could be ignored in the analysis.

REF	NCSTAR REPORT #	PAGE	PAR	COMMENT	REASON	REVISION
				to the impact? And did the analysis that concluded that encountering environmental cues increased their evacuation time only look at cues encountered during evacuation? Why would cues encountered before beginning evacuation cause longer delay times? Isn't it more likely that it was the distance they had to travel that increased their evacuation time?		
	1	185	7th bullet point	It says that 1,000 of the surviving occupants had a limitation. The analysis in NCSTAR 1-7 was using six percent of the building occupancy (over 16,000 people) on September 11th to come up with 1,000. Six percent of the survivors would be a number lower than 1,000.	This point is inconsistent with the analysis in NCSTAR 1-7.	"It is estimated that 1,000 of the occupants of the towers on September 11th had a limitation…."
	1	188	4th bullet point, last sentence	Says that notification that Stairwell A was passable should have been relayed. Who would have been in a position to relay that information, since	The point of this bullet item is that available information wasn't pooled and relayed to occupants. The condition of Stairwell A at the 78th floor isn't a valid example of	Delete mention of Stairwell A as an example.

REF	NCSTAR REPORT #	PAGE	PAR	COMMENT	REASON	REVISION
				emergency responders never knew? Also, the stairwell was intact, not necessarily passable.	information here since the information wasn't available to emergency responders, so it couldn't have been relayed.	
	1	193	3rd Bullet	The report states that "There were, and are, no field application and inspection requirements to ensure that the as-built condition of the passive fire protection, such as SFRM, conformed to conditions found in fire resistance tests of building components and assemblies…" This is not the case. Today, NFPA 5000, Section 40.5 requires that the registered design professional responsible for design prepare a quality assurance program for sprayed fire-resistive materials used in the building..	Inaccurate statement	"There were, and are, no field application…"
	1	201 202	Rec # 1	This is a rather substantial long term goal for the structural engineering and material standards communities that may have limited application to new buildings with a higher level of risk. The	Simply to point out the extraordinary coordination and research that will be necessary to execute this recommendation.	None.

REF	NCSTAR REPORT #	PAGE	PAR	COMMENT	REASON	REVISION
				application and design methodology will need to be developed by those communities. Once their documents have developed and integrated this methodology, it is anticipated that it will be adopted in NFPA 5000 through a mandatory reference to the latest editions of ASCE 7 and the associated material standards.		
	1	203	Rec # 2	This is a rather substantial medium term goal for the structural engineering community that may have limited application to new buildings with a higher level of risk. The application and design methodology will need to be developed by the structural engineering community as part of ASCE 7 or a new document. Once the appropriate requirements have been developed, it is anticipated that it will be adopted in NFPA 5000 through a mandatory reference to the latest	Simply to point out the extraordinary coordination and research that will be necessary to execute this recommendation.	None.

REF	NCSTAR REPORT #	PAGE	PAR	COMMENT	REASON	REVISION
				edition of ASCE 7.		
	1	203 204	Rec #3	This is a rather substantial medium term goal for the structural engineering community with application to a broad cross-section of new buildings. The requirements will need to be developed and coordinated by the structural engineering and materials communities as part of their design documents. Once the appropriate requirements have been developed, it is anticipated that it will be adopted in NFPA 5000 through a mandatory reference to the latest edition of these documents.	Simply to point out the extraordinary coordination and research that will be necessary to execute this recommendation.	None.
	1	204 205	Rec 4	This is a long term goal. Extensive research will be needed to evaluate alternative types of construction and fire ratings. In many instances, the necessary data simply is not available. Task Groups associated with the development of NFPA	Simply to point out the extraordinary coordination and research that will be necessary to execute this recommendation. Also, until a meaningful data collection method is developed, this will be a difficult challenge to overcome.	None.

REF	NCSTAR REPORT #	PAGE	PAR	COMMENT	REASON	REVISION
				5000 have tried to address these issues and have been extremely frustrated by the lack of research and data associated with construction classifications and the height and area requirements found in current model building codes. The next edition of NFPA 5000, 2006, will contain a new alternate approach to height and area requirements based upon compartmentation. principle.		
	1	204	Recommendation 4, footnote 21	Data necessary to do this sort of analysis of fire incidents is not collected.	Changes in NFIRS dropped some of the reporting necessary to do this sort of analysis for structure fires.	
	1	206	Rec 12	NFPA concurs with the recommendation of enhancing the performance of active fire protection systems to levels consistent the greater risks identified in the recommendation. With regard to fire alarm systems, based on the	The comment recognizes that reasonable designs have been accomplished based on anticipated design basis, and that the establishment performance consistent with the risk is already addressed and being given further attention.	NONE

REF	NCSTAR REPORT #	PAGE	PAR	COMMENT	REASON	REVISION
				information provided in the project report 1-4 and 1-4C, the design of the WTC 1 and WTC 2 fire alarm systems did include significant and realistic enhancements for performance and redundancy in upgrading the fire alarm system after the bombing incident in 1993. Among other things, the fire alarm circuit performance requirements appear to have used the highest performance levels (circuit styles) recognized in the National Fire Alarm Code, addressing single point failures to a significant degree. The events of September 11, 2001 go far beyond what would have been reasonable and realistically expected to be addressed in the system design. The National Fire Alarm Code already recognizes		

REF	NCSTAR REPORT #	PAGE	PAR	COMMENT	REASON	REVISION
				that the degree of performance must be determined by an evaluation of the risks. However, in recognition that greater guidance might be warranted, the need for a joint task to address performance (reliability) issues based on occupancy types and hazards has recently been identified by the NFPA Technical Correlating Committee on Signaling Systems for the Protection of Life and Property. Further the same committee has already established a task group on Mass Notification Systems and proposals have been introduce to provide guidance for these types of systems. Since fire alarm systems may be used in conjunction with events broader than just fires, the work of these task groups will likely evolve and consider a much the broader range of risks than are normally considered for		

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				fire alarm systems.		
	1	207	Rec # 7	This short term goal has actually been accomplished in the 2006 edition of NFPA 5000. NFPA 5000, Section 7.2.1.1 (2006 edition) requires that all types of rated construction be in accordance with Section 7.2.7, Fire Resistance Rating Requirements for Structural Elements. Proposal 5000-327(Log#106) was submitted by Richard Bukowski, NIST, and 'accepted in principal' by BLD-BLC. The only modification made by the committee was that the very last reference to 'columns' was originally recommended to be 'members'. Per the committee statement, the committee did not believe that a generic reference to 'members' was clear enough in intent. The section now reads: **7.2.7.2.3 Structural elements such as girders,**	Provided updated information as it is found in the 2006 edition of NFPA 5000.	Update final report to reflect this change.

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				beams, trusses, and spandrels having direct connections to columns carrying gravity loads and are essential to the stability of the building as a whole shall have a fire resistance rating not less than that of the columns to which they are connected.		
	1	207	Rec # 8	It is not clear how ASCE 7, AISC Specifications, ACI 318 would be involved in the implementation of this recommendation.	If possible, provide a more explicit explanation of the impact of the these documents.	None
	1	207	Rec # 9	This is a rather substantial long term goal for the structural engineering and material standards communities that may have limited application to new buildings with a higher level of risk. The application and design methodology will need to be developed by those communities. Once their documents have developed and integrated this methodology, it is anticipated that it will be adopted in NFPA 5000	While PBD options exist in NFPA 101 and NFPA 5000, along with specified goals and objectives, those goals and objectives would likely have to be modified to fit the performance levels described in this recommendation.	None.

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				through a mandatory reference to the latest editions of ASCE 7 and the associated material standards.		
	I	209 210	Rec 14	NFPA concurs with the concept that control panels at fire/emergency command stations in building should be adapted to provide useful information from active fire protection systems to aid responders in making tactical decisions. As in the case of Recommendation 13, the degree to which this information is needed and provided must be consistent with the needs and risks of the facility, and be established in concert with the Fire Safety Plan. In addition caution must be used regarding the extent that information is accepted and interpreted by the control panel. The possibility of misinterpretation considering the range of events that could occur	The comment recognizes that the degree of information needed for emergency responders will vary depending on the risks and hazards for each application and that evolving requirements and guidance already exist.	NONE

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				must be considered along with the added potential complexity introduced for responders. As noted in the comment for Recommendation 13, the National Fire Alarm Code already includes requirements for the design of a Standard Fire Service Interface, and guidance for Mass Notification Systems has been proposed.		
	1	209	Rec 13	NFPA concurs with the concept that fire alarm and communications systems could (and perhaps should in some cases) be developed to include information on the status of life safety conditions for the effective management and response to fire and other emergencies. It is noted that what constitutes "the status of life safety conditions" (aside from the status of active fire protection systems addressed in	The comment recognizes that the degree of information needed for emergency responders will vary depending on the risks and hazards for each application and that evolving requirements and guidance already exist.	NONE

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				recommendation 14) can be subject to a broad range of conditions depending on the facility and the events intended to be addressed. The criteria for the development of these features should be consistent with the needs and risks for a particular facility as noted in Recommendation 12. These criteria should be established in concert with the development of the facilities' Fire (Emergency) Safety Plan and consider the range of events expected to be addressed. It is noted that in the case of the WTC 1 and WTC 2 fire alarm systems the means to initiate occupant notification was achieved manually (rather than norm of automatic initiation) in accordance with the building Fire Safety Plan.		

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				The National Fire Alarm Code already includes requirements for the design of a Standard Fire Service Interface that was introduced in concept by NIST. The requirement states: "Where required by the authority having jurisdiction, annunciators, information display systems, and controls for portions of the fire alarm system provided for use by the fire service shall be designed, arranged, and located in accordance with the requirements of the organizations intended to use the equipment." Detailed guidance for the development of this interface is provided in related annex material and the industrial continues to refine this guidance. The development of guidance for Mass Notification Systems noted in the response to Recommendation 12		

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				may also play a role in the effective management and response to fire and other emergencies. With regard to need for pre-installed dedicated firefighter telephone service, a task group of the NFPA Technical Correlating Committee on Signaling Systems for the Protection of Life and Property has been established to address the subject of two-way communication service, including radio communication systems. Proposals on this subject have already been introduced for the next edition of the National Fire Alarm Code.		
	I	209	Rec 12	Add references to NFPA 14 , NFPA 20 NFPA 70, NFPA 92A, NFPA 92Band NFPA 110	These documents all contain requirements that were discussed within the specific reports. Specifically, requirements for standpipes, fire pumps and emergency power supplies.	Add references to: NFPA 14 NFPA 20 NFPA 70 NFPA 92A NFPA 92B NFPA 110
	1	210	Rec. 15	NFPA concurs with the	The comment recognizes that	NONE.

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				concept that systems could (and perhaps should in some cases) be developed to provide real-time off-site secure transmission of valuable information for emergency responders. The degree to which this information is needed and provided must be consistent with the needs and risks of the facility, and be established in concert with the Fire Safety Plan. However the need to preserve this information for subsequent investigations is more questionable, especially for the vast majority of installation. As noted in the comment for Recommendation 13, the National Fire Alarm Code already includes requirements for the design of a Standard Fire Service Interface, and guidance for Mass Notification Systems has been proposed. These	the degree of information needed for emergency responders will vary depending on the risks and hazards for each application and that evolving requirements and guidance already exist. It is not likely that the vast majority of installations would benefit from requirements for deliberate preservation of this information.	

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				systems have the potential to evolve in a manner that will facilitate the transmission of information off-site as needed for the particular application. As a consequence of the technologies used, preservation of the information may also be accomplished as a byproduct.		
	1	211	Rec 17	1. The words "to accommodate TIMELY full building evacuation of occupants" result in a recommendation that is too general to be understood and implemented. NIST should better define what it means by "tall buildings" (for example, >20 stories as used in Recommendation 4). If NIST is not able to recommend the acceptable full evacuation time for a building dependent on number of stories, it should provide guidance	1. The recommendation is not helpful. It does say whether the egress system sizing criteria of the current model codes are inadequate or what "timely" means. NIST needs to present a recommendation that can serve as a starting point for a SDO to consider. 2. It is not a reasonable use of resources to require the egress system to be designed to accommodate full building evacuation after a terrorist attack that produces an assault to the building that would be greater than that from power outages, major earthquakes, tornadoes,	NIST recommends that tall buildings ~~should~~ be designed to accommodate ~~timely~~ full building evacuation of occupants due to building-specific or large-scale emergencies such as widespread power outages, major earthquakes, tornadoes, hurricane without sufficient advanced warning, fires, and accidental explosions~~, and terrorist attack~~.

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				on the analysis needed to answer the question for a particular building. 2. If a "terrorist attack" involves an assault to the building that would be greater than that from "power outages, major earthquakes, tornadoes, hurricane without sufficient advanced warning, fires, accidental explosions," it is not reasonable to require the egress system to be sized to accommodate full building evacuation after such terrorist attack.	hurricane without sufficient advanced warning, fires, and accidental explosions. Steps need to be taken to prevent the terrorist attack at the building perimeter. If the perimeter protection is compromised, such as by a collision from an airplane, the other systems should not be expected to do anything more than can be expected from power outages, major earthquakes, tornadoes, hurricane without sufficient advanced warning, fires, and accidental explosions.	
	1	211	Rec # 17 Last sentence of main paragraph	The recommendation to accommodate counterflow for emergency responders is needed.	NFPA has codified the counterflow issue in NFPA 101-2006 and NFPA 5000-2006 by specifying the minimum widths needed for counterflow (on the stair and at the stair enclosure discharge door). Given that recommendation 17 relates mainly to full evacuation, NIST's recommendation that "stairwell and egress CAPACITY" (not just width) be increased is worth pursuing.	~~Stairwell and exit capacity~~ Stair and stair discharge door capacity should be adequate to accommodate counterflow due to emergency access by responders.

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	1	211	Rec 16, Part b	Delete ", and that elevators can be used if they are still in service and haven't been recalled or stopped."	As written, the last phrase in part (b) seems to contradict the preceding phrase, and could create confusion. The use of ordinary elevators during an emergency evacuation should be controlled or supervised and should be one of the things that evacuees would potentially be explicitly instructed to do by on-site incident commanders. If all building occupants wait for elevators, the evacuation ~~will~~ can take much longer ~~(as shown in NIST's own research)~~. If the elevators go out of service during the emergency, occupants on upper floors will not know that, and may continue to wait, jeopardizing their safety. [It is expected that a new generation of elevators will provide real-time information in the elevator lobbies on each floor as to operating status of the elevator, expected wait times, and other needed information, but today's elevators lack such features.] If the elevators are used under supervision, occupants with	Replace deleted phrase with a separate explanatory sentence that describes what those instructions might be: "In some cases, elevators (regular elevators?) can be used if they are still in service and haven't been recalled or stopped. Use of such elevators should be spelled out in the building's evacuation plans and should be restricted to those with mobility impairments or otherwise unable to use the stairs, and under the supervision of on-site incident commanders."

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					mobility impairments or otherwise unable to use the stairs can be efficiently assisted from upper floors. Evacuation of other occupants can be expedited, if the fire or building officials on scene determine that it could be done effectively. NFPA 101 requires stair signage for both new and existing stairs serving five or more stories. Roof access or the lack thereof must be designated by a sign that reads ROOF ACCESS or NO ROOF ACCESS. NFPA 5000 requires similar signage for new construction. The required signage can be used in the training recommended by NIST.	
	1	211	Recommendation 17 (b) first sentence	There will be people for whom self-evacuation will never an option.	There was a man killed on September 11th who had an electric wheelchair with a ventilator attached and was accompanied full-time by an aide. He couldn't be transferred to an evac chair. How would he ever be able to self-evacuate?	Qualify the statement – to the degree possible, mobility challenged occupants should be provided a means for self-evacuation…

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	1	212	Rec 18	The recommendation is needed.	Exit access remoteness and exit remoteness need further study. The placement of exit stairs within the core of a building should not be discounted provided an acceptable level of remoteness can be achieved. NFPA 101 and NFPA 5000 permit remoteness to be measured via what NIST refers to as the "walking path" where such path is provided by a minimum 1-hr corridor system. The NFPA provision is based on smoke and fire spread considerations. In view of the need to protect against more than fire, the method of measuring remoteness needs further study. NFPA 101 and NFPA 5000 currently credit scissor stairs as providing only one exit, but the width of scissor stairs is credited for purposes of capacity considerations. NFPA 101 and NFPA 5000 have exit and directional-exit sign provisions, as well as	None

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					requirements for special stair signage that provide both occupants and emergency responders with needed information. This is particularly important in tall buildings where the exit stairs are not normally used, and building occupants travel via elevators.	
	1	213	Rec 19	NFPA concurs with the concept of providing accurate, coordinated and timely emergency information for emergency responders and building occupants as indicated in Recommendation 19. The degree to which this information is provided must be consistent with the needs and risks of the facility, and be established in concert with the Fire Safety Plan. As noted in the comment for Recommendation 13, guidance for Mass Notification Systems has already been proposed for the National Fire	The comment recognizes that the degree of information needed will vary depending on the risks and hazards for each application and that guidance has already begun to be developed.	NONE

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				Alarm Code. Many of the features and considerations described in the recommendation have been considered in the development of the proposed guidance. This guidance is likely to be ongoing and evolve over time as the understanding of these needs matures.		
	1	214	Rec 20	The recommendation is needed, but the term "stairwell navigation devices" should be changed to "stair descent devices."	NFPA 101-2006 and NFPA 5000-2006 will offer significant guidance on the use of "stair descent devices" for moving persons with mobility impairments on stairs. The term "stair descent devices" better describes the product. A task group of ASME A17 is currently studying the feasibility of protected/hardened elevators and NFPA is participating in that effort. Once the hazard analysis portion of the project has been completed, NFPA 101 and NFPA 5000 are expected to address the associated construction	NIST recommends that the full range of current and next generation evacuation technologies ~~should~~ be evaluated for future use, including protected/hardened elevators, exterior escape devices, and ~~stairwell navigation devices~~ <u>stair descent devices</u>, which may allow all occupants an equal opportunity for evacuation and facilitate emergency response access.

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					details. Public proposals are again expected for the next revision cycles of NFPA 101 and NFPA 5000 to develop guidelines for the use of exterior escape devices (platforms, chutes, controlled-descent). ASTM E 06.77, High Rise Building External Evacuation Devices task group is developing the related product standard.	
	1	214	Rec 20	The recommendation is needed, but the term "stairwell navigation devices" should be changed to "stair descent devices."	NFPA 101-2006 and NFPA 5000-2006 will offer significant guidance on the use of "stair descent devices" for moving persons with mobility impairments on stairs. The term "stair descent devices" better describes the product. A task group of ASME A17 is currently studying the feasibility of protected/hardened elevators and NFPA is participating in that effort. Once the hazard analysis portion of the project has been completed, NFPA 101 and NFPA 5000 are expected to address the	NIST recommends that the full range of current and next generation evacuation technologies ~~should~~ be evaluated for future use, including protected/hardened elevators, exterior escape devices, and ~~stairwell navigation devices~~ stair descent devices, which may allow all occupants an equal opportunity for evacuation and facilitate emergency response access.

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					associated construction details. Public proposals are again expected for the next revision cycles of NFPA 101 and NFPA 5000 to develop guidelines for the use of exterior escape devices (platforms, chutes, controlled-descent). ASTM E 06.77, High Rise Building External Evacuation Devices task group is developing the related product standard.	
	1	214	Rec 21	The recommendation is needed, but subitem "a" should be deleted.	A task group of ASME A17 is currently studying the feasibility of protected/hardened elevators and NFPA is participating in that effort. The process is well into a comprehensive hazard analysis. Subitem "a" is inconsistent with the general nature of the overall recommendation. The entire subject needs considerable study before jumping ahead to one specific recommendation. The subitem is confusing in its use of the term "remote release of elevator cabs by	NIST recommends the installation of fire-protected and structurally hardened elevators … procedures and protocols. ~~a. The requirement for remote release of elevator cabs by emergency response personnel should be included in the ASME A17.1 Safety Code for Elevators and Escalators.~~

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					emergency personnel." Most emergency responders would object to some other emergency responder "releasing" an elevator that the first crew has taken under Phase 2 operation to a floor. Even if that is not what the recommendation's authors meant, it is best to delete the line for now until the ASME task group has completed its hazard analysis. For this recommendation it is best to keep the big picture in mind and let the details shake out as they will.	
	1	217	Rec 27.	Add reference to retention of system information which is currently required by such documents as NFPA 25.	Currently NFPA 25 requires that that the original records for the water based systems be retained for the life of the system. While the model codes may not contain these requirements the report should also recommend that the state and local jurisdictions adopt and enforce the requirements of NFPA 25.	Add reference to NFPA 25 requirements on records retention for water based fire protection systems.
	1	217	Rec # 27	This is a medium term goal with application to new, nonresidential buildings.	None	None

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	1-1	lii	Finding 7	Please clarify which United Kingdom document incorporates progressive collapse design requirements for all buildings.	Clarity.	Add document name.
	1-1	lii	Finding 8	ASTM E1996 is not an appropriate test standard for determining the structural integrity of stairway/elevator cores and, therefore, should not be mentioned.	The scope of ASTM E1996 states the following: "This specification covers exterior windows, glazed curtain walls, doors and impact protective systems used in buildings located in geographic regions that are prone to hurricanes."	Delete reference to ASTM E1996 and recommend that an appropriate test standard be developed for this situation.
	1-1	liv	Finding 14	The 2006 edition of NFPA 5000 contains this language now. See our response to NCSTAR 1, Recommendation 7.	Language needs to be updated to reflect current edition of NFPA 5000.	Update final report to reflect this change.
	1-1	142 143	Section on "Construction Classification"	The Types of Construction should be presented in Roman Numerals. Also, Type III construction is considered "ordinary"; while, Type V construction is considered "combustible".	Incorrect presentation of Types of Construction classifications. Also, Type I and Type II construction allow the inclusion of limited-combustible structural elements – they are not solely limited to noncombustible materials. Type V construction is not solely limited to traditional wood frame construction.	1. "The main categories are Type I1 (fire resistive), Type II2 (non-combustible), Type III3 (ordinarycombustible), Type IV4 (heavy timber), and Type V5 (combustibleordinary)." Modify numbers throughout the remaining section. 2. "Type IV5 is all other types of construction, including traditional wood frame construction. 3. "In some codes, these sub-

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						categories are identified by letters following the type (e.g., 1B or 3A) or by a set of three numbers that represent the fire resistance required (in hours) of the exterior bearing walls; columns, beams, girders, trusses and arches, supporting bearing walls, columns, or loads from more than one floor; and floor construction columns, beams, and floors, respectively (e.g., Type I(332) 1 [3,3,2])." 4. Comparisons between the different types of construction in the various model codes may be simplified by including the following table: (Table shown at end of comments)
	1-1	144	2nd Paragraph	Inaccurate statement – "If a building qualifies for more than one construction classification, such as Class 1A or Class 1B, all of the building codes do not say which classification should be used." NFPA 5000, Section 7.2.1.2 (2003 edition) states the	Inaccurate statement	"If a building qualifies for more than one construction classification, such as Class 1A or Class 1B, all oftmodel the building codes require only that it meet the requirements of the least type of constructiondo not say which classification should be used."

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				following: **7.2.1.2 Except as permitted by other provisions of this Code, wherever two or more types of construction are used in the same building, the entire building shall be classified as the least type of construction in the building and shall be subject to the requirements for that type.**		
	1-1	145	2ND Paragraph	Do not recognize open perimeter modifications.	Incomplete statement	"with modifications for the presence of fire sprinklers and sufficient open perimeter."
	1-1	145	2ND Paragraph	Why is only IBC quoted here? What is the purpose of introducing modern model codes here?	Section seems a bit unorganized	Include a reference to Section 8.2 of NFPA 5000.
	1-1 A	3	2nd Paragraph, 1st Sentence	Explain the difference between the "second and third" drafts of the NYCBC.	Unclear the significance of the two different drafts.	Clarify the difference.
	1-1 B	7	3rd Paragraph, 1st Sentence	Truncated word	Editorial	: "… provisions are written in terms of …."

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	1-1 F	Whole Document		Why does this report use the 2003 edition of the BCNYC, when all other reports use the 2001 NYCBC?	Inconsistent	Modify this report to reflect the requirements of the 2001 edition of the NYCBC.
	1-2 A	8	Figure 1-8	Lower right box is missing text	Editorial	Replace missing text.
	1-3	xxxvii	3rd Paragraph	The last two goals are not numbered.	Editorial	Add numbers to entire list.
	1-3	11	2nd Paragraph	Figure is incorrectly referenced in body of document – Figure 2-8 does not show an assembled floor panel before the concrete floor was poured.	Editorial	Correct sentence
	1-4	XXXi	7th Bullet from the top of the page	Change reference to NFPA 14 from NFPA 13.	Correct reference to standpipe standard.	Change reference to NFPA 14 from NFPA 13.
	1-4	xxxii	First bullet of E.3 /sentences 1-2	Although the context of the finding is presented more clearly than in Report 1-4C, the sentences could still be misleading.	It appears that design of the system not the events of September 11, 2001 required manual activation. Presumably the signal delay was not caused by a system fault but by a delay in signal transmission by operating staff (fire safety plan).	Revise the sentences to read: "Because the design of the WTC 1 and WTC 2 fire alarm systems required manual activation of the alarm signal to notify building occupants, the alarm signal was not transmitted until 12 min after the impact in WTC1."
	1-4	10	Paragraph 3/sentences 1	Correct NFPA 13 reference to 2002 edition from 2004 edition.	Fix editorial error.	NFPA 13-2002 ed.
	1-4	11	Paragraph 1/sentences 3	Correct NFPA 13 reference to 2002 edition	Fix editorial error.	NFPA 13-2002 ed.

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				from 2004 edition.		
	1-4	11	Paragraph 4/sentences 2	Correct NFPA 14 reference to 2003 edition from 2004 edition.	Fix editorial error.	NFPA 14-2003 ed.
	1-4	51	Last paragraph / last sentence	The statement is misleading.	The disparity in performance (circuit styles) between the different circuits is acknowledged and may have played some role in the overall performance variability. However the stated conclusion does not appear to be supported by a clear explanation in the report of how the circuit disparities caused the (unspecified) observed variability of performance. Other factors may have played a more significant role. It is worth noting that the highest level of performance established by the available styles of circuits appears to have been used.	Revise to read: "The disparity of performance between the different types of circuits may have played a role in the variability in performance of the fire alarms after impact."
	1-4	64	Entire page.	The material organization is confusing.	The organization of the material is not consistent with that in report 1-4C page 104.	Revise in accordance with report 1-4C.
	1-4	67	Second bullet of 4.6 /sentences 1-2	Although the context of the finding is presented more clearly than in Report 1-4C, the sentences could still be	It appears that design of the system not the events of September 11, 2001 required manual activation. Presumably the signal delay was not caused by a system	Revise the sentences to read: "The design of the WTC 1 and WTC 2 fire alarm systems required manual activation of the alarm signal to notify building occupants. This was

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				misleading.	fault but by a delay in signal transmission by operating staff (fire safety plan).	not accomplished until 12 min after the impact in WTC1."
	1-4	67	Third bullet of 4.6 /sentences 1-2	Although the statements are true it should be noted that the highest levels circuit performance were provided consistent with NFPA 72 circuit performance (styles).	The statements made could imply that this disparity is unique to the WTC 1 and WTC 2 fire alarm systems.	Add the following sentence: It should be noted that the highest levels of circuit performance were provided consistent with NFPA 72 circuit performance (styles).
	1-4	67	Fourth bullet of 4.6 /sentence 1	The sentence is misleading.	Telephone circuits are required to meet performance standards. The current edition of NFPA 72 addresses these in 6.9.9.	Delete Sentence.
	1-4	95	Section 6.1.2; first, second and third bullets.	Refer to comments provided for page 67, Section 4.6 second, third and fourth bullets.	Refer to reason for comments provided for page 67, Section 4.6 second, third and fourth bullets.	Refer to suggested revision provided for page 67, Section 4.6 second, third and fourth bullets.
	1-4C	xxxi	Intro par. of E.6/sentence 1	The phrase ",but not all functions performed as intended" is misleading.	The phrase suggests that the system either didn't perform as intended by its designers or that it didn't perform as intended for the events of September 11, 2001. The evidence in the report does not appear to suggest that the system operation was less than expected by its designers. The intended performance for the catastrophic events of September 11, 2001 was not	Replace the phrase with "but the system performance was reduced by the catastrophic events of September 11, 2001 that were not part of the design basis of the system."

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					part of the design basis.	
	1-4C	xxxi	Intro par. of E.6/sentence 2	The sentence is misleading.	In the context of the first sentence, the second sentence suggests that analyzed performance was that of the system on September 11, 2001. However it appears to be largely based on an evaluation of the design of the system aside from the events of September 11, 2001.	Replace the sentence with "The analysis of the fire alarm system's design has led to the following observations."
	1-4C	xxxi	Second bullet of E.6/sentences 1-2	The sentences could be misleading.	It appears that design of the system not the events of September 11, 2001 required manual activation. Presumably the signal delay was not caused by a system fault but by a delay in signal transmission by operating staff (fire safety plan).	Revise the sentences to read: "The design of the WTC 1 and WTC 2 fire alarm systems required manual activation of the alarm signal to notify building occupants. This was not accomplished until 12 min after the impact in WTC1."
	1-4C	xxxii	Fourth bullet of E.6/sentence 2	The sentence is misleading.	Telephone circuits are required to meet performance standards. The current edition of NFPA 72 addresses these in 6.9.9.	Delete Sentence.
	1-4C	106	Second bullet of 6.2.1/sentences 1-2	The sentences could be misleading.	It appears that design of the system not the events of September 11, 2001 required manual activation. Presumably the signal delay was not caused by a system fault but by a delay in signal transmission by operating	Revise the sentences to read: "The design of the WTC 1 and WTC 2 fire alarm systems required manual activation of the alarm signal to notify building occupants. This was not accomplished until 12 min after the impact in WTC1."

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					staff (fire safety plan).	
	1-5 B	124	2nd and 3rd Paragraphs	Jump into modern model building code requirements seems abrupt. Also, NFPA 5000, Chapter 40 dictates that the acceptable thickness of SFRM is as tested in accordance with ASTM E 605. This section should present the requirements of ASTM E 605.	Provides reader with additional information.	Add minimum thickness requirements from ASTM E 605.
	1-6	lxxii	Finding 6	Misspelled word and truncated sentence.	Editorial	Match the language found in Finding 6, page 315.
	1-6	lxxiii	Finding 19	Doesn't match Finding 19 on page 316.	Editorial	Match the language found in Finding 19 on page 316.
	1-6 A	5 6	Section 2.2	Type III construction is considered "ordinary"; while, Type V construction is considered "combustible".	Correction	Modify the following: 1. "The main categories are Type I (fire resistive), Type II (non-combustible), Type III (ordinary~~combustible~~), Type IV (heavy timber), and Type V (combustible~~ordinary~~)." 2. "In some codes, these sub-categories are identified by letters following the type (e.g., 1B or 3A) or by a set of three numbers that represent the fire resistance required (in hours) of the exterior bearing walls;

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						columns, beams, girders, trusses and arches, supporting bearing walls, columns, or loads from more than one floor; and floor construction ~~columns, beams, and floors~~, respectively (e.g., Type I(332) ~~1 [3,3,2]~~) (NFPA 5000 2003)." 3. Comparisons between the different types of construction in the various model codes may be simplified by including the following table: (Table at end of Comments)
	1-6 A	xxxii	Construction Types	Type III construction is considered "ordinary"; while, Type V construction is considered "combustible".	Corrections to section on Construction Types.	Modify the following: 1. "The main categories are Type I (fire resistive), Type II (non-combustible), Type III (ordinary~~combustible~~), Type IV (heavy timber), and Type V (combustible~~ordinary~~)." 2. "In some codes, these sub-categories are identified by letters following the type (e.g., 1B or 3A) or by a set of three numbers that represent the fire resistance required (in hours) of the exterior bearing walls; columns, beams, girders, trusses and arches, supporting bearing walls, columns, or

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						loads from more than one floor; and floor construction ~~columns, beams, and floors,~~ respectively (e.g., Type I(332) ~~1 [3,3,2]~~)."
	1-6 A	6	Section 2.3, 3rd Paragraph	Insert "5000" after NFPA in two places.	Editorial	"For example, ~~the~~ NFPA 5000, Building Construction and Safety Code, (NFPA 5000, 2003)…
	1-7	Throughout		The term 'normalized stairwell travel time' is confusing and should be replaced throughout. What's meant is 'flight (or story) traversal time'	Reason for Comment: Stairwell travel time is the time it takes to move down the stairs. What was done in the report is divide time in the stairs by the number of floors.	Throughout the report, replace the term 'normalized stairwell travel time' with a less confusing term, such as 'flight (or story) traversal time.'
	1-7	various		Somewhere on the lower floors of WTC1 there was a group of mobility-challenged occupants. That location is reported inconsistently in different reports. NCSTAR 1-7 page xxxv, second line: between 12 and 20 . NCSTAR 1 pages 156 and 185: 12th NCSTAR 1-8 page 10, says 'on about the 12th floor'		Revise the final report to use a consistent location.
	1-7	various (see reason			Contradictions throughout report on the number of	

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		column)			people killed in WTC2 who initially were below the impact floors. Page xxxiv paragraph 1, second line from the bottom – 11 Page xxxv, sixth line from top – 7 Page 114, 3rd paragraph, 3rd line – seven Page 120, Table 9-2 – 11	
	1-7	various (see revision column)	Various	The number of elevators doesn't add up.	inconsistent reporting	1) Page 32, Sec 2.2.3, fourth line – delete mention of 240 elevators in complex – it's irrelevant and the enumerating of elevators is already confusing enough 2) Page 32, Sec 2.2.3, fifth line – are these 7 elevators the ones that are described as freight elevators on page 34? If so, they served the towers, not just the basement levels. 3) Page 122, 5th page, 1st line – says there were 99 elevators

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						in each tower – there were more, but I'm not sure how many 4) Page 34 – there were three sets of 24 local elevators (total – 72), three types of express elevators (8 to 44th, 10 to 78th and 2 to restaurant or observation deck – total 20), seven freight elevators – that seems to be the 99 elevators frequently mentioned. They also mention five other local elevators in each tower. Car #99 is mentioned twice – once with the freight elevators and again in the next paragraph as one of the local elevators.
	1-7	xxxii and 63	Description of focus group 4	delete 'non-traditional occupants'	wording is awkward and potentially derogatory – better phrased elsewhere; these people were as much building occupants as any office worker.	"Persons with building responsibilities, to capture the unique perspective of custodians, security, maintenance, or other building staff."
	1-7	xxxiii	Paragraph 2, line 5	Inconsistent number of fatalities	Contradicts Tables 4-1 and 9-2.	Estimated number of deaths was 2,146 to 2163.
	1-7	xxxv	end of first paragraph	This assumption appears several times in the report and there is no basis for it. "…a large group of occupants from above the impact floors may have identified the	There's no basis for this assumption. There are other possible explanations and there is information available that makes this explanation highly unlikely. Three men who managed to escape past	Change to "…a large group of occupants from above the impact floors may have been making their way out of the building as it collapsed."

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				passable stairwell (Stairwell A) and may have been making their way out of the building as it collapsed."	the 78th floor in that stairwell had great difficulty. One was badly burned. None reported being followed down the stairs. It is more likely that a group of people got below the 78th floor before WTC2 was struck, but delayed somewhere on a lower floor too long and didn't make it out of the building before it collapsed.	
	1-7	2	1st paragraph, first two sentences	Reference and description aren't clear	clarity.	(1) Either the reference (NFPA, 1912) is the wrong format, or the listing in the reference page is wrong – it was hard to find. (2) "The Equitable Building was a group of five buildings <u>linked together</u>, …."
	1-7	4	Top paragraph	There are a lot of inaccuracies introduced into this description of the fire. There are details that aren't in the referenced article.	Inaccuracies	Delete "The wall coverings had complete burned out when the fire department arrived on the floor, only seven minutes after notification" – I can't find that in the article at all. Corrections to text: "The intense black smoke quickly trapped <u>most of the approximately</u> 40 occupants on the floor of origin. <u>Many</u> occupants found <u>refuge in offices</u> and closed the doors

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						behind them, breaking out windows to vent incoming smoke and waited to be rescued. At some point, one woman jumped from a 6^{th} floor window and sustained severe injuries. The fire department was notificed when an occupant of the building from another floor activated a manual pull station at approximately 10:30 a.m. Several occupants of the fire floor were leaning out of a broken 6^{th} floor window in order to breathe…."
	1-7	21	label for Floor 43, 45-47	typo	he Skylobby was on the 44^{th} floor, not the 45^{th} floor. Didn't the escalator connect the 43^{rd} and 44^{th} floors, rather than the 44^{th} and 45^{th}? (On page 34 there's mention of an elevator from the cafeteria on the 43^{rd} floor to the Skylobby on the 44^{th}.)	
	1-7	22	left column, middle row	What about the 79th floor?	Doesn't appear on any of the plans.	Need to identify Floor 79.
	1-7	33	Figure 2-14 and discussion of figure in top line	discussion doesn't match the figure	Is this the right figure? Figure 2-14 doesn't show anything about space taken by Elevator Bank A or show Elevators 24-29.	1) find a better way to explain how the reclamation of floor space is shown on this figure, or insert a more relevant figure. 2) on the graph, move the

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						pointers to local elevators to their appropriate starting positions on lobby levels.
	1-7	36	Fire Command Station	Question -- was the fire command station staffed at all times? The section on page 38 about the responsibilities of the fire safety director says that that individual is required to be on duty during normal working hours, but is that at the fire command station, or does that person report to the fire command station when necessary?	When trying to understand the emergency plan , that's a detail that would help.	Just mention in the Fire Command Station whether or not it was staffed during normal business hours, and by whom.
	1-7	38	Bottom line	This is the first mention of a police desk, and it seems to be distinct from the Fire Command Station and the Operations Control Center. Where was this police desk? It's mentioned in a couple of places in these few places.	Need a clarification if the police desk and FCC are separate and distinct.	
	1-7	40	Floor Warden System	Two questions: 1) each floor had to have a floor warden, but on multi-tenanted floors, didn't each tenant have to have a floor warden? I	Not clear on procedure for floor wardens	If multi-tenanted floors had multiple floor wardens, say so. Explain why the floor wardens had to call the police first.

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				thought the rule was that every tenant had to have a floor warden, and tenants on multiple floors had to have a floor warden on each floor. (2) The floor wardens were supposed to call the police desk (wherever that was) before reporting the incident to the Fire Command Station?		
	1-7	41	Last full paragraph at the bottom	(1) first sentence: clarify whether occupants were only told what the procedure was, or were they told to perform the procedure as part of the drill. It's not clear if evacuating three floors was actually supposed to be done as part of the drills, and in the telephone interviews, some people had gone down stairs in drills and others didn't seem to have. (2) Everything after the first sentence is interesting, but it doesn't belong here. It isn't about occupant training.	Clarity	(1) clarify drill procedure; (2) move that text to the section that has the description of the stairwells (Section 2.2.2)
	1-7	45	Ever where WTC2	Replace 'passable' with	After WTC2 was struck,	Replace 'passable' with 'intact'

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		lines 3 and 5	Stairway A is described as passable (in all documents)	'intact'	Stairway A may have been intact structurally, but two people found themselves unable to pass the 78th floor (and are probably among the dead). Three men did make it past the 78th floor, against the advice of those two people, but the fire conditions they encountered, and the fact that no one followed them down the stairs, implies that the stairway was not 'passable' although it may have been 'intact.'	when describing the condition of Stairway A after WTC2 was struck, in all documents.
	1-7	50 and thereabouts	Description of the badge list	Nowhere is the badge list described in terms of how current it was or how many names were on it, in total, for WTC1 and WTC2.	The badge list was the basis for the telephone survey sampling. It seems to have been used to estimate the population in the building, although that isn't clear. (That's another comment.) If it was out of date, that would also explain some of the difficulty in contacting people for the survey.	1) mention how current the badge list was. Since, obviously, it wasn't a list that was kept on-site, was it out-of-date (on September 11th)? 2) How many names were on the list? The list was used to estimate the number of people in the towers on September 11th, but there's no mention of the total number of people on the list.
	1-7	51	Discussion of Representativeness of Badge List	1) The reference for the CNN web site is not given, and should include the date it was taken. The list was updated over time, and the currently posted list may be	The analysis is a comparison between the media or CNN lists and the badge list – do mismatches mean that individuals were definitely not supposed to be there? Does this support the conspiracy	1) Add reference for CNN web site: 2) Explain the methodology for the comparison with the media list – who was

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				different. 2) Don't understand the procedure was comparing media list with badge list – why check only 144 names? How were they chosen ? 33) 3rd paragraph on page 51, Tables 3-1 and 3-2 – what does it mean that people "were definitely not supposed to be at WTC 1 or WTC 2 the day of the tragedy…."	theorists?? Who were these people?!?	included/excluded and why? This is just a test of representativeness. What was the reasoning behind the methodology? Isn't it possible that the badge list was out-of-date, and that's why people who apparently were killed in the towers didn't appear on the list, rather than that they *definitely weren't supposed to be there*?
	1-7	52	Discussion of telephone sample selection bullets	These terms need clearer definitions	The website referenced on Table 3-4 doesn't provide sufficient explanation,	1) 2nd bullet point – is this the 'eligible' group described later? What was the basis for this estimate? Was the assumption that 86 percent of the people on the badge list were killed or absent on 9/11?
	1-7	53	bottom two paragraphs	Typos?	Inconsistent with other sections	1) 4th para – Here and in NCSTAR 1-7B, page 16, the percentage of unlocatable phone numbers is 76.7 in the text and 76,6 in the tables. 2) 5th para, 5th line – subjects are 'unlocatable' here and 'unloadable' in NCSTAR 1-7B, page 15. Should be

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						'unlocatable'?
	1-7	54	1st paragraph, 3rd sentence	Numbers in parentheses don't match Table 3-3. This text doesn't appear in NCSTAR 1-7B.	If this isn't an error, there's no indication of where these numbers come from.	Should read "Third, the badge list included decedent names (0.7 percent) – some from the September 11, 2001, attack (0.3 percent) and others from causes not necessarily related to September 11, 2001 (e.g., cause unknown, natural causes, 0.4 percent)."
	1-7	54 55	Table 3-4 (page 55) and discussion in last two paragraphs on page 54.	(1) Not clear how eligibility was calculated, or what the difference is between eligibility and overall rates. (2) The footnote on Table 3-4 should not be to the weblink, since this document is described as a work in progress. The link currently is the 3rd edition – is that the version this authors used? In the referenced document, the correct citation is given and should be used here.	The explanation of how the telephone sample was collected is not clear, as was mentioned in an earlier comment (specifically concerning the lack of detail about the badge list). The lack of clarity continues here, and there is no additional information in NCSTAR 1-7B. The footnote for Table 3-4 says that the disposition rate definitions are 'consistent' with the AAPOR standards, but the referenced website is not helpful in understanding what the definitions used here actually are.	1) The screening rate is calculated as the proportion of names with initial phone numbers that were NOT 'can't contact/locate' or 'other refusal' or 'language barrier.' But, the text says that it's the percentage of successful telephone contacts – that would be a percentage rate twice as high as shown. Should read "approximately 46 percent of initial telephone numbers that resulted in successful telephone contacts determining whether the potential respondent was present…." Define the categories of people that make up the 'interview' category. There's no explanation of how that rate is calculated and it's not clear from the numbers shown in Table 3-3. The 'overall'

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						category is the product of the 'screening' rate and the 'interview' rate, but there's no explanation of what that means. What is the 'eligible' response rate and how is it calculated? How and why does that differ from the 'overall' response rate?
	1-7	63	Last sentence	Unclear; better phrased in NCSTAR 1-7B	cCarity; 'notes taken in duplicate' sounds like copies and that's not how it was done.	"Two notetakers recorded the discussion and notes were later compiled into a single summary of the focus group."
	1-7	67	2nd paragraph, 3rd sentence	The text states that the response rate analysis in Section 3.2.2 'leads directly' to a projection of the number of people present during the attacks.	Nowhere in this report is that calculation explained, and the discussion in Section 3.2.2, which is unclear as to how the response rate was calculated, does not 'lead directly' to any calculation of number of people present	Detail how this calculation was done. The estimate of people present appears throughout the investigation reports and deserves a paragraph or two of explanation.
	1-7	76, 78 , 82, 85, 105 and 113	Tables 5-1, 5-2, 6-2, 6-6, 8-1 and Table 8-3	n=440 – how is that correct?	There were 427 subjects in WTC1, so n shouldn't be greater than 427.	Correct the n value, or explain where the extra observations came from.
	1-7	83	Bottom paragraph, second sentence; Table 6-4; and anywhere throughout where perception of risk is discussed. (Page 93, bottom paragraph and Table 6-12)	Using the term 'perception of risk' obscures the power of the questions actually asked.	When people read about 'perception of risk,' they can be left asking 'risk of what?" -- injury, death, entrapment? The survey asked people twice each for themselves and others around them – did they think they or others were in danger of being killed. This is a powerful question and given how many people	Before very specific that the question survivors' perception of of risk to themselves and others was risk of death, not some vague feeling of danger.

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					answered in the affirmative, it gives an indication of how great people's perception of the danger was.	
	1-7	84 90	Page 84, bottom line; page 90, 9th line.	Cubicle misspelled 'cubical'	Typos	
	1-7	86	2nd paragraph, 1st sentence	This sentence says that damage on the 22nd floor is mentioned several times in NCSTAR 1-7A, but that's not accurate.	Wrong reference.	I'm not sure what the authors are referring to here. There is mention of damage on floors in NCSTAR 1-7A, but not specifically the 22nd floor. Are they actually referring to the matrix? The matrix is not part of that document. Rather than NCSTAR 1-7A, should the reference be 'Fahy and Proulx, 2003,' which is the reference to the database used elsewhere?
	1-7	101	Figure 7-3	This figure isn't helpful in showing the damage.	The legend uses plan boxes to describe two different things (partitions and structural damage); the stairwell locations aren't shown.	Show location of stairwells, since this was crucial in the evacuaiton of a handful of people from above impact. Use a legend that explains what the boxes are. (Only 'floor system removed' is clear; the other boxes are identical.)
	1-7	106	1st paragraph, 25th line, starting 'Only the staircase furthest away…"	Refers to Stairwell A as 'passable' and says severe damage is shown in Figure 7-1.	'Passable' is a misleading word and Figure 7-1 doesn't show any damage to Stairwell A.	1) Change 'passable' to 'intact' or 'relatively intact' for this context. 2) Either use a figure that shows damage to Stairwell A, or delete reference to Stairwell A.

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	1-7	114	3rd paragraph, 3rd line	More contradictory mentions of the number of people killed in WTC2 who initially were below the impact; was it 11 or 7? Page 114, 3rd paragraph, 3rd line – seven Page 120, Table 9-2 – 11	The sections should have the same numbers.	
	1-7	114 167	114, 3rd paragraph, sentence 2-5; page 167, top of page	This repeated suggestion that there were more people traveling down from above the impact point in WTC 2 should be deleted.	This suggestion, which appears in more than one place, is not convincingly substantiated. The authors assume that the people observed in the stairwell shortly before the collapse must have passed the point of impact. This contradicts the observations of three people who DID come from above the 78th floor after impact. Their descriptions of the blockage in the stairs, and the smoke/fire conditions, make it sound very unlikely that a large group of people had been moving down the stairs after them. A more likely explanation is the this was a group of people who left the upper floors before impact and were resting/waiting on a lower floor, and waited too long to continue their evacuation.	Delete this discussion – there are other possible explanations (as the authors state), so there's no point in advancing this one as the most likely. In fact, there is plenty of reason to doubt that it is correct.
	1-7	115	1st paragraph, 1st	624-680 occupants is	Contradicts reporting in	"...many of the 630 to 684

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			sentence	wrong	Table 9-2	occupants…"
	1-7	120	1st full paragraph, 1st line (discussion of Table 9-2)	NIST states that is is 'likely' that people were on their floor when the building was hit.	This is only an assumption and should be stated as such. Many people were arriving at work at the time of the attacks, or were in the cafeterias on upper floors getting breakfast. In the absence of reported observations, NIST can make the assumption that they were on the floor recorded on the badge list, but it's too strong a statement to say that that was their likely location.	Simply state that this is an assumption, given no other information. Report what is known; don't make assumptions about the rest.
	1-7	121	5th and 6th bullet points in the middle of the page	These two bullet points don't belong in the list.	This section is enumerating the number of people 'known' to be killed below the impact points. These two points are describing people whose locations were never determined. These people are the reason that the number of deaths are reported as a range.	After the 4th bullet point, "In addition, there were up to 24 individuals who were somewhere in the building, but may have been above or below impact regions in either building and another 17 individuals for whom no information could be located."
	1-7	121	3rd and 4th bullet points at the bottom of the page	These two bullet points don't belong in the list.	This section is enumerating the number of people 'known' to be killed at or above the impact points. These two points are describing people whose locations were never determined. These people are the reason that the number of deaths are reported as a range.	After the 2nd bullet point, "In addition, there were up to 24 individuals who were somewhere in the building, but may have been above or below impact regions in either building and another 17 individuals for whom no information could be located."
	1-7	121	Middle paragraph, last sentence	Delete this sentence	People were still alive above the impact points when the	Delete this sentence

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			("Assuming that all of these individuals were alive at the time that his or her respective building…."		towers collapsed. This sentence doesn't add anything to the discussion, and is inaccurate.	
	1-7	121	1st sentence in section at the bottom.	individuals were "at from above"	typo	Believe this is supposed to be "at or above" the floors of impact.
	1-7	122	Header at the top of the page	Delete "Estimated" from the title of this section	The number of passengers and crew is known, not estimated.	Delete the word 'Estimated' from the title of this section. Also, the sentence just before Section 9.2.1 isn't related to the number of passengers and crew. Maybe the section at the top of the page should be titled "Other Victims" so that the people in the planes and the people outside the building fit logically in the same section.
	1-7	122	5th paragraph, 1st sentence	There were more than 99 elevators in each tower.	The correct number of elevators should be used in this discussion.	Use the correct number of elevators. Some o the victims might have been building staff in freight elevators.
	1-7	128	Last paragraph, sentences 4-5	Awkward and inaccurate phrasing.	Initiating evacuation and choosing to initiate evacuation are not the same thing, and would have occurred at different points in time, as evacuation is defined in this report.	"In WTC 2, over 90 percent of the occupants (meaning survivors?) began to evacuate before their building was attacked."
	1-7	132	Paragraph 2, sentence 4	This sentence says "Floor also increased	Contradictory statements	Did floor increase or decrease time to begin evacuation?

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				delay in starting evacuation…." On page 134, it says "In both towers, floor's effect was negative, that is, the more floors one was from the exit, the quicker people were to initiate their evacuation." Which is it?		
	1-7	134	1st paragraph, sentence 9 (3rd sentence from the end)	On page 128 (and elsewhere), the report states that evacuation initiation delay increased with building height (meaning floor the respondent was on). Here, the report says that higher a person was in the building, the quicker people were to initiate their evacuation.	Contradictory statements	Did location at impact increase or decrease delay times? Be consistent. (These results are repeated in several places.)
	1-7	135	10.2.2	"Normalized stairwell evacuation time" is a poor term for what is actually the average number of seconds per flight of stairs, apparently calculated as the floor of origin divided by travel time.	Evacuation time is generally taken to mean total duration – in this case, it would seem to mean travel time in the stairs. There are already enough conflicting definitions of 'evacuation time' in the literature without introducing another one. The authors are talking about number of seconds per flight – use a term that clearly means number of	Replace throughout with a more accurate term, such as average flight traversal time.'

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					seconds per flight.	
	1-7	138	First paragraph	Not enough explanation of what this all means	Need more explanation to make this analysis meaningful and/or useful.	Explain why environmental cues would make a person travel the stairs faster or slower. The environmental cues reported by the subject could have been the smoke, fire, etc., observed when the building was struck. Why would that have any impact on travel time in the stairs? The analysis is restricted to only the data sought in the questions (obviously), but there is at least one serious omission here logically in that fatigue is never mentioned as being a potential factor in one's travel time. Explain why this analysis has any value or meaning when environmental cues before egress are used but physiological factors like fatigue excluded.
	1-7	160	1st sentence	Since the investigation didn't determine how many of the victims below the impacts had a mobility impairment, it isn't appropriate to determine that they were not over-represented in the decedent population.	Conclusions made without sufficient evidence.	Delete this comment since the condition of these victims hasn't been determined. CDC is beginning a project that will look at the victims from below the impact points in order to try to determine why these individuals died. Their mobility will be of major interest in that

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						study.
	1-7	160	paragraph 3, sentence 2	The egress modeling appears in Appendix D.	Typo	Change Appendix E to Appendix D.
	1-7	160	Section 10.4	Should mention that all of the evacuation model were used well beyond the limitations for which they were validated.	None of the models here were validated using 110-story structures. Using any model beyond the limits for which it was designed is potentially problematic, not that the analysis isn't interesting, but this should be mentioned..	Just mention this as a limitation of the analysis.
	1-7	165	Section 11.1, 1st and 2nd bullet points	The ranges for number of deaths in each tower doesn't match what's reported in Tables 4-1 and 9-2 or on page 115, and possibly elsewhere.	Different numbers for number victims appear throughout the report	First bullet point should probably be 1,462-1,533. Second bullet point should probably be 630-701.
	1-7	166	4th and 5th bullet points on this page	Neither of these points appears anywhere in this report.	The findings section shouldn't include material that hasn't been discussed in the report. Neither of these two points appear in the analysis of the relevant questions or discussion. While it's true that some people delayed or interrupted their evacuation (this was reported by survivors themselves), what is the basis for concluding that that explains all the deaths of those	1) time per floor should be discussed in the report where stairwell travel is covered. 2) in 5th bullet point, delete "resulting in over 100 deaths below the impact region."

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					originally from below the impact points? What about those who were trapped, injured or had serious mobility impairments?	
	1-7	167	Section 11.3, first bullet point	something is wrong with the first sentence "caused people out to find…"	Typo?	Don't know what they're trying to say here.
	1-7	167	2nd bullet point	1) second sentence again says that floor increased delay and refers to Section 10, which says that floor decreased delay. 2) 3rd sentence says that observation of environmental cues increased the amount of time people spent in the stairs – this is based on regression analysis, which does not determine cause and effect.	1) contradictory statements; 2) regression analysis is used to indicate which variables are good predictions of the dependent variable in the equation. Regression analysis does not determine that one variable has a cause and effect relationship with that other variable. The variables used in this regression analysis are so interdependent it is wrong to conclude, as stated here, that observation of environmental cues increased time spent in the stairs. (How, exactly, could that even be the case – a person sees smoke and fire out the window, and it makes him slower in the stairs? Doesn't it make more sense that a person on a higher floor was more likely to see fire and smoke and, being on a higher floor,	Eliminate the contradictory statements throughout the report. Explain in more detail what contribution the causal analysis made to the findings in the study, given that key variables explaining long evacuation time (e.g., fatigue) were not available.

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					required more time to travel down the stairs, resulting in more fatigue and more interference from crowding thus, more time in the stairs?) 3) It wasn't really necessary to use a causal model to determine that any interruption in the process of evacuation would increase evacuation time.	
	1-7	167	Bullet point at the bottom.	"Contrary to the perceptions of the occupants, …." Nowhere in the report did occupants report a perception that firefighters increased their total evacuation time. They were asked in the telephone interview if any of a list of factors made their evacuation more difficult while in the building. Saying yes to firefighters or police moving up the stairs doesn't mean that they were saying that their total travel time was impacted significantly. (44 percent said they were helped by police or firefighters – in the media accounts, it was clear that the firefighters	The analysis here reads too much into the occupant responses to a slightly different question than implied here.	Delete "Contrary to the perceptions of the occupants," – the point of the analysis was to show that other factors had more of an impact on increased evacuation times.

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				who helped were the firefighters encountered in the stairs.)		
	1-7	168	1st bullet point	This is essentially the same as a paragraph that appears on the previous page.		Delete one of the duplicate paragraphs.
	1-7	169	Section 11.5, 2nd bullet point	The location of the mobility-challenged evacuees is reported here to have been 'somewhere between floors 12 and 20' – this needs to be reported consistently throughout the report.	Inconsistent throughout the report	Appears elsewhere as: NCSTAR 1-7 page xxxv, second line: between 12 and 20 NCSTAR 1 pages 156 and 185: 12th NCSTAR 1-8 page 10, says 'on about the 12th floor'
	1-7	241	Table D-2, description of Zone 2	There was an escalator between floors 44 and 45 and between 43 and 45?	On page 21 it says that there was an escalator between 44 and 45. I thought that was a typo (the Skylobby wasn't the 45th floor). These descriptions of elevators should be checked and should match.	Replace here and on page 21 with whatever is correct.

Table A.7.2.1.1 Cross-Reference of Building Construction Types

NFPA 5000 and 220	I(442)	I(332)	II(222)	II(111)	II(000)	III(211)	III(200)	IV(2HH)	V(111)	V(000)
UBC	—	I FR	II FR	II 1 hour	II N	III 1 hour	III N	IV HT	V 1 hour	V-N
B/NBC	1A	1B	2A	2B	2C	3A	3B	4	5A	5B
SBC	I	II	—	IV 1 hour	IV unp	V 1 hour	V unp	III	VI 1 hour	VI unp
IBC	—	IA	IB	IIA	IIB	IIIA	IIIB	IV	VA	VB

unp: Unprotected.

[Source: NFPA 5000, Table A.7.2.1.1]

Subject: NFPA SUPPLEMENTAL COMMENTS-RECOMMENDATIONS 25 AND 26
From: "Solomon, Robert" <rsolomon@NFPA.org>
To: <wtc@nist.gov>

WTC Technical Information Repository
Attention: Mr. Stephen Cauffman
National Institute of Standards and Technology
Stop 8610
Gaithersburg, MD 20899-8610

Mr. Cauffman:

Here are the two comments I mentioned in my first email. These are in addition to the comments you received in the previous email and that you will receive via hard copy and CD today.

Robert Solomon, PE
National Fire Protection Association

Rec 25 STAFF COMMENTS ON NIST WTC STUDY.doc

Rec 26 STAFF COMMENTS ON NIST WTC STUDY.doc

NFPA COMMENTS ON NIST WTC STUDY

NAME: NFPA

Report Number: NIST NCSTAR 1,WTC Investigation

Page Number: 216

Paragraph/Sentence: paragraph 9.2.7 / Recommendation 25

Comment:

Address governmental entities in the Recommendation. Cite the importance of qualified design, construction, and inspection professionals in ensuring safety in buildings.

Reason for Comment:

Though the Recommendation refers to non-governmental and quasi-governmental entities that own or lease buildings not being subject to building and fire safety requirements, governmental entities often exempt the buildings they own or lease from building and fire regulations.

We concur with the need for third party inspection during construction and operation of the building. Licensing and certification of engineers, architects, designers, and inspectors helps ensure that people are qualified to design, construct, and inspect buildings. Design , construction management, field inspections, and plan reviews should only be performed by qualified individuals.

Building owners may opt for construction project review and oversight by an independent engineer or architect on a contractual basis or use qualified professionals (licensed or certified) in their employ. Designs and as-built conditions should be reviewed by code inspectors in the local jurisdiction for compliance with building and fire regulations.

We concur that contractors should not be permitted to self certify their work in lieu of third party code enforcement inspections.

Suggestion for Revision:

Recommendation 25. Entities that own or lease buildings and are not subject to building and fire safety code requirements of any governmental jurisdiction must be concerned about the safety of the building occupants and the responding emergency personnel. NIST recommends that such entities should be encouraged to provide a level of safety that equals or exceeds the level of safety that would be provided by strict compliance with the code requirements of an appropriate governmental jurisdiction. To gain broad public confidence in the safety of such buildings, NIST further recommends that it is important that as-designed and as-built safety be certified by a qualified third party Engineers, architects, designers, contractors, construction managers and code inspectors should be qualified through certification or licensure to perform their functions. Engineers, architects, designers, contractors, construction managers and building owners should not use self-certification or self-approval of their work or materials for code enforcement purposes in areas including interpretation of code provisions, design approval, product acceptance, certification of the final construction, and post-occupancy inspections over the life of the buildings.

NFPA COMMENTS ON NIST WTC STUDY

NAME: NFPA

Report Number: NCSTAR 1

Page Number: 217

Paragraph/Sentence: Recommendation 26: (paragraph 2/sentences 2-4)

Revise first "non-bold" sentence in recommendation that includes a list of codes addressing the needs of existing buildings (see below).

Add new sentence to the end of recommendation (see below).

Comment:

1. Add reference to NFPA 5000, Chapter 15.

2. Stress retroactive sprinkler high-rise building provision included in NFPA 1, Uniform Fire Code.

Reason for Comment:

Current list of codes is incomplete without NFPA 5000, Chapter 15 (that chapter is equivalent to the information included in the recommendation for the International Existing Buildings Code.

Since focus of this investigation is the protection of high-rise buildings, emphasis should be made that NFPA 1 is the only model code that requires the retroactive installation of sprinklers in all high-rise buildings.

Suggestion for Revision:

Revised sentence:
Provisions related to egress and sprinkler requirements in existing buildings are available in such codes as the *International Existing Buildings Code (IEBC), International Fire Code,* NFPA 1, NFPA 101, **chapter 15 of NFPA 5000** and ASME A 17.3.

Add new sentence:
NFPA 1 is the only model code that requires the retroactive installation of sprinklers in all high-rise buildings regardless of occupancy.

NATIONAL
FIRE
SPRINKLER
ASSOCIATION, INC.

40 Jon Barrett Road, P.O. Box 1000, Patterson, NY 12563 Tel 845-878-4200 Fax 845-878-4215

August 2, 2005

Dr. Shyam Sunder
Deputy Director, Building and Fire Research Laboratory
National Institute of Standards and Technology
100 Bureau Drive
Gaithersburg, MD 20899

Dear Dr. Sunder:

We appreciate the opportunity to provide comments based on our review of the draft "Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Towers." It is an impressive piece of work, and we congratulate your team on its efforts to date.

As a national organization dedicated to the concept of fire sprinkler protection of buildings, we are obviously most concerned with findings and recommendations relating to active fire protection systems. Within Section 8.4.1, the statement is made that the active fire protection systems were designed to meet then-current practice, and another statement is made that "Except for specific areas that were exempted from the required sprinkler coverage, sprinkler systems were installed throughout the towers." Someone referring to this section might get the false impression that fire sprinkler systems were included as part of the original design of the World Trade Center towers, and of course they were not. Although the technology was available at the time of construction, fire sprinkler systems were avoided, and only installed later on a retrofit basis. This information is currently found within footnote 44 on page 217 of the report and briefly on page 194, but deserves a more prominent position.

This issue is important to those who would question the amount of structural fire resistance provided within the building. Obviously, since automatic fire suppression systems were not contemplated as part of the original design, no reductions in fire resistance were provided in recognition of sprinklers.

With regard to recommendations, we support your Recommendation 12 that performance and redundancy of active fire protection systems be enhanced to accommodate buildings of greater risk, and enthusiastically support Recommendation 26 that state and local jurisdictions adopt and aggressively enforce available provisions in building codes to ensure that egress and sprinkler requirements are met by existing buildings.

We are obviously concerned that Recommendation 4 includes a review of the extent to which active fire protection should be permitted to substitute for passive fire protection. While we believe that a risk-based approach that considers potential failure modes of both active and passive systems is fair and appropriate, we are opposed to arbitrary assumptions that an active system can be simply considered compromised or nonoperational for design purposes. Active fire suppression systems, more specifically automatic fire sprinkler systems, have a long history of proven ability and reliability. Any proposed limitation on recognizing the contribution of fire sprinkler systems to the separate objectives of occupant life safety, prevention of fire spread and structural integrity runs counter to your Recommendation 9 supporting the use of performance-based codes and Recommendation 28 to involve fire protection engineers as part of the design team for innovative or unusual fire safety systems.

As stated in Recommendation 28, however, we believe many of the recommendations should be focused on applying the lessons of the World Trade Center to buildings that similarly include innovative features or high-risk profiles. There is an old maxim that "hard cases make bad law", and we believe it would be a mistake to attempt to apply all of these recommendations to the broader building regulatory system.

As stated on page 199 of the report, NIST reportedly considered "Whether these findings relate to the unique circumstances surrounding the terrorist attacks of September 11, 2001, or to normal building and fire safety considerations." It appears that NIST concluded the situation was not unique, noting on the same page that "While there were unique aspects to the design of the WTC Towers and the terrorist attacks of September 11, 2001, the design, construction, operation, and maintenance of the WTC Towers...were based on procedures and practices that are commonly used for normal conditions."

At least with regard to automatic sprinkler protection, this is totally wrong. Going back to 8.4.1, the report notes that "all the fires that occurred in sprinklered spaces in the towers prior to September 11, 2001 were controlled with three or fewer sprinklers", and that "The sprinkler system could have provided fire control at coverage areas of up to two or three times the specified design area of 1500 ft^2." As demonstrated by experience, the specified 1500 ft^2 design area itself includes a safety factor relative to normal experience. Yet the report goes on to note that "the extent of the initial fires in WTC 1 and WTC 2 were considerably greater than three times these specified design areas." To consider this applicable to normal building and fire safety considerations means that the impact of fuel-laden jets is to become a design consideration for normal buildings.

We believe that NIST should revisit the question of which recommendations are really appropriate to normal building construction. To apply the lessons of the World Trade Center to all buildings may well increase construction costs without any appreciable increase in occupant life safety or prevention of fire spread beyond that available through current model building codes.

Very truly yours,

Russell P. Fleming, P.E.
Executive Vice President

From: David May <dmay@walshgroup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/26/2005.

Name : David May
Affiliation :
Email Address : dmay@walshgroup.com
Phone : 312-492-0620
Report Number : NCSTAR 1
Page Number :
Paragraph :
Comment : I assume that the fire sprinkler risers were broken by the planes crashing thru the bldg. I assume that if those risers had been located within cast-in-place concrete shear wall stairwells, they would not have been broken. I suspect that if sprinklers within the fire floors had been activated, that the large amount of water they could have put into the fires -even if it would not have controlled the fires and even if it would niot have pre3vented some of the flammable materials from igniting- would have mostly been boiled. The energy to boil this much water would have significantly reduced the amount of heat energy transferred into the steel structure. Maybe the combustibles would all have been fully burnt before the steel failed. In that case, the buildings would not have collapsed.
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

In

From: David.J.Thomas, MSCE, "P.E." <balallan01@earthlink.net>
To: wtc@NIST.GOV
Cc: dlowe@NIST.GOV
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 6/29/2005.

Name : David J. Thomas, MSCE, P.E.
Affiliation : none (public comment)
Email Address : balallan01@earthlink.net
Phone : 301-424-3648
Report Number : NCSTAR 1
Page Number : 197-98
Paragraph : Section 9.1 Building Standards and Codes: Who is In Charge? (Entire Section)
Comment : Delete Section 9.1 from report.
Comment Reason : This section deals with state and local code enforcement, which was not a consideration in the WTC case, since PANYNJ was both the authority having jurisdiction and the owner of the facility. The condition of being simultaneously the owner, builder, reviewer, and inspector of the facilities in question does not obtain in most jurisdictions in the U.S. Where independent review and independent inspection are not part of the equation, generalized comments regarding the necessity of code enforcement, based on national model codes, by local and state building and fire officials are irrelevant to the cases of WTC 1,2,7. These generic comments should be struck from the report as not being part of the findings, since they do not pertain to the WTC. The NYC code, which was used by PANYNJ to make decisions regarding many aspects of the WTC facilities, was not then and still is not a national code, and was not fully based on any of the national model codes. NYC is still at this date moving to adopt documents based on national model codes. The arms-length condition that normally obtains in review and inspection did not obtain in the case of the WTC. No lessons about the state of regular review and inspection by state and local code authorities can be drawn from the information in this report. NIST has no information in this report about code review and enforcement in other than the WTC. Section 9.1 violates the charge of the report.

Revision Suggestion : Inclusion of generic statements not based on the specific conditions of the WTC facillities does a real disservice to those named in such generic statements. There are no facts or items in this report that they can challenge, because none of them have been responsible at any time for the WTC facilities, or for anything like the PANYNJ arrangement. NIST has no basis for making generic statements about code enforcement on the basis of this report. Comparative statments made in the report must cite specific issues found in actual US jurisdictions. Section 9.1 does not do this, and should be removed in its entirety.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

In

From: David.J.Thomas, MSCE, "P.E." <david.thomas@fairfaxcounty.gov>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/26/2005.

Name : David J.Thomas, MSCE, P.E.
Affiliation : Fairfax County Fire Prevention Division
Email Address : david.thomas@fairfaxcounty.gov
Phone : 703-246-4819
Report Number : NCSTAR 1
Page Number : 209
Paragraph : Under Recommendatiion 13, lines 8,9:
"Pre-installed dedicated firefighter telephone systems in buildings are of limited use and effectiveness, and their installation is not encouraged."
Comment : This statement is untrue in terms of the evidence presented in NIST NCSTAR 1-8, WTC Investigation.
On page 10 of NIST NCSTAR 1-8, you state: "The Warden phones did not work, and attempts to use the wire line phone to upstairs were unsuccessful."
This makes no mention of the firefighters phones, and whether or not they functioned on the levels below that of impact. In fact, if your stairwells had remained intact, the firefighters phones even to the upper levels might have been of value. At present, you have no evidence that radio communications can replace firefighters phones, and your statement under Recommendation 13 should be modified or removed. All evidence that you have shown in this series of reports indicates that there are still severe problems with radios even where assisted by repeaters, and those problems have not been solved. Hence to make a blanket statement to discourage firefighters phones maintained within protected fire-resistive enclosures is wrong, and this sentence should be corrected.
Comment Reason : Evidence both internal and external to the report indicates that this sentence is untrue.

Revision Suggestion : Remove sentence from report.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: "Edwina Juillet" <edwina@shentel.net>
To: <wtc@nist.gov>
Cc: "Sivaraj Shyam-Sunder ...snip... William.Grosshandler@nist.gov>
Subject: My Comments

Geez Louise, the terms "wheelchair bound" and "the mobility challenged" have been out of main stream usage for ages. Yet, this language appears throughout the WTC report.

I have attached a set of writing guidelines by *The Research Training Center/Independent Living (RTC/IL) NIDRR*. It is one of the better, if not the best, on the topic of writing guidelines, for example:

• Incorrect: "confined to a wheelchair," "**wheelchair-bound,**" or "crippled."

Disability groups also strongly object to using euphemisms to describe disabilities. Terms such as "**physically challenged**" are considered condescending. (from attached document)

How, difficult would it be for the person charged with the 'final write' to do the word search, (as I have), make the edits, bringing the document in line with common usage?

Sincerely submitted,

Edwina Juillet
edwina@shentel.net

[Filename: Appendix A FA-235.lnk, Content-Type: unknown/unknown]
ALERT This is an auto-generated message. There was an attachment to this email message. The NIST firewall has stripped the attachment because it may contain a virus or malicious code. For further information, please refer to http://www-i.nist.gov/cio/itsd/firewall/pp_nist/policy/policy_blockedAttachments.htm ***ALERT***

From: GenadyC@netscape.net
To: wtc@nist.gov
Cc: inquiries@nist.gov
Subject: "On the WTC collapse" by Genady P. Cherepanov

Content-Type: text/plain; charset=iso-8859-1
Content-Disposition: inline
X-MIME-Autoconverted: from 8bit to quoted-printable by loggerhead.nist.gov id j671BVHV028901

Dear Dr.Hratch Semerjian and Dr. Shyam Sunder: This is to respond the NIST WTC Team call for improvements of the draft report. This report has no merits because it is based on the wrong analysis of Bazant and Zhou attached herewith as a reminder. The correct explanation is given in my paper attached herewith, too. Regards Genady Cherepanov

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BazantZhou_WTC_JEMD02.pdf

On the WTC Collapse.doc

On the WTC Collapse

Genady P. Cherepanov
6413 SW 113 Avenue, Miami, Florida

Abstract: The generally-accepted explanation of the collapse of the World Trade Center towers on September 11, 2001 is based on the speculative "theory" of progressive buckling of bearing columns at the speed of free fall triggered by creep buckling of the columns of the floor subject to the conflagration from the spilled fuel, and by dynamic impact of the upper structure. In the present paper it is shown that this "theory" is wrong because it is built on false assumptions and incorrect calculations. The "theory" cannot explain the free fall, explosion sound, and pulverization of the buildings as well as other facts of this event. The simultaneous collapse of the neighboring 47-story tower directly contradicts to the "theory". It is shown that, consistent with all known facts of the matter, the scenario of all collapses was this: (i) heating of bearing columns in the "hot" spot caused high compressive thermal stresses in these columns, (ii) these stresses combined with internal stresses triggered a fracture wave, and (iii) the fracture wave disintegrated the entire building for less than 0.1 s producing the sound of explosion and providing the conditions necessary for free fall of steel fragments and dust clouds of tiny fragments of glass, marble and concrete. The theory of fracture waves supports this scenario.

Keywords: World Trade Center, tower, building, column, collapse, explosion, structure free fall, debris, structure pulverization, fracture wave, thermal stresses, internal stresses, creep, buckling, dynamic impact, progressive failure, triggering mechanism, accurate vs. approximate analysis.

Contents

1. Introduction

"Why did you think the towers collapse?", Larry asked his guest, a prominent member of the September 11 Commission, on a recent Larry King show. "This is still under investigation", the guest answered. Evidently, the public has not, as yet, accepted the "theory" by Bazant and Zhou (2002). Meanwhile, the engineering community has, without any hesitation, recognized the "theory" as correct and comprehensive. This author has felt this official recognition on his own skin after the editors and anonymous referees of numerous technical journals refused to publish his understanding of the collapses as contradicting to this "theory".

The "theory" has suggested the following scenario of the collapse: creep buckling of bearing columns of the critical floor, free fall and dynamic impact of the upper structure, and progressive, floor-by-floor, buckling failure of bearing columns of the underlying structure. This "theory" has been unable to explain these well-known facts of the matter:

(i) Free fall regime of all collapses;

(ii) Sound of explosion produced by each collapse;
(Sound is generated by cracking. If the cracking had continued for ten seconds, as the "theory" asserts, a boom would have been heard, not an explosion.)

(iii) Pulverization of the buildings collapsed .
(By the "theory" the debris after the collapse would have consisted of steel segments of columns about two meters long, and nothing more.)

According to the "theory" the neighboring 47-story building should NOT have collapsed. But, it did.

According to the "theory" the Empire State Building should have collapsed in 1945 under similar conditions of aircraft crash and conflagration. But, it did NOT.

Meanwhile, for every person familiar with industrial implosions, when a building is intentionally demolished by uniformly distributed explosives to produce small debris for their easier transport, the WTC collapse has strikingly resembled that of a designed implosion caused by previously distributed explosives. Indeed, each tower collapse took about ten seconds, that is all parts of each building were falling free, without any resistance. It is exactly what happens after a building is disintegrated by explosives. It is no wonder that the conspiracy theory, consistent with the well-known facts of the matter contrary to the official "theory", has become widely spread in the world.

In what follows, it is shown that the official "theory" is built on false assumptions and miscalculations, and hence wrong; and a scientific explanation consistent with all known facts is suggested.

2. Triggering mechanism: thermal stresses vs. creep

"A loss of protective thermal insulation of steel columns during the initial blast accelerated the heating of the columns to very high sustained temperature well above 800°C which lowered the yield strength and caused creep buckling of more than half of the columns in the critical floor, so that the upper part of the structure above this floor fell down and, by enormous vertical dynamic load, destroyed the underlying segment of the tower; and so the series of impacts and failures proceeded all the way down", the official "theory" says, when paying no attention to thermal stresses and residual technological stresses arisen from rolling, welding, assembling, etc. Amazingly, the "theory" ignores even the main event – the combustion of spilled fuel in the critical floor, the event that caused all the collapses.

All assumptions and claims of this "theory" are false. First, the loss of the protective thermal insulation of more than half of the 260 columns of the critical floor by the initial blast is nothing but a miracle necessary for the "theory" because for creep time is essence. Remember that the time between each crash and collapse took about one hour which was, by itself, a very little time for a creep action in a steel column at the level of stresses, at least, three times less than the yield strength and/or the buckling stress at normal temperature, due to the safety factor, even if the entire lateral surface of the column was exposed to the temperature 800°C all this time.

The rate of heat propagation is controlled by the thermal diffusivity, which is equal to 12×10^{-6} m^2/s for steel and about a fifty times less for the protective thermal insulation. How fast is this process in terms of time? Let us provide an accurate example. Suppose the initial temperature of a steel half-space is zero. It takes one hour to increase the temperature to 650°C at the distance 8 cm from the surface kept at 800°C all this time. For the thermal insulation, the corresponding distance is about 1 cm, all other conditions being the same. In other words, one hour is about the time necessary for the heat to penetrate through the protective thermal insulation of a bearing column; it takes one more hour to warm up the column itself. There is no time for creep action.

Secondly, the assumption that 800°C was the temperature of four-meter-long bearing columns of the critical floor during the fire, is quite frivolous. Again, let us examine an example of accurate calculation. Suppose n-octane fuel is burned in the constant pressure, adiabatic combustor of an aircraft engine with 40% excess air, and the fuel is injected into the combustor at 25°C while the air from the compressor enters this combustor at 600 KPa, 300°C. One can find that the combustion products leave the combustor for the turbine at the temperature 769°C, so that the mean temperature of turbine blades is well below 700°C. These are the real conditions of the fuel combustion in the engines of the Boeings that crashed into the towers.

Let us compare the combustion of the fuel spilled in the critical floor of the WTC tower with the combustion of this fuel in the Boeing engine. The combustor will be the whole floor, open-to-air, space with a liquid fuel layer on the bottom, with the air entering this combustor from the atmosphere at 100 KPa, 25°C. Compare the temperature of the Boeing turbine blades with that of thermally-protected columns of the floor. The combustion in the engine runs under the perfect conditions of homogeneous turbulence in a homogeneous mixture designed to achieve the temperature of combustion products as high as possible. The combustion in the open, non-adiabatic floor is, evidently, incomplete, far from the stoichiometric balance, with cold air and a low air-fuel ratio, with the reaction taking place in convective flames providing a very non-uniform distribution of temperature in space and time. For example, the temperature of the tip of the convective flame of a candle can achieve 500°C but you can put it out with a finger because the mean temperature of the flame is below 100°C. And so, the mean temperature in the burning surroundings of the bearing columns was probably below 500°C while locally, at some spots close to the ceiling of the floor, it could achieve 1000°C and higher because of high adiabatic flame temperatures of the fuel. For creep buckling to be true, the entire column should be at a high temperature for a long time.

Thirdly, the decrease of the yield strength of steel was too little to play any role in the collapses. Structural hot-rolled steel used in columns has the yield strength about 600 MPa and the ultimate strength about 900 MPa, at 20°C. At 800°C the numbers are 10 to

20% lower while the nominal stress in columns was, at least, three times less than the yield strength.

From this analysis of conflagration, it follows that the claim of creep buckling of the "theory" is groundless. A measurable creep of structural austenitic steels starts from about 540°C. Meanwhile, this and higher temperatures could be achieved only locally, in the top parts of some bearing columns where the flame temperature was maximal. And because of the thermal protection, these temperatures could be sustained during some time much less than one hour.

For the "theory", it is essential that each bearing column of the floor should be, from the bottom to the top, heated to one and same high temperature sustained for a long time, because in the case of uniform heating of all columns there are no thermal stresses in the columns, so that the thermal stresses can be ignored. If only some of the columns are heated, the thermal stresses arise that can achieve an order of αET where α is the thermal expansion coefficient, E is Young's modulus, and T is the temperature. For steel $\alpha = 12\times10^{-6}$ /°C and $E = 200$ GPa so that at 800°C the thermal stress can achieve 2 GPa which is about four times greater than the yield strength of steel at 800°C.

The calculation of the time-space distribution of temperature and thermal stresses in a building under the real conditions of a fire is a delicate procedure responsible for providing a correct prediction or explanation of a final outcome. Whether a building would collapse or be preserved depends on the thermal stress distribution. Any material volume or structure will be torn into pieces by thermal stresses if some part of the structure is heated too fast to a high temperature.

Just for the purpose of rough estimate, let us do some calculations using the notion of a "hot spot" inside the building. The bearing columns in the hot spot are heated to one and same temperature T while the bearing columns outside the hot spot retain the initial temperature $T = 0$. And so, the thermal stresses in the hot columns are compressive while in the cold columns they are tensile. In the case of the conflagration in the WTC towers and adjacent 47-story building, the core columns were probably in the hot spot while, at least, some bearing columns of framed tube cooled by atmospheric air were outside the hot spot. Compressive thermal stresses, being diffused only by bending floor trusses and cold columns of framed tube, penetrated far into cold columns of the underlying structure. Combined with gravitational and residual technological stresses, the compressive thermal stresses inside the building created a ticking bomb like that of a Batavian tear, so that a fracture wave was born that disintegrated the entire tower for less than 0.1 s.

Let us remind that a Batavian tear, just taken from a glass bath and treated by fluoric acid to dissolve the cracked surface layer, has a core under high compressive stresses and a flawless surface layer under high tensile stress about 5 GPa. Breaking the tiny tail on the Batavian tear releases the elastic energy of compressive stresses in a fracture wave that propagates at the speed of sound and pulverizes glass into micron-size fragments. (See Appendix) Also, as a reminder the compressive residual stress from rolling in steel columns can achieve a half or more of the yield strength.

Suppose S_A is the cross-section area of all bearing columns of the critical floor. Let us assume that βS_A is the cross-section area of the hot bearing columns heated to the temperature T and $(1-\beta)S_A$ is the cross-section area of cold bearing columns at the temperature $T = 0$. As a result, the hot columns will be subject to the compressive thermal stress

$$\sigma = -\delta(1-\beta)\alpha ET \quad \text{where} \quad 0 < \beta < 1, \ \ {}^{1}\!/_{2} < \delta < 1, \tag{1}$$

while the cold columns will be subject to the tensile thermal stress

$$\sigma = \delta\beta\alpha ET \qquad \text{where} \quad 0 < \beta < 1, \ \ {}^{1}\!/_{2} < \delta < 1. \tag{2}$$

The coefficient δ takes into account the elastic reaction of the ends of columns. For rigid floor trusses $\delta = 1$, and for very soft floor trusses, when the elastic reaction of supports is created by the columns themselves, $\delta = 0.5$. And so, the hot columns will be under action of the sum of compressive gravitational and thermal stresses while the cold columns will be unloaded by the thermal stresses. In this illustrative estimate, we ignore residual stresses.

A collapse can start either from tensile failure of cold columns or from the buckling of hot columns in the critical floor. Let us estimate the critical size of the hot spot for both cases.

Suppose that the buckling of hot columns occurs at $\beta = \beta_b$ and that $-f\sigma_Y$ is the nominal stress in all columns of the floor from the weight of the upper structure, where f is the safety factor and σ_Y is the yield strength of steel. Let $-f_o\sigma_Y$ be the stress in hot columns when the buckling occurs, where $f_o \geq f$ evidently. From here and equation (1) it follows that

$$f\sigma_Y + \delta(1-\beta_b)\alpha ET = f_o\sigma_Y, \tag{3}$$

and

$$\beta_b = 1 - \frac{(f_o - f)\sigma_Y}{\delta\alpha ET}. \tag{4}$$

Now, suppose that the failure of cold columns from tensile stresses occurs at $\beta = \beta_T$. From here and equation (2), it follows that

$$\delta\beta_T\alpha ET - f\sigma_Y = \sigma_b, \tag{5}$$

and

$$\beta_T = \frac{\sigma_b + f\sigma_Y}{\delta\alpha ET}, \tag{6}$$

where σ_b is the ultimate tensile strength of structural steel. Make the ratio β_b / β_T from equations (4) and (6)

$$\frac{\beta_b}{\beta_T} = \frac{\delta\alpha ET - f_o\sigma_Y + f\sigma_Y}{\sigma_b + f\sigma_Y}. \tag{7}$$

From equation (7) it follows that

$$\frac{\beta_b}{\beta_T} > 1 \qquad \text{because} \qquad \delta\alpha ET > \sigma_b + f_o\sigma_Y . \tag{8}$$

For example, for typical values when $\alpha ET = 2\,\text{GPa}$, $\sigma_Y = 0.5\,\text{GPa}$, $\sigma_b = 0.7\,\text{GPa}$, $f_o = 0.5$, $f = 0.25$, and $\delta = 0.75$, we get $\beta_b / \beta_T = 5/3$.

It means that the collapse started from tensile failure of cold columns because the critical size of the hot spot in this scenario was less than that in the scenario of the buckling of hot columns. The hot spot was evidently expanding during the fire.

And so, the failing cold columns of the critical floor played the role of a tiny tail of a Batavian tear that explodes into small fragments when the tail is broken. The failure of the cold columns of the critical floor started the process of release of elastic energy of compressive stresses that occurred in a fracture wave because it is only the fracture wave that can pulverize material.

3. Dynamics: accurate vs. approximate analysis

According to the "theory" the upper part of the tower above the critical floor freely fell down in the beginning of the collapse and created an "enormous" dynamic stress in the bearing columns of the underlying structure, so that the maximum dynamic stress was 64.5 times greater that the nominal static stress in these columns from the weight of the upper structure. "This estimate is calculated from the elastic wave equation", the "theory" says.

Let us verify this calculation. Suppose mass m falls down under gravitational force and hits the end of a vertical elastic column or bar at the speed V_o and sticks to the end. It is easy to find the material velocity v_x and stress σ_x in the column/bar arising from this impact:

$$v_x = \frac{mg}{SE}c + \left(V_o - \frac{mg}{SE}c\right)\exp\left[\frac{SE}{mc^2}(x-ct)\right]. \tag{9}$$

$$\sigma_x = -\frac{mg}{S} + \left(-\frac{V_o}{c}E + \frac{mg}{S}\right)\exp\left[\frac{SE}{mc^2}(x-ct)\right]. \tag{10}$$

Here: $0 < x < ct$; t is the time from the moment of impact $t = 0$; x is the coordinate along the bar located at $x > 0$; E is Young's modulus and c is the speed of elastic waves in the column equal to $\sqrt{E/\rho}$ where ρ is the density; and S is the column cross-section area. For $x > ct > 0$ both σ_x and v_x equal zero.

In particular, at the end of the column at $x = 0$ $t > 0$, the stress and velocity are:

$$\sigma_x = -\frac{mg}{S} + \left(-\frac{V_o}{c}E + \frac{mg}{S}\right)\exp\left[-\frac{SE}{mc}t\right], \tag{11}$$

$$v_x = \frac{mg}{SE}c + \left(V_o - \frac{mg}{SE}c\right)\exp\left[-\frac{SE}{mc}t\right]. \tag{12}$$

The maximum stress is equal to:

$$\sigma_x = -\frac{V_o}{c}E \quad \text{when} \quad x = 0 \quad t = 0. \tag{13}$$

If the assumption of the "theory" about free fell of the upper structure is accepted, then $V_o = \sqrt{2gh} = 8.5\,\text{m/s}$ because the height of the floor $h = 3.7\,\text{m}$ and $g = 9.8\,\text{m/s}^2$. For steel columns, $c = 5.1\,\text{Km/s}$ and $E = 200\,\text{GPa}$, so that according to equation (13) the maximum stress in the columns of the underlying structure is equal to $340\,\text{MPa}$. Based on the indicated estimate of the "theory" the nominal static stress in these columns, that is mg/S, should be equal to 340/64.5=5 MPa which is a hundred times less than the yield strength of steel. It is unbelievable! Even a teen girl can produce such a pressure on the floor by her high heels. The approximate estimate of the "theory" is very inaccurate.

However, even the maximum stress 340 MPa from the impact, greatly exaggerated due to the free fall assumption, is about six times less than the maximum thermal stress 2 GPa. And so, the role of dynamic overload from the impact of the upper structure turns out to be secondary as compared to the thermal stresses. The dynamic stress could contribute to the compressive thermal stresses of the underlying columns to mutually create a fracture wave, if these columns had not been disintegrated still earlier by a fracture wave. The time of free fall of the upper structure for the height $h = 3.7\,\text{m}$ equals $\sqrt{2h/g} = 0.75\,\text{s}$ which is much greater than the time 0.05 s necessary to disintegrate the whole building by a fracture wave if it was created immediately after the tensile failure of cold bearing columns.

By the way, the authors of the "theory" missed the fact that the maximum dynamic stress would travel all the way down at the speed 5 Km/s and that the fracture wave of disintegration should immediately follow the shock wave of compression because no material could bear the "enormous" compression stress that was, according to the theory, 64.5 times greater than the static stress. And so, the "theory" supports the fracture wave mechanism of the collapses, not the progressive failure mechanism. But, what happened is more complicated than what implied by the "theory".

Beyond the present calculation of dynamic overload, there is direct evidence that it is the thermal, not dynamic, stress that triggered the collapse of the neighboring 47-story tower. A portion of spilled fuel got on the top of the latter building and set a fire there. There were no upper structure above to fall down and start the collapse as the "theory" claims. It is only the thermal stresses that could trigger a fracture wave of disintegration in this case.

4. Free fall: fracture wave vs. progressive failure

To explain the free fall regime of the collapses, the "theory" assumes that at any moment of collapse there are exist an upper part of the tower that moves down and an underlying structure that rests intact, and that the underlying structure produces no reaction and resistance to the falling upper part because "the inelastic energy dissipation in plastic hinges of collapsing columns is much less than the kinetic energy of the falling mass".

This thesis is an evident blunder. The loss of kinetic energy of the falling mass is caused, mostly, by the elastic deformation of the underlying structure, and the resistance of a solid structure is due, mostly, to the elastic reaction that can stop the falling mass even if the inelastic energy dissipation is zero. For example, the "enormous" dynamic overload from the impact of the upper structure on the critical floor, which is according to the "theory" 64.5 times greater than the static load, should be also applied to the moving mass creating the force of resistance, by the Newton law, which is disregarded by the "theory".

Even within the framework of progressive failure model, the inelastic energy dissipation was miscalculated. It is true that the energy dissipated in plastic hinges of buckling columns of the underlying structure is about 8.4 times less than the decrease of the gravitational energy of the upper structure falling down in the critical floor. However, it is valid with account of only one plastic hinge per column of one floor, which contradicts to the following facts. First, the dynamic instability of columns/bars occurs by higher order modes of buckling (the greater is the dynamic load, the higher is the mode of buckling). Secondly, the debris should be two-meter-long segments of columns, which is very far from the reality. The same calculation would predict the ratio 2.8, and not 8.4, if three plastic hinges per column of one floor would be taken into account. In this case the debris would be one-meter-long segments of columns, which is closer to the reality. Any accurate calculation would show that the inelastic energy dissipation during the collapse is significant and comparable with the decrease of gravitational energy and the value of the corresponding kinetic energy.

Let us analyze the model of "progressive failure" avoiding the mistakes of the "theory". Suppose that all columns of the critical floor disappeared and the upper structure freely fell down on the underlying structure, as suggested in the "theory". From the accurate solution of Section 3 it follows that the maximum total stress in the columns of the underlying structure from the impact is equal to 340 MPa which is almost twice less than the yield strength of steel. This value must be close to the buckling stress of well-designed columns, with account of the safety factor. Taking into consideration that 340 MPa is greatly exaggerated by the free fall assumption and that this maximum stress is kept for a quite short time much less than about 0.01 s, it is doubtful that this improvised impact could produce any fracture or failure in the columns of the underlying structure. The buckling failure could be possible only in the case of very flexible columns of a very bad design because the buckling stress of even flexible columns is several times greater for the dynamic load than that for the static load due to higher modes of buckling.

Hence, the progressive failure is nothing but a result of the miscalculations of the "theory".

The only possible scientific explanation of the free fall regime of the collapses is that the buildings were disintegrated by fracture waves at the beginning of each collapse, which took about 0.05 s because fracture waves propagate at the speed about 6 Km/s in steel, glass, concrete, and marble. The disintegration by cracking is unnoticeable for such a short time because the volume of cracks is very small as compared to the volume of intact material, with no visible deformations during that time. The cracking of the tower for 0.05 s produced the sound emission heard as an explosion. A boom would be heard if the cracking took 10 s as suggested by the "theory" of progressive failure. For a fracture wave to propagate, a material should be loaded by compressive stresses of high energy because this energy is released in the fracture wave. (See Appendix).

The material velocity of fragments behind the fracture wave has an order of 10 to 100 m/s depending on material and stress; for glass it is about four times greater than for steel. The size of fragments behind the fracture wave depends on stress and material; for steel it is about 5 to 50 cm, and for glass, concrete and marble it is about 0.1 to 10 μm. Combination of free gravitational fall of heavy steel fragments and explosive sweep-away of particles of glass, concrete and marble in the form of dust clouds created the picture of the collapses observed on TV screens.

A classical example of the fracture wave action is a Batavian tear of glass. If one breaks a tiny tail on the Batavian tear, it explodes into a cloud of dust with a loud sound. It takes 10^{-5} s to pulverize a five-centimeter tear by a fracture wave and 10^{-2} s to create a one-meter cloud of micron-size particles of glass.

And so, the fracture wave mechanism of the WTC collapse and the collapse of the neighboring 47-story building is supported by the following facts:

(i) All buildings collapsed in free fall regime;
(ii) Each collapse was accompanied by a sound of explosion;
(iii) The size of steel fragments and dust particles of glass, concrete and marble corresponds to that calculated in the theory of fracture waves;
(iv) Dust particles created clouds expanded for several hundred meters.

5. Fracture wave vs. shock wave

Let us summarize the basic properties of shock waves and fracture waves following Cherepanov (1979). Both waves represent some fronts of discontinuity of material density, velocity, and stresses.

Shock waves are produced by impacts and explosions in gases, liquids, and solids. The density of material behind a shock wave is always greater than in front of the wave. The maximum compressive stress behind a shock wave is always greater than in front of the wave. The normal velocity of a shock wave is always greater than the speed of sound (in solids and liquids, slightly greater). The thickness of a shock wave is defined by viscous properties of a material.

It is a widely-spread but wrong belief that a shock wave can disintegrate a material into small fragments*. To disintegrate means to crack, but a shock wave cannot crack a solid because any cracking is accompanied by a dilatation of the solid. A fracture wave should always follow a shock wave in order to disintegrate a material.

Fracture waves can be produced only by compressive stresses in solids. Fracture wave separates an intact material in front of the wave from a destructed material behind the wave. The thickness of a fracture wave has an order of the size of material fragments behind the wave. The mean density of a material behind a fracture wave is always less than in front of the wave. The maximum compressive stress behind a fracture wave is always less than in front of the wave. The normal velocity of steady fracture waves is

* Dr. Bazant and many anonymous referees have stuck to this opinion.

equal to the speed of sound (longitudinal elastic wave). For unsteady fracture waves, the normal velocity is less than the speed of sound and determined from the solution of a particular problem, that is, depends on boundary and initial conditions.

6. Conclusions

It was shown that, in the tragic collapses on September 11, 2001:

(i) Creep played no part, and these were the thermal stresses that triggered the collapses;

(ii) Tensile failure of some cold bearing columns from the thermal stresses started the collapses, and not the creep buckling of hot columns;

(iii) Dynamic stress from the impact of the upper structure on the initial stage of each collapse was insufficient even to produce a failure of the underlying structure, not to say about a progressive failure of entire buildings;

(iv) A fracture wave, originated after tensile failure of some cold bearing columns in the critical floor, disintegrated each building for about 0.05 s and produced the sound of explosion, and steel fragments freely fell down while glass, concrete and marble fragments created dust clouds.

The fracture wave mechanism is the most plausible hypothesis because it is supported by the facts of the matter and by accurate calculations. However, the exact conditions triggering fracture waves need to be studied which is a challenging problem for the future.

Acknowledgement

This author thanks the editors and anonymous referees of the technical journals that rejected the author's explanation because it contradicted to the official "theory". Their comments have stimulated this author to undertake the present analysis of the "theory" that many trust to so deeply.

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Appendix. The theory of fracture waves

The fracture wave is a front of discontinuity of mass density, material velocity and stresses that separates an intact material in front of the fracture wave from a destructed one behind. The mass density behind a fracture wave is always less than that in front of the wave because any cracking of a solid dilates it. The thickness of a fracture wave has an order of the size of fragments of the destructed material behind the wave.

The conservation laws on the fracture wave can be written as follows:

mass conservation

$$\rho_0(V - v_0) = \rho_F(V - v_F), \tag{A.1}$$

momentum conservation

$$-\sigma_0 + \rho_0(V - v_0)^2 = -\sigma_F + \rho_F(V - v_F)^2, \tag{A.2}$$

energy conservation

$$\frac{1}{2}(V - v_0)^2 + \frac{U_0}{\rho_0} - \frac{\sigma_0}{\rho_0} = \frac{1}{2}(V - v_F)^2 + \frac{U_F}{\rho_F} - \frac{\sigma_F}{\rho_F} + \frac{D}{\rho_F}. \tag{A.3}$$

Here: lower index 0 refers to the intact material in front of the fracture wave, lower index F refers to the destructed material behind the fracture wave, V is the normal velocity of the fracture wave, v is the material velocity normal to the fracture front, ρ is the material density, U is the volume density of elastic energy of the material, σ is the stress component normal to the fracture front, D is the volume density of surface energy of the destructed material.

Equations (A.1) and (A.3) can be re-written as follows:

$$\frac{1}{\rho_0} - \frac{1}{\rho_F} = \frac{1}{\rho_0}\frac{v_F - v_0}{V - v_0}, \tag{A.4}$$

$$\sigma_0 - \sigma_F = \rho_0(V - v_0)(v_F - v_0), \tag{A.5}$$

$$\frac{D}{\rho_F} = \frac{U_0}{\rho_0} - \frac{U_F}{\rho_F} + \frac{1}{2}(\sigma_0 + \sigma_F)\left(\frac{1}{\rho_F} - \frac{1}{\rho_0}\right). \tag{A.6}$$

Let us assume that the intact material is at rest, i.e., $v_0 = 0$. Then, the values of ρ_F, v_F and D can be found from equations (A.4) to (A.6) as follows:

$$\rho_F = \frac{\rho_0}{1 - \dfrac{\sigma_0 - \sigma_F}{\rho_0 V^2}}, \tag{A.7}$$

$$v_F = \frac{\sigma_0 - \sigma_F}{\rho_0 V}, \tag{A.8}$$

$$D = \frac{\rho_F}{\rho_0}\left(U_0 - \frac{\sigma_0^2 - \sigma_F^2}{2\rho_0 V^2}\right) - U_F. \qquad (A.9)$$

From equations (A.7) and (A.8), it follows that $v_F < 0$ and $\sigma_0 < 0$ because $\rho_0 > \rho_F$ due to the physical meaning of the fracture wave. It means that the fracture wave can propagate only in a compressed material and the velocity of destructed material is always opposite to the normal velocity of the fracture wave.

Let us confine ourselves by steady fracture waves. Assume for a moment that $V < c$ where c is the speed of longitudinal elastic waves in the material. An elastic forerunning field ahead of such a fracture wave would also be steady-state. However, from the theory of elasticity it follows that steady elastic field can propagate only at the speed of c. (The shear wave is, evidently, impossible). It means the assumption is not valid, so that $V \geq c$ for steady fracture waves. From equation (A.7) it follows that ρ_F is very close to ρ_0, i.e. $\rho_F \approx \rho_0$ because $\sigma_0 << E$ and $\rho_0 V^2 \geq \rho_0 c^2 \approx E$. And so, equation (A.9) becomes

$$D = U_0 - \frac{\sigma_0^2}{2\rho_0 V^2} - \left(U_F - \frac{\sigma_F^2}{2\rho_0 V^2}\right). \qquad (A.10)$$

Let us neglect the mutual contacts of fragments of the destructed material because of lost coherence, so that $\sigma_0 >> \sigma_F$ and $U_0 >> U_F$, and equations (A.8) and (A.10) take the form

$$v_F = \frac{\sigma_0}{\rho_0 V}, \qquad D = U_0 - \frac{\sigma_0^2}{2\rho_0 V^2}. \qquad (A.11)$$

Let us analyze D as a function of V. Based on the principle of minimum of surface energy the value of D should be minimum possible because D is the surface energy of the destructed material in unit volume. From this principle, it follows that $V = c$, because D is minimal at $V = c$. In 1967, the same conclusion was derived by this author and Leo A. Galin based on the analogy between the fracture wave and detonation wave in TNT (the Chapman-Jouguet hypothesis).

And so, the basic equations of steady fracture waves can be summarized as follows:

$$V = c, \qquad D = U_0 - \frac{\sigma_0^2}{2\rho_0 c^2}, \qquad v_F = \frac{\sigma_0}{\rho_0 c}, \qquad \rho_F \approx \rho_0. \qquad (A.12)$$

These equations are valid for any anisotropic, quasi-brittle materials whose dimensions are much greater than the thickness of the fracture wave, that is the size of fragments of the destructed material. Using the effective surface energy Γ of the cracking

of the material known from fracture mechanics tests, one can estimate the size of fragments of the destructed material in terms of Γ and D. E.g., one can find that:
if fragments are identical cubes with rib d,

$$d = 12\frac{\Gamma}{D}, \qquad \text{and} \tag{A.13}$$

if fragments are long identical needles of hexagonal cross-section with rib r,

$$2r = \frac{8}{\sqrt{3}}\frac{\Gamma}{D}. \tag{A.14}$$

The needle shape of fragments was observed in some experiments with glass specimens.

Suppose an isotropic material is in the state of hydrostatic compression by stress σ_0 in front of the fracture wave. In this case, we have

$$U_0 = \frac{3}{2}\frac{(1-2\nu)}{E}\sigma_0^2, \qquad \rho_0 c^2 = \frac{E(1-\nu)}{(1+\nu)(1-2\nu)}. \tag{A.15}$$

Here E and ν are Young's modulus and Poisson's ratio. Using equations (A.12) to (A.15) we get the following results for silicate glass at $\Gamma = 2\,\text{N/m}$, $\rho_0 = 2.4\,\text{g/cm}^3$, $E = 7\times10^4\,\text{N/mm}^2$, and $\nu = 0.17$: $V = c = 5950\,\text{m/s}$ and
at $\sigma_0 = -500\,\text{N/mm}^2$: $v_F = -35\,\text{m/s}$, $D = 1.9\,\text{N/mm}^2$, $d = 12.8\,\mu\text{m}$, $2r = 5\,\mu\text{m}$;
at $\sigma_0 = -1\,\text{KN/mm}^2$: $v_F = -70\,\text{m/s}$, $D = 7.5\,\text{N/mm}^2$, $d = 3.2\,\mu\text{m}$, $2r = 1.2\,\mu\text{m}$;
at $\sigma_0 = -5\,\text{KN/mm}^2$: $v_F = -350\,\text{m/s}$, $D = 187.5\,\text{N/mm}^2$, $d = 0.1\,\mu\text{m}$, $2r = 0.05\,\mu\text{m}$.

The glass needles in the range of $2r$ from about 1 μm to about 10 μm were observed experimentally, Cherepanov (1979). For rocks and building materials like concrete, marble, and wood the figures for v_F, D, d, and r are comparable to those in glass because their specific surface energy Γ is comparable with that of glass.

The dust produced by the collapses of three buildings on September 11, 2001 was created by micron-size fragments of glass, concrete and marble, in correspondence with these calculations because the thickness of fracture waves in these materials was much less than any structural dimension.

Suppose, now, that a fracture wave propagates in a steel column between the bottom and ceiling of a floor. Suppose that the column is a solid, vertical, round cylinder and that the steel fragments behind the fracture wave represent some segments of the column cracked along sliding planes inclined at 45° to the axis of the cylinder. In this case the height of the segment h_s is equal to

$$h_s = 2\sqrt{2}\frac{\Gamma}{D}, \tag{A.16}$$

and

$$U_0 = \frac{\sigma_0^2}{2E}, \qquad \rho_0 c^2 = \frac{E(1-\nu)}{(1+\nu)(1-2\nu)}. \tag{A.17}$$

Here σ_0 is the mean compressive stress in the intact segment in front of the fracture wave from gravitational, thermal and technological stresses (e.g. from rolling, welding, and assembling). The fracture wave releasing the potential energy of compressive stresses outstrips the group speed $\sqrt{E/\rho_0}$ so that at the distance of 4 m, the height of the column, it goes ahead by about 0.3 m.

Using equations (A.12), (A.16) and (A.17) one can find for steel: at $\Gamma = 20$ KN/m, $\rho_0 = 7.9\,\text{g/cm}^3$, $E = 200\,\text{GPa}$, and $\nu = 0.33$: $V = c = 5850\,\text{m/s}$ and
at $\sigma_0 = -1$ KN/mm^2: $v_F = -21\,\text{m/s}$, $D = 0.83\,\text{N/mm}^2$, $h_s = 6.8\,\text{cm}$;
at $\sigma_0 = -500\,\text{N/mm}^2$: $v_F = -10\,\text{m/s}$, $D = 0.2\,\text{N/mm}^2$, $h_s = 27.2\,\text{cm}$.

It should be noted that the effective surface energy Γ of steel includes the plastic energy dissipated in a thin layer on the crack surface. And so, the rough estimate of the size of steel debris based on the accurate energy balance in the fracture wave provides a realistic picture relevant to the collapses of all three buildings on September 11, 2001 because h_s is much less than the height of a column in a floor.

Another approach to the estimate of steel debris created during the collapses of the buildings is to model the building as a solid material volume of the same mass and shape, structurally orthotropic with vertical axis of symmetry and polar planes of symmetry, whose stiffness in these directions is equal to the stiffness of the building. The effective surface energy of this model material is equal to $(1-\varepsilon)^\Gamma$ where ε is the ratio of the empty space volume to the volume of the building, and Γ is the effective surface energy of steel. The propagation of fracture waves in porous materials requires a similar approach.

RAPID COMMUNICATION

Why Did the World Trade Center Collapse?—Simple Analysis[1]

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Abstract: This paper presents a simplified approximate analysis of the overall collapse of the towers of World Trade Center in New York on September 11, 2001. The analysis shows that if prolonged heating caused the majority of columns of a single floor to lose their load carrying capacity, the whole tower was doomed.

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CE Database keywords: New York; New York City; Disasters; Buildings; High-rise; Collapse; Analysis; Terrorism.

Introduction and Failure Scenario

The 110-story towers of the World Trade Center were designed to withstand as a whole the forces caused by a horizontal impact of a large commercial aircraft (Appendix I). So why did a total collapse occur? The cause was the dynamic consequence of the prolonged heating of the steel columns to very high temperature. The heating lowered the yield strength and caused viscoplastic (creep) buckling of the columns of the framed tube along the perimeter of the tower and of the columns in the building core. The likely scenario of failure is approximately as follows.

In stage 1 (Fig. 1), the conflagration, caused by the aircraft fuel spilled into the structure, causes the steel of the columns to be exposed to sustained temperatures apparently exceeding 800°C. The heating is probably accelerated by a loss of the protective thermal insulation of steel during the initial blast. At such temperatures, structural steel suffers a decrease of yield strength and exhibits significant viscoplastic deformation (i.e., creep—an increase of deformation under sustained load). This leads to creep buckling of columns (Bažant and Cedolin 1991, Sec. 9), which consequently lose their load carrying capacity (stage 2). Once more than half of the columns in the critical floor that is heated most suffer buckling (stage 3), the weight of the upper part of the structure above this floor can no longer be supported, and so the upper part starts falling down onto the lower part below the critical floor, gathering speed until it impacts the lower part. At that moment, the upper part has acquired an enormous kinetic energy and a significant downward velocity. The vertical impact of the mass of the upper part onto the lower part (stage 4) applies enormous vertical dynamic load on the underlying structure, far exceeding its load capacity, even though it is not heated. This causes failure of an underlying multifloor segment of the tower (stage 4), in which the failure of the connections of the floor-carrying trusses to the columns is either accompanied or quickly followed by buckling of the core columns and overall buckling of the framed tube, with the buckles probably spanning the height of many floors (stage 5, at right), and the upper part possibly getting wedged inside an emptied lower part of the framed tube (stage 5, at left). The buckling is initially plastic but quickly leads to fracture in the plastic hinges. The part of building lying beneath is then impacted again by an even larger mass falling with a greater velocity, and the series of impacts and failures then proceeds all the way down (stage 5).

Elastic Dynamic Analysis

The details of the failure process after the decisive initial trigger that sets the upper part in motion are of course very complicated and their clarification would require large computer simulations. For example, the upper part of one tower is tilting as it begins to fall (Appendix II); the distribution of impact forces among the underlying columns of the framed tube and the core, and between the columns and the floor-supporting trusses, is highly nonuniform; etc. However, a computer is not necessary to conclude that the collapse of the majority of columns of one floor must have caused the whole tower to collapse. This may be demonstrated by the following elementary calculations, in which simplifying assumptions most optimistic in regard to survival are made.

For a short time after the vertical impact of the upper part, but after the elastic wave generated by the vertical impact has propagated to the ground, the lower part of the structure can be approximately considered to act as an elastic spring [Fig. 2(a)]. What is its stiffness C? It can vary greatly with the distribution of the impact forces among the framed tube columns, between these columns and those in the core, and between the columns and the trusses supporting concrete floor slabs.

[1]The original version with Eqs. (1) and (2) was originally submitted to ASCE on September 13, 2001, and an expanded version with Eq. (3) was submitted to ASCE on September 22, 2001. The appendices were added between September 28 and October 5, 2001; The preliminary report (Bažant and Zhou 2001) on which this article is based was posted on September 14, 2001, at (http://www.civil.northwestern.edu/news), (http://www3.tam.uiuc.edu/news/200109wtc), and (http://math.mit.edu/~bazant).

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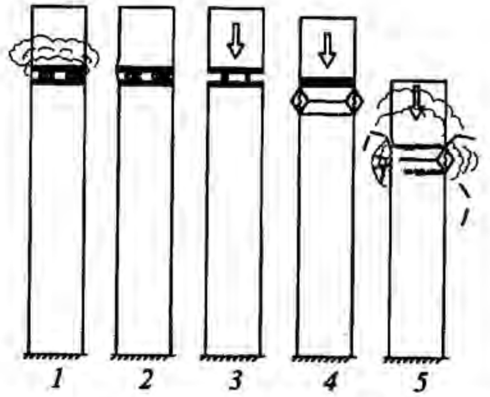

Fig. 1. Stages of collapse of the building (floor height exaggerated)

For our purpose, we may assume that all the impact forces go into the columns and are distributed among them equally. Unlikely though such a distribution may be, it is nevertheless the most optimistic hypothesis to make because the resistance of the building to the impact is, for such a distribution, the highest. If the building is found to fail under a uniform distribution of the impact forces, it would fail under any other distribution. According to this hypothesis, one may estimate that $C \approx 71$ GN/m (due to unavailability of precise data, an approximate design of column cross sections had to be carried out for this purpose).

The downward displacement from the initial equilibrium position to the point of maximum deflection of the lower part (considered to behave elastically) is $h+(P/C)$ where P = maximum force applied by the upper part on the lower part and h = height of critical floor columns (= height of the initial fall of the upper part) ≈ 3.7 m. The energy dissipation, particularly that due to the inelastic deformation of columns during the initial drop of the upper part, may be neglected, i.e., the upper part may be assumed to move through distance h almost in a free fall (indeed, the energy dissipated in the columns during the fall is at most equal to $2\pi\times$ the yield moment of columns, $\times$ the number of columns, which is found to be only about 12% of the gravitational potential energy release if the columns were cold, and much less than that at 800°C). So the loss of the gravitational potential energy of the upper part may be approximately equated to the strain energy of the lower part at maximum elastic deflection. This gives the equation $mg[h+(P/C)]=P^2/2C$ in which m = mass of the upper part (of North Tower) $\approx 58\times10^6$ kg, and g = gravity acceleration. The

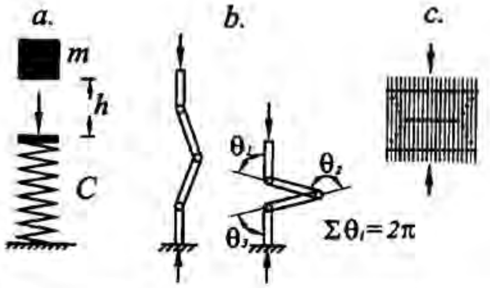

Fig. 2. (a) Model for impact of upper part on lower part of building; (b) Plastic buckling mechanism on one column line; (c) Combination of plastic hinges creating a buckle in the tube wall

solution $P=P_{dyn}$ yields the following elastically calculated overload ratio due to impact of the upper part:

$$P_{dyn}/P_0 = 1+\sqrt{1+(2Ch/mg)} \approx 31 \qquad (1)$$

where $P_0 = mg$ = design load capacity. In spite of the approximate nature of this analysis, it is obvious that the elastically calculated forces in columns caused by the vertical impact of the upper part must have exceeded the load capacity of the lower part by at least an order of magnitude.

Another estimate, which gives the initial overload ratio that exists only for a small fraction of a second at the moment of impact, is

$$P_{dyn}/P_0 = (A/P_0)\sqrt{2\rho g E_{ef} h} \approx 64.5 \qquad (2)$$

where A = cross section area of building; E_{ef} = cross section stiffness of all columns divided by A; and ρ = specific mass of building per unit volume. This estimate is calculated from the elastic wave equation which yields the intensity of the step front of the downward pressure wave caused by the impact if the velocity of the upper part at the moment of impact on the critical floor is considered as the boundary condition (Bažant and Cedolin 1991, Sec. 13.1). After the wave propagates to the ground, the former estimate is appropriate.

Analysis of Inelastic Energy Dissipation

The inelastic deformation of the steel of the towers involves plasticity and fracture. Since we are not attempting to model the details of the real failure mechanism but seek only to prove that the towers must have collapsed and do so in the way seen ("Massive" 2001; *American* 2001), we will here neglect fracture, even though the development of fractures, especially in column connections, is clearly discerned in the photographs of the collapse. Assuming the steel is to behave plastically, with unlimited ductility, we are making the most optimistic assumption with regard to the survival capacity of the towers (in reality, the plastic hinges, especially the hinges at column connections, must have fractured, and done so at relatively small rotation, causing the load capacity to drop drastically).

The basic question to answer is: Can the fall of the upper part be arrested by energy dissipation during plastic buckling, which follows the initial elastic deformation? Many plastic failure mechanisms could be considered, for example: (1) the columns of the underlying floor buckle locally (Fig. 1, stage 2); (2) the floor-supporting trusses are sheared off at the connections to the framed tube and to the core columns and fall down within the tube, depriving the core columns and the framed tube of lateral support, and thus promoting buckling of the core columns and of the framed tube under vertical compression [Fig. 1, stage 4, and Fig. 2(c)]; or (3) the upper part is partly wedged within the emptied framed tube of the lower part, pushing the walls of the framed tube apart (Fig. 1, stage 5). Although each of these mechanisms can be shown to lead to total collapse, a combination of the last two seems more realistic [the reason: multistory pieces of the framed tube, with nearly straight boundaries apparently corresponding to plastic hinge lines causing buckles on the framed tube wall, were photographed falling down, "Massive 2001"; *American* 2001].

Regardless of the precise failure mode, experience with buckling indicates that while many elastic buckles simultaneously coexist in an axially compressed tube, the plastic deformation localizes (because of plastic bifurcation) into a single buckle at a time

[Fig. 1, stage 4, and Fig. 2(c)], and so the buckles must fold one after another. Thus, at least one plastic hinge, and no more than four plastic hinges, per column line are needed to operate simultaneously in order to allow the upper part to continue moving down [Fig. 2(b)] (Bažant and Cedolin 1991). (This is also true if the columns of only one floor are buckling at a time.) At the end, the sum of the rotation angles θ_i ($i=1,2,\dots$) of the hinges on one column line, $\Sigma\theta_i$, cannot exceed 2π [Fig. 2(b)]. This upper-bound value, which is independent of the number of floors spanned by the buckle, is used in the present calculations since, in regard to survival, it represents the most optimistic hypothesis, maximizing the plastic energy dissipation.

Calculating the dissipation per column line of the framed tube as the plastic bending moment M_p of one column (Jirásek and Bažant 2002) times the combined rotation angle $\Sigma\theta_i=2\pi$ [Fig. 2(b)] and multiplying this by the number of columns, one concludes that the plastically dissipated energy W_p is, optimistically, of the order of 0.5 GN m (for lack of information, certain details such as the wall thickness of steel columns, were estimated by carrying out approximate design calculations for this building).

To attain the combined rotation angle $\Sigma\theta_i=2\pi$ of the plastic hinges on each column line, the upper part of the building must move down by the additional distance of at least one floor below the floor where the collapse started, and so the total release of gravitational potential energy is $W_g=mg\cdot 2h\approx 2\times 2.1\ \mathrm{GN\,m}=4.2\ \mathrm{GN\,m}$. To arrest the fall, the kinetic energy of the upper part, which is equal to the potential energy release, would have to be absorbed by the plastic hinge rotations, i.e., W_p would have to be larger than W_g. Rather,

$$W_g/W_p\approx 8.4 \tag{3}$$

So, even under the most optimistic assumptions by far, the plastic deformation can dissipate only a small part of the kinetic energy acquired by the upper part of building.

When the next buckle with its group of plastic hinges forms, the upper part has already traveled many floors down and has acquired a much higher kinetic energy; the percentage of the kinetic energy dissipated plastically is then of the order of 1%. The percentage continues to decrease further as the upper part moves down. If fracturing in the plastic hinges were considered, a still smaller (in fact much smaller) energy dissipation would be obtained. So the collapse of the tower must be an almost free fall. This conclusion is supported by the observation that the duration of the collapse of each tower, reported as roughly 10 s, was about the same as the duration of a free fall in a vacuum from the tower top $H=416$ m to the top of the heap of debris ($H_0=25$ m), which is $t=\sqrt{2(H-H_0)/g}=8.93$ s. It further follows that the brunt of vertical impact must have gone directly into the columns of the framed tube and the core, and that the front of collapse of the floors could not have advanced substantially ahead of the front of collapse of the framed tube, since otherwise the collapse of the framed tube would have had to take significantly longer than 9 s.

Closing Comments and Problems of Disaster Mitigation

Designing tall buildings to withstand this sort of attack seems next to impossible. It would require a much thicker insulation of steel with blast-resistant protective cover. Replacing the rectangular framed tube by a hardened circular monolithic tube with tiny windows might help to deflect much of the debris of impacting aircraft and the fuel sideways, but regardless of cost, who would want to work in such a building?

The problems appear to be equally severe for concrete columns because concrete heated to such temperatures undergoes explosive thermal spalling, thermal fracture, and disintegration due to dehydration (Bažant and Kaplan 1996). These questions arise not only for buildings supported on many columns but also for the recent designs of tall buildings with a massive monolithic concrete core functioning as a tubular mast. These recent designs use high-strength concrete which, however, is even more susceptible to explosive thermal spalling and thermal fracture than normal concrete. The use of refractory concretes as the structural material invites many open questions (Bažant and Kaplan 1996). Special alloys or various refractory ceramic composites may, of course, function at such temperatures, but the cost would increase astronomically.

It will nevertheless be appropriate to initiate research on materials and designs that would postpone the collapse of the building so as to extend the time available for evacuation, provide a hardened and better insulated stairwell, or even prevent collapse in the case of a less severe attack such as an off-center impact, or the impact of an aircraft containing less fuel.

An important puzzle at the moment is why the adjacent 46-story building, into which no significant amount of aircraft fuel could have been injected, collapsed as well. Despite the lack of data at present, the likely explanation seems to be that high temperatures (though possibly well below 800 °C) persisted on at least one floor of that building for a much longer time than specified by the current fire code provisions.

Appendix I. Elastic Dynamic Response to Aircraft Impact

A simple estimate based on the preservation of the combined momentum of the impacting Boeing 767-200 ($\sim 179{,}000\ \mathrm{kg}\times 550\ \mathrm{km/h}$) and the momentum of the equivalent mass M_{eq} of the interacting upper half of the tower ($\sim 141\times 10^6\ \mathrm{kg}\times v_0$) indicates that the initial average velocity v_0 imparted to the upper part of the tower was only about $0.7\ \mathrm{km/h}=0.19\ \mathrm{m/s}$. The response may be assumed to be dominated by the first free vibration mode, of period T_1. Then the maximum deflection $w_0=v_0T_1/2\pi$. Approximately, $T_1=14$ s, based on estimating (very roughly) the bending stiffness of the tower and approximating it as a vibrating cantilever of a uniform mass distribution. This gives $w_0=0.4$ m, which is well within the range of the elastic behavior of the tower. So it is not surprising that the aircraft impact per se damaged the tower only locally.

The World Trade Center was designed for an impact of a Boeing 707-320 rather than a Boeing 767-200. But note that the maximum takeoff weight of that older aircraft is only 15% less than that of a Boeing 767-200. Besides, the maximum fuel tank capacity of that aircraft is only 4% less. These differences are well within the safety margins of design. So the observed response of the towers proves the correctness of the dynamic design. What was not considered in design was the temperature that can develop in the ensuing fire. Here the experience from 1945 might have been deceptive. That year, a two-engine bomber (B-25), flying at about 400 km/h, hit in fog the Empire State Building (381-m tall, built in 1930) at the 79th floor (278 m above ground)—the steel structure suffered no significant damage, and the fire was confined essentially to one floor (Levy and Salvadori 1992).

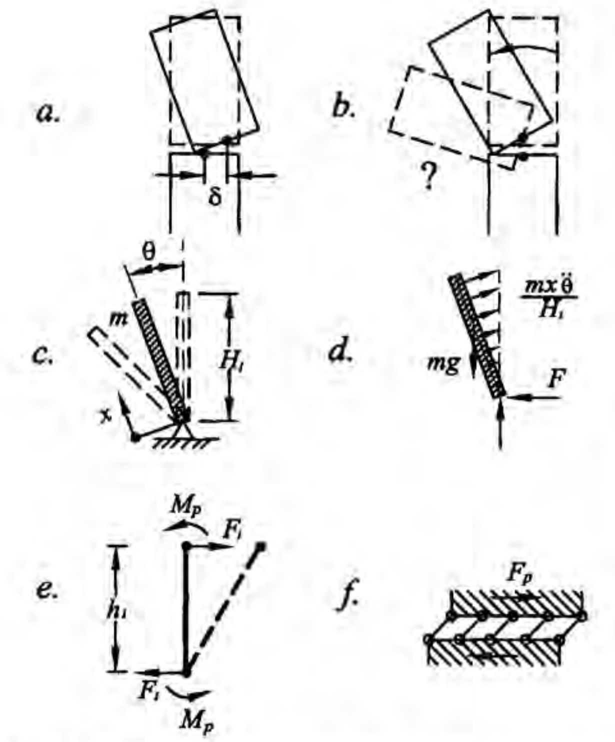

Fig. 3. Pivoting of upper part of tower about its base, (a,b) with and without horizontal shear at base; (c) Model for simplified analysis; (d) Free-body diagram with inertia forces; (d,e) Plastic horizontal shearing of columns in critical floor at base

Appendix II. Why Didn't the Upper Part Pivot About Its Base?

Since the top part of the South Tower tilted [Fig. 3(a)], many people wonder: Why didn't the upper part of the tower fall to the side like a tree, pivoting about the center of the critical floor? [Fig. 3(b)]. To demonstrate why, and thus to justify our previous neglect of tilting, is an elementary exercise in dynamics.

Assume the center of the floor at the base of the upper part [Fig. 3(b)] to move for a while neither laterally nor vertically, i.e., act as a fixed pivot. Equating the kinetic energy of the upper part rotating as a rigid body about the pivot at its base [Fig. 3(c)] to the loss of the gravitational potential energy of that part (which is here simpler than using the Lagrange equations of motion), we have $mg(1-\cos\theta)H_1/2 = (m/2H_1)\int_0^{H_1}(\dot{\theta}x)^2 dx$ where x = vertical coordinate [Fig. 3(c)]. This provides

$$\dot{\theta} = \sqrt{\frac{3g}{H_1}(1-\cos\theta)}, \quad \ddot{\theta} = \frac{3g}{2H_1}\sin\theta \qquad (4)$$

where θ = rotation angle of the upper part; H_1 = its height; and the superposed dots denote time derivatives [Fig. 3(c)].

Considering the dynamic equilibrium of the upper part as a free body, acted upon by distributed inertia forces and a reaction with horizontal component F at base [Fig. 3(d)], one obtains $F = \int_0^{H_1}(m/H_1)\ddot{\theta}\cos\theta x\,dx = \frac{1}{2}H_1 m\ddot{\theta}\cos\theta = \frac{3}{8}mg\sin 2\theta$. Evidently, the maximum horizontal reaction during pivoting occurs for $\theta = 45°$, and so

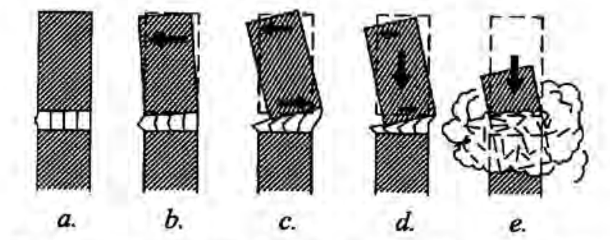

Fig. 4. Scenario of tilting of upper part of building (South Tower)

$$F_{max} = \tfrac{3}{8}mg = \tfrac{3}{8}P_0 \approx 320\text{ MN} \qquad (5)$$

where, for the upper part of South Tower, $m \approx 87 \times 10^6$ kg.

Could the combined plastic shear resistance F_p of the columns of one floor [Fig. 3(f)] sustain this horizontal reaction? For plastic shear, there would be yield hinges on top and bottom of each resisting column; Fig. 3(e) (again, aiming only at an optimistic upper bound on resistance, we neglect fracture). The moment equilibrium condition for the column as a free body shows that each column can at most sustain the shear force $F_1 = 2M_p/h_1$ where $h_1 \approx 2.5$ m = effective height of column, and $M_p \approx 0.3$ MN m = estimated yield bending moment of one column, if cold. Assuming that the resisting columns are only those at the sides of the framed tube normal to the axis of rotation, which number about 130, we get $F_p \approx 130F_1 \approx 31$ MN. So, the maximum horizontal reaction to pivoting would cause the overload ratio

$$F_{max}/F_p \approx 10.3 \qquad (6)$$

if the resisting columns were cold. Since they are hot, the horizontal reaction to pivoting would exceed the shear capacity of the heated floor still much more (and even more if fracture were considered).

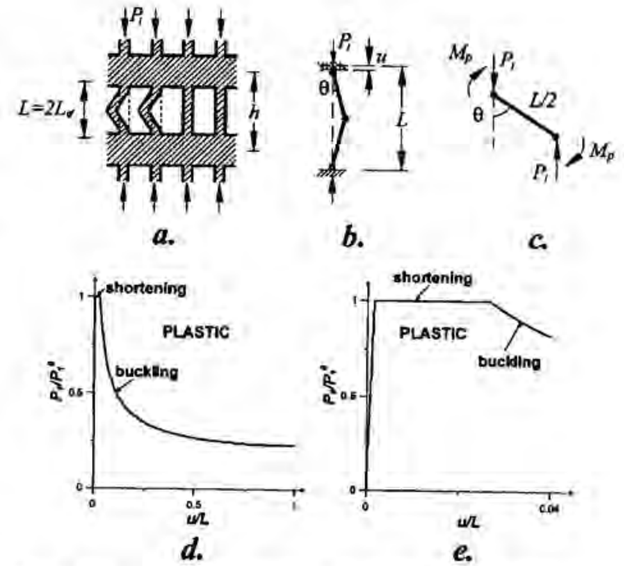

Fig. 5. (a) Plastic buckling of columns; (b) Plastic hinge mechanism; (c) Free-body diagram; (d) Dimensionless diagram of load P_1 versus axial shortening u of columns of the towers if the effects of fracture and heating are ignored; and (e) Beginning of this diagram in an expanded horizontal scale (imperfections neglected)

Since F is proportional to $\sin 2\theta$, its value becomes equal to the plastic limit when $\sin 2\theta = 1/10.3$. From this we further conclude that the reaction at the base of the upper part of South Tower must have begun shearing the columns plastically already at the inclination

$$\theta \approx 2.8° \tag{7}$$

The pivoting of the upper part must have started by an asymmetric failure of the columns on one side of building, but already at this very small angle the dynamic horizontal reaction at the base of the upper part must have reduced the vertical load capacity of the remaining columns of the critical floor (even if those were not heated). That must have started the downward motion of the top part of the South Tower, and afterwards its motion must have become predominantly vertical (Fig. 4). Hence, a vertical impact of the upper part onto the lower part must have been the dominant mechanism.

Finally, note that the horizontal reaction $F_{\max}$ is proportional to the weight of the pivoting part. Therefore, if a pivoting about the center of some lower floor were considered, $F_{\max}$ would be still larger.

Appendix III. Plastic Load-Shortening Diagram of Columns

Normal design deals only with initial bifurcation and small deflections, in which the diagram of load versus axial shortening of an elasto-plastic column exhibits hardening rather than softening. However, the columns of the towers suffered very large plastic deflections, for which this diagram exhibits pronounced softening. Fig. 5 shows this diagram as estimated for these towers. The diagram begins with plastic yielding at load $P_1^0 = A_1 f_y$ where A_1 = cross section area of one column and f_y = yield limit of steel. At axial shortening 3%, three plastic hinges form as shown in Fig. 5 (if we assume, optimistically, fixed ends). From the condition of moment equilibrium of the half-column as a free body (Fig. 5), the axial load then is $P_1 = 4M_p/L \sin\theta$, while, from the buckling geometry, the axial shortening is $u = L(1-\cos\theta)$, where L = distance between end hinges. Eliminating plastic rotation θ, we find that the plastic load-shortening diagram is given by

$$P_1 = \frac{4M_p}{L\sqrt{1-[1-(u/L)]^2}} \tag{8}$$

which defines the curve plotted in Fig. 5. This curve is an optimistic upper bound since, in reality, the plastic hinges develop fracture (Bažant and Planas 1998), and probably do so already at rather small rotations.

Note Added in Proof

An addendum to this paper will be published in the March 2002 issue of the *Journal of Engineering Mechanics*. An edited manuscript containing the information in the addendum was received by ASCE on October 13, 2001.

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Jirásek, M., and Bažant, Z. P. (2002). *Inelastic analysis of structures*, Wiley, New York.

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"Massive assault doomed towers." (2001). *Eng. News-Rec.*, 247(12), 10–13.

DISCUSSIONS AND CLOSURES

Discussion of "Why Did the World Trade Center Collapse?—Simple Analysis" by Zdeněk P. Bažant and Yong Zhou

January 2002, Vol. 128, No. 1, pp. 2–6.
DOI: 10.1061/(ASCE)0733-9399(2002)128:1(2)

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The writers deserve commendation for their lucid analysis of the World Trade Center collapse. The discusser would like to raise the following points.

1. The writers have mentioned that the fracture of hinges at the column connections must have caused the load capacity to drop drastically. More often in many tall buildings the floor-to-floor heights are not uniform and differ considerably at the bottom floors and at certain few top floor levels. Because of the creep buckling and differential shortening of the columns the connections give away, as they cannot resist any secondary moments. Hence, the hinge connections do not influence the failure of the columns and the converse is not true. As such, there is no scope for the formation of a plastic mechanism.

2. The discusser does not agree with the contention of the writers that the walls of the framed tube are pushed apart during the collapse. The structure being a tubular one, there is a complete void near to the center of gravity of the tower. During collapse the core columns will tend to fall inwardly and the perimeter columns also follow suit. Also, the upper part can partly wedge within the emptied framed tube of the lower part, only when the upper floor can fall as a single block. The core columns, floor trusses, and the perimeter columns separate out at collapse and fall mostly as individual units onto the lower floor and wedging is not possible.

3. The aircraft had hit the North Tower between the 90 and 96 floors and the impact was an almost centered one. But, the South Tower was hit by an aircraft between the 75 and 84 floors and the impact was an off-centered one affecting the corner portion of the building heavily. The 78th floor of the South Tower had a sky lobby and could have had a different structural arrangement, with a load capacity lower than that of the other floors. The off-centered impact could have produced a torque, which might have influenced the tilting of the upper part of the South Tower. It is interesting to note that the destroyed floors of the North Tower by direct impact of the aircraft had no sky lobby floor.

4. The columns in the floor that were directly hit by the aircraft lost their capacity to transmit and bear loads any further. Instead, they hung onto the top floors and because of their enormous self-weight exerted a pulling force on the floors above leading ultimately to a pancake failure of the tower. This is evident in the early failure of the South Tower where the number of floors, above the direct hit destroyed floors, is higher than the North Tower.

5. The bending rigidity index (BRI) (Taranath 1998) of the towers is 33, implying a greater flexibility. After the impact of the aircraft, the South Tower because of its flexibility swayed for a duration of around 7–10 s. If the upper part of the South Tower has to pivot about its base, it should have happened during the period of sway, by shifting the center of gravity away by several feet, which is impossible.

Reference

Taranath, S. B. (1998). *Steel, concrete, and composite design of tall buildings*, 2nd Ed., McGraw-Hill, New York.

Closure to "Why Did the World Trade Center Collapse?—Simple Analysis" by Zdeněk P. Bažant and Yong Zhou

January 2002, Vol. 128, No. 1, pp. 2–6.
DOI: 10.1061/(ASCE)0733-9399(2002)128:1(2)

Zdeněk P. Bažant, F.ASCE,[1] and Yong Zhou[2]

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[2]Graduate Research Assistant, Northwestern Univ., Evanston, IL 60208.

Srivakumar's comments are thought provoking and deeply appreciated. However, although his five points introduce interesting connotations, the writers cannot agree with his reservations and objections, for the following reasons.

1. It is not true that "there is no scope for the formation of a plastic failure mechanism." Even though the connection is probably weaker than the column itself, its moment capacity is not zero, which means that the failing connection will not act as a hinge but as a plastic hinge (or fracturing hinge). Moreover, even if the connections are weaker than the columns, the plastic hinges will not necessarily form at the connections because the connections might not in general lie at the locations that create the failure mechanism with the lowest energy dissipation requirement.

2. It was not stated in the paper that "the walls of the framed tube are pushed apart during collapse." What was stated in the paper is that one may consider the *possibility* that "the upper part is partly wedged within the emptied framed tube of the lower part, pushing the walls of the framed tube apart" (p. 2). The writers cannot agree with the statement that the "wedging is not possible." This possibility cannot be excluded. But the point is anyway extraneous. The wedging was not considered in the analysis because the stated aim was to prove that the towers must have collapsed. For that purpose, the most optimistic assumptions about the structure resistance had to be made, and the assumption of wedging would not be of that kind.

3. While it is of course true that the off-center impact of aircraft into the South Tower must have "produced a torque," this torque could have affected only the initial vibrations of the tower lasting less than a minute and could not have had any effect on

the collapse which occurred much later. The tilting of the upper part observed during the collapse must have been caused by anoff-center hole in the building but not by the initially produced torque.

4. It is dubious to say that "the columns in the floor that were directly hit by the aircraft." ... "hang on top of the floors and because of their enormous self-weight exert a pulling force on the floors above." They of course exert some force, but compared to the load from the upper part this force is negligible.

5. The writers agree that the pivoting of the upper part of the South Tower about its base was not possible during the initial period of swaying after the impact. But, what the analysis addressed was the question of pivoting during the collapse, which was shown to have little effect.

From: Lionel Lemay <LLemay@nrmca.org>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/4/2005.

Name : Lionel Lemay
Affiliation : National Ready Mixed Concrete Association
Email Address : LLemay@nrmca.org
Phone : 847 918 7101
Report Number : NCSTAR 1
Page Number : Page 221
Paragraph : Table 9.1
Comment : Hardened egress routes are appropriate for □Selected Other Buildings□ as well as buildings over 20 stories in height. Recommendation 24 retaining an effective uninterrupted operation of a command and control center should also be applicable to □Selected Other Buildings.□
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Lionel Lemay <LLemay@nrmca.org>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

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Name : Lionel Lemay
Affiliation : National Ready Mixed Concrete Association
Email Address : LLemay@nrmca.org
Phone : 847 918 7101
Report Number : NCSTAR 1
Page Number : Page 214
Paragraph : Section 9.2.6 Group 6
Comment : Improved and hardened egress and access routes should be included in this recommendation and Recommendation 18. Hardened passageways will help assure that routes to hardened elevators are not obstructed by debris, and if properly designed and ventilated may serve as safe havens until assistance arrives.
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Email Address : LLemay@nrmca.org
Phone : 847 918 7101
Report Number : NCSTAR 1
Page Number : Page 207
Paragraph : Section 9.2.3 Group 3
Comment : Re-occupying structures after burnout is desirable and achievable, as was demonstrated by buildings surrounding the WTC site, especially 90 West Street, and more recently the LaSalle Bank Building in Chicago where the fire was confined to several floors. In the latter case there were no sprinklers. Concrete provided adequate fire protection and compartmentation, no deaths occurred and the damaged areas of the building are being retrofitted for future use.
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
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Name : Lionel Lemay
Affiliation : National Ready Mixed Concrete Association
Email Address : LLemay@nrmca.org
Phone : 847 918 7101
Report Number : NCSTAR 1
Page Number : Page 202
Paragraph : Section 9.2.1 Group 1
Comment : NIST should modify its discussion to encourage design that considers the benefits of other building components in increasing the fire endurance and structural integrity of individual components or structural systems. A properly designed fire separation partition may perform as an element to resist deflections and/or transfer loads to other structural elements when the failure conditions of a particular structural component are reached.
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Information Submitted on: 8/4/2005.

Name : Lionel Lemay
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Email Address : LLemay@nrmca.org
Phone : 847 918 7101
Report Number : NCSTAR 1
Page Number : Page 200
Paragraph : Section 9.2
Comment : This section is lacking any discussion regarding the potential impact of a building or building system collapse on adjacent buildings.
Recommendations may be needed for developing a method to determine if impact on or from other buildings warrants consideration in a building design and what if any provisions might be incorporated into model building codes and standards.
The collapse of WTC 1 and 2 had a significant impact on WTC 3, 4, 5, 6, and 7 and several other surrounding buildings. If all the buildings surrounding the twin towers were of similar construction as WTC 7 and not of more robust construction like 90 West Street, there might have been more building collapses as a result of the collapse of the twin towers and additional collapses from the collapse of neighboring buildings.
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Affiliation : National Ready Mixed Concrete Association
Email Address : LLemay@nrmca.org
Phone : 847 918 7101
Report Number : NCSTAR 1
Page Number : Page 200
Paragraph : Section 9.2
Comment : Improved building evacuation will benefit from more robust egress routes including corridors, stairways, and elevator shafts.
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Name : Lionel Lemay
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Phone : 847 918 7101
Report Number : NCSTAR 1
Page Number : Page 200
Paragraph : Section 9.2
Comment : Discussion of □structural frame□ is limited to girders, beams, trusses and spandrels. This excludes some concrete components. Composite structures of concrete and steel should be addressed for all buildings, especially those 20 stories or more in height. Concrete shear walls intended to serve primarily as fire protection or for compartmentation may limit deformations of, reduce temperatures of, and transfer loads from girders, beams, trusses, spandrels, and columns which are subjected to excessive loads. It may be more practical to transfer loads through elements primarily intended for fire safety than to incorporate other redundancies into the structural design of the building.
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/4/2005.

Name : Lionel Lemay
Affiliation : National Ready Mixed Concrete Association
Email Address : LLemay@nrmca.org
Phone : 847 918 7101
Report Number : NCSTAR 1
Page Number : Page 74
Paragraph : Section 5.7
Comment : This section should emphasize that the weakened steel floor trusses resulted in excessive sagging in the floor system. Since trusses were quite deep, the thin 4□ concrete floor remained in compression and likely prevented the trusses from complete collapse. Without such clarification, it may be interpreted by readers that structural concrete floor members failed.
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Name : Lionel Lemay
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Report Number : NCSTAR 1
Page Number : Page 68
Paragraph : Section 5.6
Comment : The title of this section should be revised. The discussions are limited to the fire protection of steel columns which do not address other passive fire protection. This may lead to unintended misinterpretations that passive fire protection in general may be inadequate. To be consistent with the terminology of ASCE 29, it is suggested that □Passive Fire Protection□ be replaced with □Fire Protection of Structural Steel.□ Discussion in this section might also include statements that SFRM was selected for this project in lieu of other fire protection methods such as encasing structural steel in concrete or masonry. Substantiation for such discussion may have been discovered if the scope of the report on the performance of buildings impacted by the events of September 11, 2001 included the buildings that did not collapse, such as 90 West Street.
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Lionel Lemay <LLemay@nrmca.org>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/4/2005.

Name : Lionel Lemay
Affiliation : National Ready Mixed Concrete Association
Email Address : LLemay@nrmca.org
Phone : 847 918 7101
Report Number : NCSTAR 1
Page Number : Page 53
Paragraph : Section 5.2.2
Comment : This section provides a comparison of three building codes in place elsewhere in the United States at the time the twin towers were designed and erected. However, the comparisons appear to be limited to structural design loads. The fire protection provisions of these codes also differed. For example the 1967 Municipal Code of Chicago would have classified this structure as an E occupancy and would have required Type I-A construction due to the building□s unlimited floor area and height. The use of Type 1-B construction would have limited the building to 12 stories. In this 1967 code for Type 1-A construction, all columns, interior and exterior, except those supporting the roof, required a 4-hr rating. Similarly, beams and girders, except those supporting the roof, required a 3-hour rating.
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Lionel Lemay <LLemay@nrmca.org>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/4/2005.

Name : Lionel Lemay
Affiliation : National Ready Mixed Concrete Association
Email Address : LLemay@nrmca.org
Phone : 847 918 7101
Report Number : NCSTAR 1
Page Number : Page xlix
Paragraph : Table E-1
Comment : Several Buildings surrounding the WTC towers experienced burnout and did not collapse. The robustness of building elements and the ability of building elements to assist in transferring loads and limiting deflections appear to have played a significant role in allowing such buildings as 90 West Street to be reoccupied.
For example, comprehensive designs of buildings with steel exterior structural elements and concrete cores are not addressed. In addition, the report does not provide adequate recommendations for providing built-in redundancies by combining active and passive fire protection. Also, when fire resistance requirements were first developed for building construction, the majority of the fire protection was provided by robust concrete and masonry elements that provided additional benefits to the structure including increased robustness and structural integrity. These benefits appear to have been jeopardized with recent trends in design which focused on developing the least expensive and lightest weight systems to satisfy the fire endurance requirements of the standard fire test, ASTM E 119. A robustness component for all passive fire protection, including sprayed-on fire resistive materials (SFRM), may be needed.

Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: "P DeGregory" <peggy@nwcma.org>
To: <wtc@nist.gov>
Subject: Comments on NCSTAR 1

Attached is a document with comments on NCSTAR1 from Tom Young, Executive Director of Northwest Concrete Masonry Association. Any questions can be directed to him at 425-697-5298 or tcyoung@nwcma.org.

Peggy DeGregory
Northwest Concrete Masonry Association
425-670-2274
peggy@nwcma.org

Comments on NIST NCSTAR 1.doc

Comments on NIST NCSTAR 1 (Draft)

Federal Building and Fire Safety Investigation of the World Trade Center Disaster
Final Report of the National Construction Safety Team on the Collapse of the World Trade Center Towers (Draft)

Contact:
Thomas Young, P.E.
Executive Director
Northwest Concrete Masonry Association
19109 36th Ave. West, Suite 211
Lynnwood, WA 98036-5767
425.697.5298
tcyoung@nwcma.org

General Comments

1. The Northwest Concrete Masonry Association (NWCMA) applauds NIST for its efforts in the development of this report and the recommendations. NWCMA will continue working to influence model building codes and standards for increased fire safety.

2. Many of the report recommendations that relate to technical provisions of building codes have been discussed previously and failed to be approved. NWCMA is concerned that there will be continued resistance to improvements in life safety, property protection, and welfare of the general public in future codes and standards. Disapproved code change proposals have attempted to strengthen code provisions by increasing the required fire resistance ratings of assemblies thus improving compartmentation, eliminating sprinkler trade-offs, and modifying the hose stream test of ASTM E-119 to require the more rigorous test for all specimens. The general reason cited for their disapproval is that fire data do not indicate a need for change. Mandatory requirements for reporting the performance of building construction in fires are needed to substantiate revision to these building codes and reference standards.

Specific Comments

1. Summary of Findings
   Page xlix, Table E-1

   This table calls for structures to achieve burnout without local or global structural collapse in uncontrolled building fires. Buildings surrounding the WTC towers experienced burnout and did not collapse. The robustness of their building elements and their ability to transfer loads appears to have played a significant role in allowing them to be reoccupied.

The use of individual building elements for multiple purposes and the use of multiple structural elements within buildings do not appear to be adequately addressed in the recommendations of this report. For example, when masonry walls are placed between structural elements (or serve as structural elements) they are providing compartmentation in addition to limiting deflections at high temperatures. Also, the report does not provide adequate recommendations for providing built-in redundancies by combining active and passive fire protection.

2. Chapter 5
   Page 68, Section 5.6 "Passive Fire Protection"

   The title of this section should be changed. The discussions are limited to the fire protection of steel columns and do not address other passive fire protection. This may lead to unintended misinterpretations that passive fire protection in general may not be adequate.

3. Chapter 9 – Recommendations
   Page 197, Section 9.1 "Building Standards and Codes: Who is in Charge?"

   NWCMA supports the adoption of local fire ordinances to further regulate building design and construction to best suit the needs of a community.

4. Chapter 9 – Recommendations
   Page 200, Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders," Item 2

   This section needs to be expanded to include an evaluation of the performance criteria of typical construction tested per ASTM E-119. If existing fire resistance test methods are discovered to warrant revision, provisions should be incorporated into the recommendations calling for the development of a methodology that can demonstrate compliance using test results obtained from existing test standards.

   Collection of data regarding the fire performance of building construction after actual structure fires would be useful in determining if priorities should be placed upon revision of existing fire test standards or on the development of additional test methods to determine the robustness of passive protection.

5. Chapter 9 – Recommendations
   Page 200, Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders," Items 3 and 4

   There is a need for further evaluation and development of provisions to address balanced design for fire safety with appropriate redundancies.

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6. Chapter 9 – Recommendations
   Page 202, Section 9.2.1, Group 1 "Increased Structural Integrity"

   We encourage NIST to support design that considers the benefits of other building components in increasing the fire endurance and structural integrity of individual components or structural systems.

7. Chapter 9 – Recommendations
   Page 207, Section 9.2.3, Group 3 "New Methods for Fire Resistant Design of Structures," Recommendation 8

   Consider expanding the scope of this section to buildings not defined as tall (20 stories). Prevention of collapse is important for many other buildings dependent upon the occupancy classification.

8. Chapter 9 – Recommendations
   Page 207, Section 9.2.3, Group 3 "New Methods for Fire Resistant Design of Structures," Recommendation 8

   NWCMA strongly supports this recommendation for burnout without local or global collapse. Reoccupying structures after burnout is desirable and possible as demonstrated by buildings surrounding the WTC site and others.

9. Chapter 9 – Recommendations
   Page 221, Table 9.1 "Improved Emergency Response"

   Hardened egress routes are appropriate for "selected other buildings" as well as buildings over 20 stories in height.

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MICHAEL A. CARDOZO
Corporation Counsel

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LAW DEPARTMENT
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August 4, 2005

Sent by email to wtc@nist.gov

WTC Technical Information Repository
Attn: Mr. Stephen Cauffman
National Institute of Standards and Technology
Stop 8610
Gaithersburg, Maryland 20899

Re: New York City Comments to NIST NCSTAR 1 and NCSTAR 1-8

Dear Mr. Cauffman,

The City of New York submits this letter in response to NIST's final draft report on the Collapse of the World Trade Center Towers and the Emergency Response Operations on September 11, 2001. While we do not concur in all portions of NIST's assessment of the City of New York's response on 9/11, the City found the report overall to be well researched, balanced, and helpful. The City appreciates and commends the hard work and dedication by all the NIST employees who contributed to the report.

We write primarily to advise NIST of the many improvements the City has implemented in its emergency operations since 9/11 and request that they be noted in NIST's final report. However, there is one factual inaccuracy in the draft report that we particularly want to bring to your attention. In the draft "Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Towers", NIST NCSTAR 1, Chapter 8.4.3 Emergency Response, p. 187, the report states that "NYPD aviation unit personnel reported critical information about the impending collapse of the WTC towers several minutes prior to their collapse. No evidence has been found to suggest that the information was further communicated to all emergency responders at the scene." This is factually inaccurate. The NYPD aviation unit never reported anything about the potential collapse of the South Tower prior to its collapse. The City asks that this inaccuracy be corrected in NIST's final report. We also note that both the New York City Police and Fire Departments issued orders to evacuate the North Tower independently of and prior to any aviation unit transmissions regarding a possible collapse of that Tower. We request that this fact also be acknowledged in the final report.

The NIST report includes many important recommendations as to how the City can improve its emergency response. Over the past few years, the City has implemented many of the same improvements recommended by NIST, in particular improved communications, and command and control techniques, and greater coordination among its agencies through a series of exercises and table top drills. These improvements and drills are described below in greater detail and we believe the report would benefit by mention of them in NIST's final report.

Improvements in FDNY Communications:

- The Department successfully tested and deployed newly modified handie-talkie radios to the field in February 2003. These analog radios have several features that provide significant advantages over the previous digital model. The Department's radios now have an emergency alert function, many more channels, allow for greater penetration in buildings and allow for interoperability among Fire, EMS and other emergency service agencies, including NYPD. The new analog radios are generally more efficient during incidents when many firefighters and officers are attempting to communicate at the same time over the same frequency and allow for more messages getting through without being "stepped on" by other messages.
- FDNY developed and implemented a new communications system consisting of the new handie-talkies, high-powered post radios and Battalion car repeaters, providing increased reliability during high rise building responses. The FDNY currently has 13 Battalion cars with the repeaters. The post radios are interoperable-capable 45-watt radios, which were designed initially for use by the Incident Commander at the command post. Because they fit in a small specially designed hard-shell suitcase and are light enough to be carried, they can be used at any assigned post within a high-rise. The post radios are used regularly.

Improvements in Interoperability:

Equipment:

- TRP 1000 – OEM, FDNY and NYPD have successfully field tested and deployed the TRP 1000, a new piece of equipment that provides radio interoperability during incidents that require communications across multiple organizations using different radios and different frequencies. The TRP 1000 units allow interagency communications at incident scenes without requiring responding personnel to carry multiple radios. The TRP was successfully field tested and was ready for use during the Republican National Convention held in New York City in 2004.
- FDNY battalion and higher ranking chiefs have access to an interoperability channel on their handie-talkies which can be used to communicate with NYPD. The interoperability channel has been successfully tested in drills.

- All FDNY personnel have the capability to communicate with the NYPD Special Operations units on a dedicated tactical channel ("TAC U"). This is a police frequency that FDNY programmed into the handie-talkies of all chief officers and all FDNY units.

Liaison:

- Fire Department commanders ride in police helicopters to help them better coordinate operations at major fires. Interoperable radios on police helicopters were successfully field tested. Also, NYPD helicopter video can now be down-linked to the FDNY Operations Center.
- A police captain is now required to respond to any two-alarm fire. In addition, the Police and Fire Departments have senior staff assigned to one another's headquarters to address any issues that may arise.
- FDNY and NYPD have initiated regular interagency practice drills to enhance joint response.

FDNY improvements in Command and Control:

- FDNY has been at the forefront of the development of Electronic Command Boards (ECB's), which will enable chiefs to communicate wirelessly between several ECB's at an incident and download critical information to the Fire Department Operations Center in real time.
- FDNY implemented a flexible recall program in order to efficiently mobilize all or part of its firefighter and EMS personnel in the event of a large-scale emergency or an increase in the terrorism threat level. The Department's regulations were amended in Spring 2003 to clarify and emphasize that recalled members must report to their firehouse, unless instructed otherwise.
- FDNY has modified its staging procedures to ensure that the incident commander (IC) can effectively maintain command and control of resources as incidents escalate. Its new staging regulations require the designation of a Staging Area Chief and the establishment of a staging area at all third or greater alarms. The IC can make such designations for any alarm level, if necessary.
- FDNY units are now prohibited from "riding heavy." There are a designated number of assignments on each apparatus and no extra firefighters may ride along.

Other City improvements regarding Command and Control:

- CIMS - NYPD, FDNY, OEM and all other relevant City agencies follow the Citywide Incident Management System (CIMS), ensuring that all responders know which agency is responsible and in a leadership role at any incident.

Drills/Exercises:

OEM has facilitated numerous exercises in conjunction with NYPD and FDNY. Since 9/11, FDNY and NYPD have both participated in the following inter-agency drills, most of which were coordinated by OEM:

- Operation Tripod (5/22/02) -- OEM conducted Operation Tripod at Pier 92 in Manhattan, which addressed response to a possible bioterrorism attack.
- Yankee Stadium Drill (9/29/02) -- HazMat drill at Yankee Stadium in the Bronx.
- Operation SADD (10/5/02) -- The Port Authority conducted a simulated aircraft disaster drill at LaGuardia Airport in Queens.
- Ft. Hamilton HazMat Drill (10/17/02) -- HazMat decon drill at Fort Hamilton in Brooklyn.
- HazMat Drill (10/27/02) -- HazMat preparedness drill took place at the Verrazano Narrows Bridge in Staten Island.
- Broad Street HazMat Drill (4/27/03) -- The Transit Authority conducted an inter-agency preparedness exercise in Manhattan at the Broad Street subway station that involved a simulated chemical release and evacuation of passengers from the station.
- Winter Sun (5/18/03) -- OEM conducted an inter-agency HazMat preparedness exercise in Brooklyn.
- Grand Central Terminal Drill (10/27/03) -- FDNY Division 3 conducted a drill in the Waldorf train yard of Grand Central Terminal in Manhattan. The drill involved a simulated electrical malfunction in the M-50 substation of the Waldorf yard resulting in an explosion and fire in the vicinity of the substation. The simulated malfunction also caused a power surge into the third rail resulting in an ensuing fire in a parked train.
- Operation United Response (3/14/04) -- OEM conducted a preparedness exercise at Shea Stadium in Queens simulating a large-scale, multi-casualty incident.
- Operation Transit Safe (5/16/04) -- OEM conducted a preparedness exercise at the Bowling Green subway station in Manhattan. This exercise simulated a large-scale, underground multi-casualty incident.
- Staten Island Ferry (10/04) – OEM conducted a drill simulating the sinking of a Staten Island Ferry.
- PODEX (6/2/05) – OEM, FDNY, NYPD, and DOHMH participated in a city-wide preparedness exercise simulating a biological attack. In this drill, city, state and federal agencies all worked together to further develop an integrated response to a biological exposure.
- Bronx Train Derailment (6/15/05) -- OEM, FDNY and NYPD conducted a tabletop exercise to practice multi-agency response to a chemical spill.

If you have any questions or comments please feel free to contact me at your convenience.

Very truly yours,

Gary Shaffer
Deputy Chief, World Trade Center Unit

cc: Melissa Lieberman, Esq.

The City of New York

FIRE DEPARTMENT

250 LIVINGSTON STREET BROOKLYN, N.Y. 11201-5884

BUREAU OF FIRE COMMUNICATIONS

January 19, 1994

Mr. Alan L. Reiss
Supervising Engineer
Plant and Structures
The World Trade Center
1 World Trade Center
New York, NY 10048

Re: FDNY Radio Communications
The World Trade Center

Dear Mr. Reiss:

Please accept the appreciation of the N.Y.C. Fire Department (FDNY) for the installation our Radio Repeater System in the World Trade Center by your very capable staff. During our radio coverage tests we concluded that the system worked exceptionally well.

Special thanks also goes to your very valuable Mr. David Geller. As reported by this Bureau's Systems Engineering and Maintenance Unit, Mr. Geller was responsible for the design and installation of the FDNY Radio Repeater System. He was extremely helpful throughout the various stages of this project from its inception to its completion.

It is requested that your office inform Captain Joseph Mastella, The Port Authority of New York and New Jersey Police, that the FDNY Radio Repeater System should remain off when FDNY is not using it. This radio system can cause interference with other Fire Department radio operations if it is left on. The radio system can be turned on and off by the operation of the "FDNY Repeat" pushbuttons on the Police Radio Console.

It is hoped that this Bureau will have the opportunity and the pleasure of again working with you and your staff. Our thanks for assigning a most capable group of technicians to this project.

Yours truly,

Stephen M. Gregory

Stephen M. Gregory
Assistant Commissioner for
Communications

SMG:GPC:gb
cc: G.P. Coorssen
SEAM/File
WTC: D. Geller

SAVE WATER SMOKE DETECTORS SAVE LIVES SAVE WATER

From: "greening" <greening@sympatico.ca>
To: <wtc@nist.gov>
Cc: "Eric Douglas" <ericscottdouglas@yahoo.com>
Subject: NIST WTC Report Comments

To whom it may concern:

I am writing to comment on the NIST Draft Report on the WTC Investigation. While I believe that NIST has done an excellent job in covering many key areas of the tragic events surrounding the collapse of the Twin Towers, I also believe that a number of crucial issues have not been addressed. Therefore, although I would certainly like to adhere to the style of comment suggested on your website (i.e. chapter, page No, etc), please allow me to first provide a list of issues that I believe are still in need of investigation by NIST:

1. A topic that gets very little coverage in any of the NIST or FEMA documents dealing with the WTC disaster is the jet fuel explosions that accompanied both aircraft impacts with the Twin Towers. I believe that a detailed examination of these explosions is essential to a full understanding of the extent of the damage caused to the Twin Towers by the aircraft impacts. I would therefore like to see a Section in the NIST Report that addresses key questions surrounding these explosions. For example:

- What was the source of the bright flash close to the point of impact of the aircraft as it struck the south face of WTC 2?
- What ignited the fireballs within the Twin Towers?
- Were the fireballs the result of a fuel deflagration or detonation within each Tower?
- How much energy was released in the air-fuel explosions?
- What was the blast overpressure of the explosions?

2. In mechanical terms, the aircraft strikes on the Twin Towers involved a collision between two metal frame structures, one made mainly from aluminum and the other made mainly from steel. Such collisions are modeled quite effectively using calculations based on the mechanical properties of the structural members involved. (See for example Appendix C of the NIST Interim Report.) But not included in these "engineering calculations" are the *chemical interactions* that came into play during and after the aircraft impacts – interactions that are specific to the combination of materials present in the damaged Twin Towers, namely, aluminum, steel, concrete and jet fuel. The Colorado School of Mines recently published a report, (No. MT-CWJCR-002-024), entitled "*Feasibility of Thermite Sparking with Impact of Rusted Steel onto Aluminum Coated Steel.*" This study shows that intense, thermite-induced, sparking occurs between relatively small (~ 100 gram) aluminum and rusty steel projectiles at impact velocities as low as 12 m/s. In light of these findings there can be no doubt that thermite-enhanced sparking occurred within the Twin Towers when the Boeing 767 aircraft, traveling at about 200 m/s, struck the perimeter and core columns. This is highly significant for a number of reasons. First, it provides a source for the bright flash close to the point of impact of the aircraft as it struck the south face of WTC 2. Secondly, it provides a mechanism for a deflagration-to-detonation transition within the fuel vapor clouds that formed in the Twin Towers immediately after the aircraft impacts.

3. The physical and chemical behavior of the concrete in the WTC is not covered in sufficient detail in the NIST report. For example, the pulverization of the WTC concrete to a fine dust is not considered at all. It is well known that the removal of water from concrete results in irreversible changes to the microstructure of the material that has deleterious effects on its strength. Thus, when the temperature of concrete is raised to 250° C, up to 75 % of the stoichiometric mass of water is lost and the compressive strength of the material declines. Studies conducted by researchers at NIST, (See NIST Report No.

6475, March 2000), have shown that in the temperature range from 240° to 280° C, *explosive spalling* of some concrete specimens occurs due to the rapid release of chemically bound water. This process may well have occurred in regions of the Twin Towers exposed to fires. While the NIST Report does mention the formation of *molten aluminum* in the Twin Towers just prior to their collapse, the possibility of the explosive spalling of concrete by reaction with aluminum is not considered

4. Examination of photographs of the remains of the Twin Towers after the events of 911 shows that most of the core and perimeter columns in the debris field were *not* severely buckled. On the other hand, fracture of A325 bolts at the column splice plates appears to have been a common failure mode. This suggests that the strength of the column connecting bolts was *not* well matched to the strength of the column members they were designed to hold. It would therefore appear that the A325 connecting bolts failed before the full strength of many of the columns was realized, explaining why most of the columns were not severely buckled. While the NIST *Interim Report* provides some information on the behavior of A325 bolts used in the WTC, (See for example, Appendix C, page C-30), a comparison of the energy dissipated within the bolts and the core columns during the collapse of the Twin Towers is not presented; details on the number and layout of the bolts used for the core column splices would be of value in this respect.

5. It would be useful to see detailed energy transfer calculations of the collapse of each of the Twin Towers as part of the NIST Report. I have made some preliminary studies of this topic using a stepwise momentum transfer calculation for each floor and determined that the collapse of WTC 1 took 12.6 seconds, and WTC 2 took 11.5 seconds. Thus it is possible to follow the detailed *floor-by-floor* progress of the collapse of each WTC tower and show how the delay in the fall of each tower develops compared to the free-fall of an object from 416 meters, which takes about 9 seconds.

Finally, I would like to comment on one specific topic that *is* included in the NIST Report. This is the write up on sample K-16 as described in NCSTAR 1-3C, starting on page 229. Figures 6-20 and 6-23 certainly show a badly corroded column, but I have problems with NIST's proposal that sample K-16 was subject to erosion/corrosion *as a result of exposure to high temperatures from the WTC fires*. I say this for the following reasons:

(1) Although investigators are not sure of the precise origin of the column from which K-16 was cut, NIST note that it is of type 143, a column that was only used *below* the 53rd floors in each tower. The problem with this is that there were no major fires in this lower portion of the Towers.

(2) I also have problems with the *appearance* of the column. It does not look like it was exposed to a fire. There are no scorch marks or sooty deposits. Photographs of the WTC fires show fuel-rich, smoky flames. I would expect to see black deposits on K-16 if it had been exposed to the WTC fires, but the area where the sample was cut (see Fig. 6-23) is pretty much reddish-brown and looks like air/water-formed corrosion deposit, i.e. common rust.
(3) The micrographs provided by NIST (e.g. Fig 6-21) show an oxide scale on K-16 that is 100 microns or more in thickness. NIST also provide a micrograph, Figure 6-8, that shows only about 20 microns of oxide growth on HSLA steel *after 2 hours at 625 degrees C.* Since the WTC fires typically lasted less than 1 hour at any location, and the average temperature at the location was probably less than 625 C, it is very unlikely that the WTC fires could have produced 100 micron oxide scales as proposed by NIST.

In conclusion, I once again commend NIST for the excellent work its researchers have completed to date. I certainly hope my comments are of use.

Sincerely,

Dr. F. R. Greening
12 Uplands Ave
Hamilton, Ontario
Canada, L8S 3X7

Tel 905-317-4544

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 300
Paragraph : Finding 19
Comment : The post impact state of the building has not been assessed rigorously. It would have been useful to see how the DCR□s based on estimated actual loads at the time had changed as a result of the impact damage and re-distributed loads paths □ we believe this was part of the scope of work was identified in the solicitation notice. This is discussed further in our comments on Report 1.
Comment Reason : The significance of load redistribution and effects of the sway have not been assessed using the global modes.

Revision Suggestion : Justifications for not examining load redistribution and sway effects need to be stated or further analysis is needed.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page xliv E-3
Paragraph : Summary of Findings bullet 4
Comment : The implication in Report 1-2A (see page 350) is that stairwell 3 was impassable. This paragraph suggests otherwise.

Comment Reason : .Contradiction with Report 1-2A (page 350)

Revision Suggestion : Clarify

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page 41
Paragraph : Section 3.3 Paragraph 1
Comment : The number of core columns severed (9) and heavily damaged (1) do not tie up with the numbers identified in Report 1-2B, page 365 (5 failed, 4 heavy damaged)?
Comment Reason : Contradiction with other reports

Revision Suggestion : Clarify

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@NIST.GOV
Cc: dlowe@NIST.GOV
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page 41
Paragraph : Section 3.3 second Section 3.3 second bullet
Comment : The numbers of core columns severed do not tie up with paragraph 1 on page 41. (or Report 1-2B page 365)
Comment Reason : Contradiction

Revision Suggestion : Clarify

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR 1
Page Number : Page 99
Paragraph : Section 6.6.4 sub section Core Framing, bullets 1-3
Comment : The analyses undertaken suggest that the condition of the core is key to identifying what margins existed immediately following the impact. The analysis does not seems to account for the swaying of the building following impact or examine the reserve or DCRs using estimated □actual□ loads on the building at the time of the impact. Similarly, as the analysis was essentially done statically no assessment seems to have been done to examine the way the loads re-distributed as columns were removed.
Comment Reason : While the response of the building is such that it will not influence the damage caused by the aircraft impact, the response will be significant in assessing the redistribution of loads or any additional damage induced by the building swaying. As the building was show to be unstable when gravity loads were applied in Case B severe impact damage, it would have been prudent to check the analysis model further by examining the effects of the sway and loads redistribution.

Revision Suggestion : We suggest sway and load redistribution are examined to demonstrate how much these potentially adverse effects influence the stability of the tower.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR 1
Page Number : Page 102
Paragraph : The Aircraft Structural Model
Comment : Our understanding is that no detailed information concerning the construction of the aircraft was released by Boeing. Was any attempt made by NIST to get Boeing to comment on the accuracy for the model? Significant portions of the aircraft appear to have been modelled using uncertain data.
Comment Reason : While it is likely for many parts the lack of precise details would not have been too significant, areas such as the wing spars and undercarriage support structure would be critical to assessing core column damage. Any analysis relies on the quality of input data to achieve It seems rather

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552051
Report Number : NCSTAR 1
Page Number : Page 203
Paragraph : Recommendation 3
Comment : While this is a reasonable suggestion, limiting sway deflections may have an adverse effect on energy absorption in impact events and almost certainly will have economic cost implications.
Comment Reason : Further work should be done to substantiate the cost benefits of this recommendation.

Revision Suggestion : Remove this recommendation until further research has been undertaken.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page lx
Paragraph : Table E-3

Comment : The impact speeds, lateral approach angles, vertical and lateral fuselage orientations in Table E-3 don□t tie up with those shown in Tables E-6 & E-7
Comment Reason : Apparent inconsistency between tables E-3, E-6 and E-7

Revision Suggestion : Clarification in the terms refined aircraft impact conditions and baseline terms.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page lx
Paragraph : Table E-3
Comment : The impact speeds, lateral approach angles, vertical and lateral fuselage orientations in Table E-3 don□t tie up with those shown in Tables E-6 & E-7
Comment Reason : Apparent inconsistency between tables E-3, E-6 and E-7

Revision Suggestion : Clarification in the terms refined aircraft impact conditions and baseline terms.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Pg 40
Paragraph : Section 3.2.1 Core Model Development
Comment : What allowances were made for elevator guide rails, cables, counterweights & cars? We believe only the structural steel is assumed in the model?
Comment Reason : No reference regarding how the elevator components were accounted for within the core.

Revision Suggestion : Check what these components were and, if necessary, re-examine to include additional structure in core model.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@NIST.GOV
Cc: dlowe@NIST.GOV
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : pg 52
Paragraph : Section 3.2.4 Interior Contents Model Development, third paragraph, last sentence.
Comment : Why were the superimposed dead loads also applied to columns - it is not usual to do so?
Comment Reason : This would potentially alter the results of the analysis as the effective mass of the columns would be increased.

Revision Suggestion : Check input data and if this statement is true re-run analyses without superimposed loads applied to the column.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup- London
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Pg 75
Paragraph : Section 4.3.1 Airframe Model Development
Comment : The main landing gear support structure and wheel well bulkhead are comparatively more substantial components than the fuselage. Was any attempt made to obtained detailed engineering design drawings of these components?
Comment Reason : The main landing gear support structure is a large component of strength comparable to or exceeding the wing box. Any breach made by the fuselage, nose landing gear and other components prior to the main landing gear components arriving at the external walls would have given the main landing gear support structure a relatively easy path through to the core. We argue that the input data used for the landing gear support structure components therefore would be critical to estimating the core damage. Because of the limited description of the model details and we believe the lack of engineering drawings made available by Boeing, we question the accuracy of the data used for these components.

Revision Suggestion : Clarify the data used for these components and check with Boeing for accuracy.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : 77
Paragraph : Table 4-4
Comment : We note the dry weight differences between GE CF6 and PWJT9D engines were not included in the respective WTC1 and WTC2 aircraft models □ were any runs done with the heavier GE CF6 engine weights?
Comment Reason : The engines were identified as potential damaging component so the correct (known) engine weights should have been used for each analysis.

Revision Suggestion : Justify that the heavier engine would not have altered the results of the analysis.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 89
Paragraph : General Comment on chapter 5
Comment : Was any attempt made to check the aircraft model by examining an impact with an immovable wall and comparing forces with methods based on rate of change of momentum models such as that developed by Riera as described in Chapter 10 page 367?
Comment Reason : No validation of the model is presented in the report to show how the overall forces generated by the model compare with other established methods.

Revision Suggestion : Demonstrate model robustness and overall forces are reasonable.

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup- London
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : page 175
Paragraph : Chapter 8 Uncertainty analysis
Comment : The solicitation notice requested a formal, integrate approach was followed and include references outlining the procedure. The approach used here is considerably simpler. Why was the approach modified?
Comment Reason : The approach used falls short of the original ambitions required by NIST

Revision Suggestion : Clarification that the approach used in not as rigorous as originally intended.

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 178
Paragraph : Table 8.1
Comment : The strength variations used seems rather low compared to the variations shown in Report 1-1, (page 67/68 of that report show measured/specified ratio in 10% - 30% range see Table 5.4 column data).

It is unclear whether the baseline values for material properties used were nominal or as per the values obtained from test data?

Why are the minimum values for horizontal and vertical locations the same as the baseline?

Exactly what is meant by varying strain rate effects by 1000%?

Comment Reason : Unclear

Revision Suggestion : Clarification needed

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 180
Paragraph : Section 8.2.1 Engine-Core Column Component Analysis, paragraph 1
Comment : The characterisation of the deformed columns takes no account of the building movements following the impact. While we agree gravity loads in the columns make little difference during the aircraft impact, were axial loads and P-Δ effects induced by the response of the building after the impact considered?
Comment Reason : We think this needs to be examined both at a component analysis and global level

Revision Suggestion : Demonstrate by analysis that the response of the building does not cause further damage or additional deformations.

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 183
Paragraph : Table 8-3
Comment : We question the large value used for the weight factors used in the wing parameters. Information from Boeing or detailed measurements could have been able to eliminate this uncertainty.
Comment Reason : Wing weight has a high response value in the uncertainty analysis.

Revision Suggestion : Examine why such a high variation was used.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 190
Paragraph : Figure 8-10 and also page 111 paragraph 1, sentence 4
Comment : Figure 8-10 would imply the engine trajectory was mainly horizontal on exit. Intuitively this feels incorrect.
Comment Reason : We question whether the workstations and the relatively lightweight concrete/steel composite floor would have been able to deflect a 4 ton engine travel at speed. Our own work examining penetrations of components on composite floor suggest that the contribution from the metal decking can significantly enhance the impact performance when compared with concrete slabs. (see Assessing perforation limits of steel section impacts on reinforced concrete slabs -Technical Note, The Structural Engineer, IStructE, December 2004). This is contrary to the findings page 111, first paragraph.

Revision Suggestion : Re-analysis using better representation of concrete/steel decking composite floor model.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 191
Paragraph : Section 8.3 Global Impact Analyses Parameter Selection, Paragraph 2

Comment : Although the report notes that the vertical impact position was significant in the subassembly analysis, the vertical impact location was not varied for the global analysis.
Comment Reason : It is difficult to understand the logic used not to investigate this further.

Revision Suggestion : Include vertical impact variations in the global analysis

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 192
Paragraph : Section 8.3 Global Impact Analyses Parameter Selection, Paragraph 1
Comment : The validity of the statement concerning the coupling effect of increasing strength and ductility increasing energy absorption is questioned.
Comment Reason : In conventional steels, higher yield strength only marginally increases energy absorption as the ductility of higher yield steels tends to decrease.

Revision Suggestion : Clarify by revising paragraph 1

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR 1
Page Number : Page 195
Paragraph : 9.2 Assumptions and Limitations Paragraph 1
Comment : Please see our comments on Nist Report NIST NCSTRA 1-2, Page 93, Section 5.1 Introduction concerning limitations.
Comment Reason : As per page 93

Revision Suggestion : Re-assess the models using 64 bit precision.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 195
Paragraph : 9.2 Assumptions and Limitations Paragraph 1

Comment : Please see our comments on Nist Report NIST NCSTRA 1-2, Page 93, Section 5.1 Introduction concerning limitations.
Comment Reason : As per page 93

Revision Suggestion : Re-assess the models using 64 bit precision.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 196
Paragraph : 9.2 Assumptions and Limitations second Paragraph (first bullet)
Comment : What effect would the window weight have if it had been included in the external columns?
Comment Reason : The additional mass of windows on the external columns would have altered the response and deformations of the columns.

Revision Suggestion : Justification for leaving the mass of the windows out of the impact models. Justification for not including them in the impact models to show containment of fuel.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : 0+44 077552195
Report Number : NCSTAR1-2B
Page Number : Page 206
Paragraph : Figure 9-7b
Comment : A scale on this figure would be useful?
Comment Reason : The figure is meaningless without any scale

Revision Suggestion : Add scale

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page 210
Paragraph : Subsection Floor Truss and Slab Damage, second paragraph
Comment : Part of the requirements of the original solicitation was to examine the stability of two towers after losing the columns and show that the towers stood up after the event (Page 10 of SB1341-03-Q-0334).
Comment Reason : See also our previous comments concerning natural frequency, we do believe the method used takes account of possible damage that may occur during the post impact sway and therefore subsequent stability.

Revision Suggestion : Re-assess to take account of any damage resulting from post impact sway response.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page 218
Paragraph : Paragraphs 3 and 4
Comment : What technical validation has been done regarding the modelling of fuel dispersion?
Comment Reason : We recognise that the fuel dispersal simulation is technically challenging. It is therefore sensible to undertake some validations using simple experiments before embarking on a complex study such as this.

Revision Suggestion : Clarify what level of confidence there is in the fuel dispersion work?

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 234
Paragraph : Figure 9-29
Comment : Figure 9-29 b) identifies debris at time=0.715s. Page 227 states that this model only ran to 0.62s.

Also a scale on diagram b) might be useful.

Comment Reason : We think the time note on diagram b) is erroneous

Revision Suggestion : Modify time and add scale

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 207755212195
Report Number : NCSTAR1-2B
Page Number : Page 343
Paragraph : Second paragraph
Comment : Very little information about debris found beyond the vicinity of the towers seems to have been made available to NIST. For example, the size of panel and mass of landing gear shown in figure 9-123 is unknown. How could this collection of this data following a tragedy be improved?
Comment Reason : Improved process for data collection of debris needed.

Revision Suggestion : It would be useful to make sure some comment about debris collection/recording is put in findings.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2B

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2B
Page Number : Page 361
Paragraph : Section 9.11.3 Comparison with Observables Paragraph 2
Comment : Recognising that the overall trajectories are a difficult thing to predict, the trajectories of components as they left the building were poorly predicted in the simulations. As this is critical to establishing the damage to the core it would have been useful to discuss the reasons for this in more detail.
Comment Reason : Critical to establishing the core damage key objective

Revision Suggestion : Discussion concerning the reasons for poor correlation of analysis with observables.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : v
Paragraph : Paragraph 2 last sentence
Comment : The SPH approach used by ARA in the analysis for the fuel dispersion following the impact is relatively untried and is not well validated through experiments. Could the researchers clarify what level of confidence they have in the accuracy of predicting fuel dispersion and how this might have influenced the subsequent fire analysis?
Arup□s experience in the modelling fluids suggests fuel dispersion an exceedingly difficult thing to predict and an area where any analysis needs to be considered carefully and supported by laboratory based experimental validation. Given the importance of this study, we believe some testing should have been carried out to confirm the analytical models used prior to assuming dispersal patterns are adequate or correct.

Comment Reason : The report does not adequately explain the limitations of the technical approach taken.

Revision Suggestion : Clarification of the level of confidence or uncertainty in these results.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : x1vi
Paragraph : E.2.1 Global Models of Towers
Comment : Was any attempt made to correlate the total weight of the building with the debris removed?
Comment Reason : While accepting that this would have been an approximation, the data could have been used to estimate the overall loads on the building at the time of impact. This would have given greater confidence in the levels of reserve available at the time of the impact.

Revision Suggestion : Compare amount of debris known to have been removed during the clear operation with the mass used in the global analysis models.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1iv and 1v
Paragraph : Demand Capacity Ratios (DCRs) Paragraph 2
Comment : The baseline analysis examines the DCRs for design loads on the complete tower (figures E-5 and E6). Given that the actual building would typically see less load than this, has any estimate of the actual DCRs for the building in its Sept 11 2001 states? Given that the corners, which general had DCRs in excess of 1, were shown to buckle during the building collapses it might be useful quantify the reserve capacity in the column by checking the DCRs for actual loads on the day for pre and (immediately) post impact states and check these were less than unity.
Comment Reason : Looking a actual DCR□s would provide better estimate of the condition of the building post impact, a main objective of project 2.

Revision Suggestion : Re- analyse using actual loads

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1viii
Paragraph : Section E.5.1 Development of Tower Impact Models
Comment : We believe the global model (of the type shown in figure E-11) had no initial stress in the column and that this was justified by some simple tests using column models. The global model also ignored the overall response of the structure, presumably on the basis that the duration of the impact event was significantly less than the natural period of the building. Could NIST clarify how any P-Δ effects (as a result of the swaying) in the post impact condition were accounted for? From the work reported, post impact P-Δ effects before the fire took hold seem to have been neglected but there is no justification is given. Could P-Δ effects as a result of the significant swaying of the building after impact have influenced the severity of the column damage?
Comment Reason : Inadequancy in the analysis

Revision Suggestion : Justification for neglecting this or re-analysis taking load re-distribution and P-Δ effects into account.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xv
Paragraph : Section E.5.2 Development of Aircraft Impact Models, Paragraph 1
Comment : The report is vague as to exact details of the aircraft data used □ much of the aircraft model seems to have been developed without detailed engineering drawings or more than some cursory measurements. Whilst it might be argued that the strength of the fuselage is not that significant, the 1-2B report (page 368, section 10.2, last paragraph) notes, and we agree, that the strength of some of the denser elements are significant. Recognising Boeing□s desire to retain proprietary information, have Boeing engineers scrutinised the component masses, thicknesses and dimensions used in these models? Have other LS-Dyna experts checked the aircraft impact model in the same way that SOM checked the building models?
Comment Reason : The limited data used to develop the aircraft models may not have been adequately bounded by the uncertainty analysis. Given that the structure of a B767 aircraft is known it seems sensible to check this data where possible.

Revision Suggestion : Clarification regarding the level of checking used in developing the aircraft data.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxviii
Paragraph : Section E7.1 WTC1 Base Case Analysis, Paragraph 2
Comment : As noted previously (see comments on pg lxv) the aircraft models appears to be based on relatively sparse engineering data □ this is surprising, given that B767 design data exists and any inaccuracies in the aircraft model would increase the level of uncertainty in the result. Our concern relates to the limited details in the report about the undercarriage structure and assembly and wing supports (typical weighing 10-12tons)?
Comment Reason : These would have been critical elements determining the state of the core.

Revision Suggestion : Clarify what detailed information was used to model this component and how was this data collected?

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxixx
Paragraph : Section E.7.1 WTC1 Base Case Analysis, sub section External Wall Damage, Paragraph 2
Comment : How were gravity and aero-elastic forces on the wing applied? It seems the wing deflections in flight were accounted for but the report if unclear how this was done?
Comment Reason : Limited information in report

Revision Suggestion : Clarification

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 1xxxv
Paragraph : Section E.7.1 WTC1 Base Case Analysis, sub section Fuel and Debris Distribution Paragraph 1,
Comment : Limited experimental validation work that has been carried out using this method for fuel dispersion. As the analysis ignored the containing effect of the windows, wetting and the multi phase nature of the fuel combustion process during impact, the actual results are at best subjective.
Comment Reason : Inadequacy in the analysis

Revision Suggestion : Clarification regarding the accuracy and level of the uncertainty in the fuel dispersion.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : ci
Paragraph : E.7.2 WTC2 Base Case Analysis, sub section Fuel and Debris Distribution Paragraph 2,
Comment : See previous comments on (pg lxxxv above) regarding the use of SPH to model fuel dispersal.
(The report notes that the work could not reconcile the fuel getting through 200/300 sides.)

Comment Reason : Inadequacy in the analysis

Revision Suggestion : Clarification regarding the accuracy and level of the uncertainty in the fuel dispersion.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : cix
Paragraph : Section E.7.7
Comment : Detailed comparison of damage on □back□ walls (ie south wall of WTC1 and north face of WTC2) between observables and analysis are not shown. The reports notes later that correlation between the impacts and analyses are poor on these faces.
Comment Reason : Limited information in report

Revision Suggestion : Clarification of impact damage estimates

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 6
Paragraph : Section 1.3 Aircraft Impact Damage Analysis Bullet 2
Comment : The sensitivity analysis seems to neglect much of the uncertainty in the aircraft data used in the model. (see our previous comments relating to Page lxxvii)
Comment Reason :

Revision Suggestion :

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 93
Paragraph : Section5.1 Introduction
Comment : We have often found in large civil and building engineering models, used to explicitly simulate impact and seismic events in real time, variation of results between LS-Dyna analyses using 32 bit and the higher precision 64 bit software. We have occasionally seen significant rounding errors on 32 bit computer software when representing physically large dimensions where relatively small displacements in elements trigger failures. Were any of the results models checked using 64 bit precision to test the accuracy of results? The limitations on models size noted in the report are related to 32 bit operating systems. If the impact models had been run on 64 bit operating systems we believe the limitations on model size would have been avoided.

Comment Reason : One dimensionally large model the accuracy of the analysis results needs to be checked using double precision.
The original NIST objective of using state of the art analyses for the Project 2 seems to have been missed. The limitation on model size could have been avoided by using computers with 64 bit operating systems.

Revision Suggestion : Re-analysis of a few of the larger models using 64 bit software.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 269
Paragraph : Section 7.10.1 , Comparison with Observables on WTC1 Landing gear Trajectory
Comment : We accept that the trajectory calculations are difficult. Our calculations show this to be 120mph if no rolling occurred. Was there any evidence of rolling or ricocheting down the road?
Comment Reason : Limited information concerning the observables

Revision Suggestion : Comments regarding the processes used for recording debris data.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 281
Paragraph : Section 7.10.2, Comparison with Observables on WTC2, Engine Trajectory Comparison
Comment : Could the crash investigators tell whether this was a starboard or port engine?
Comment Reason : Limited information

Revision Suggestion : Clarifcation

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 289
Paragraph : Section 7.11.1 Comparison of External Wall Damage
Comment : See our previous comments about the modelling of fuel in the impact. Was any sensitivity study carried out using the SPHs to correlate this with fuel falling out of the building?
Comment Reason : Shortcoming in SPH method

Revision Suggestion : Clarification of limitations

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 298
Paragraph : Finding 11
Comment : Although conventional office buildings tend not to consider aircraft impact as a foreseeable hazard, nuclear facilities in the US and elsewhere do. The finding that an aircraft impact was considered at the time of the design of the WTC1 and 2 demonstrates that the possibility of impacts whether accidental or deliberate may need to be considered in some circumstances. Although current building codes don□t consider aircraft impact, it seems reasonable to assume that tall buildings or iconic architecture can be considered targets. The work carried out here should be developed to provide useful information to assist those wishing to design more robust buildings and other facilities irrespective of the building codes.
Comment Reason : General observation

Revision Suggestion : None

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: John Lyle <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : John Lyle
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 298
Paragraph : Finding 13
Comment : While generally in agreement that this could be the case, the SPH methodology used should be properly validated. Whether or not this has been done as part of this investigation is unclear.
Comment Reason : There is limited information in the reports to support this finding

Revision Suggestion : Clarification

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: j <john.lyle@arup.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-2

Information Submitted on: 8/1/2005.

Name : j
Affiliation : Arup ATG
Email Address : john.lyle@arup.com
Phone : +44 2077552195
Report Number : NCSTAR1-2
Page Number : 300
Paragraph : Finding 18
Comment : The implication that the tower had sufficient reserve capacity because the natural frequency of the buildings post impact was similar to the undamaged state is incorrect. Because the construction of the towers is essentially tube like, the natural frequencies would not alter significantly even if the core was severely damaged. The following simple FE models demonstrate the insignificance of the core:
Simplistic Model Results

Results from five simple finite element models (of roughly the same geometric proportions as WTC1 and WTC2) demonstrate that a large hole in the side of a tube and the missing parts of the core do not significantly influence the natural frequency (see table 1).

Table 1 Variation of Natural Frequency (in Hz)

	Model 1	2	3	4	5
Bending	0.1653	0.1647	0.1643	0.1636	0.1637
Torsion	0.5981	0.5889	0.5981	0.5891	0.5889

Model 1

Tube & core
No holes Model 2

Large hole in side & no core. Model 3

No hole with core Model 4.

Large hole in side with core Model 5

Large hole in side and core missing at same level

Comment Reason : The stability of the towers immediately following the impact has not really been proven by the impact analysis. Simply taking the results of the impact damaged structure and loading it statically effectively ignores and damage that may have resulted due to swaying.

Revision Suggestion : Provide a more detailed analysis to take account of load path re-distribution in the core and the P-Δ effects of sway following the impact.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

To: wtc@nist.gov
From: "P.R. Conant" <prconant@yahoo.com> (by way of Inquiries <inquiry@nist.gov>)
Subject: Regarding Case B

Dear Dr. Ganns,

I have reviewed the NCSTAR reports and can locate nothing of substance regarding the soffit accounted for in the Case B model.
Specifically, can you tell me what the soffit was composed of and precisely what its location was in relation to the floor system. Also, what does "1.2m" mean in the phrase "1.2m soffit"? Is this a side length or vertical length from the metal deck?
NIST's main report also uses the table with the "soffit remains" note. Yet after reading NCSTAR 1-6, I was unable to be sure whether the "soffit remains" scenario was used in the final computer models that describe the sequences for WTCI and II.
At another point in your report [NCSTAR 1-5], your team says that the pressure pulses from the anomalous "puffs of smoke" did not imply a force sufficient to cause structural damage. What reasoning was used to substantiate this assertion?

I am taking the liberty of sending copies of this email to two other NIST addresses.
I may quote from this email and your response for future publication.

Thank you.

Best regards,
Paul Conant
732 947 0749

Subject: PCA Comments on Final Report of the National Construction Safety Team on the Collapse of the World Trade Center Towers (Draft)
From: "Szoke, Stephen" <SSzoke@cement.org>
To: <wtc@nist.gov>

Please find the comments prepared by the Portland Cement Association attached. Thank you for this opportunity.

Steve
Stephen S. Szoke, P.E.
Director, Codes and Standards
Portland Cement Association
5420 Old Orchard Road
Skokie, Il 60077
847-972-9078
sszoke@cement.org

WTC12 Comments 050727 FINAL.doc

Portland Cement Association
Comments on
NIST NCSTAR 1 (Draft)
Federal Building and Fire Safety Investigation of the World Trade Center Disaster
Final Report of the National Construction Safety Team on the Collapse of the World Trade Center Towers (Draft)

Contact
Stephen S. Szoke, P.E.
Director, Codes and Standards
Portland Cement Association
5420 Old Orchard Road
Skokie, IL, 60077
847-972-9078
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Introduction

Portland Cement Association is a non-for-profit association founded in 1916 representing the portland cement manufacturers in the United States and Canada. To accomplish its mission: "*Improve and expand the uses of portland cement and concrete*," PCA conducts market development, engineering, research, education, and public affairs programs. PCA actively participates in the development of model building codes and reference standards and is an American National Standards Institute (ANSI) accredited national standards writing organization. The following comments on the Final Report of the National Construction Safety Team on the Collapse of the World Trade Center Towers (Draft) are offered by PCA to improve the fire safety of buildings and to correct misconceptions.

General Comments

G-1. PCA applauds NIST for its efforts in the development of this report and the recommendations. PCA will continue its efforts, many of which are consistent with the recommendations of the report, to influence model building codes and national reference standards for increased life safety, property protection, and welfare of the general public. To that end, PCA will work with NIST and organizations involved in model building codes and reference standards development to ensure that economical and effective provisions consistent with the intent of the model building codes and reference standards writing organizations and the mission of PCA are developed and incorporated into such codes and standards.

G-2. PCA recognizes that the report on World Trade Center Building 7 will be prepared separately and plans to provide comments on that report when it becomes available. PCA reiterates its concern that the resources and scope of the evaluations were limited only to buildings that collapsed on September 11, 2001. PCA recognizes that setting priority under the constraint of limited resources caused a perceived need to focus on those buildings that collapsed, but we continue to believe that an opportunity to identify building designs and construction practices that performed exceptionally well was lost due to the limited scope. For example, 90 West Street was damaged by debris from the collapse of nearby structures and fires spread throughout the building. This building did not collapse and has since been renovated and is now being re-occupied.

G-3. PCA remains concerned that there will be continued resistance to improvements in life safety, property protection, and welfare of the general public in future developments of the model building codes and reference standards. Many of the recommendations that relate to technical provisions of building codes have been discussed in the model code development arenas for the past several decades, including during the development and subsequent changes to the first edition of the International Code Council's *International Building Code* and National Fire Protection Association's *Building Construction and Safety Code*, NFPA 5000. PCA and its allies in the cement-based product industries have initiated many of these discussions via code change proposals. Such proposals have attempted to strengthen code provisions by increasing the required fire resistance rating of the structural frame; eliminating sprinkler trade-offs; improving compartmentation by increasing the required fire resistance rating and/or requiring fire resistance rated barriers where codes presently do not require rated walls, with specific emphasis on exit stairway walls; and by modifying the hose stream test of American Society for Testing and Materials (ASTM) *E 119 Standard Test Methods for Fire Tests of Building Construction and Materials* to require the more rigorous test for all specimens. Almost all of these proposals have been disapproved. The reason generally cited for their disapproval is that fire data do not indicate a need for change.

G-4. Mandatory requirements for reporting the performance of building construction in fire scenarios are needed to substantiate revisions to model building codes and reference standards. Mandatory requirements for reporting the performance of building construction are missing components of the United States Fire Administration's (USFA) National Fire Incidence Reporting System (NFIRS). Methods other than NFIRS and/or the use for fire services to accurately identify building construction, evaluate the performance of building construction, retain a database, and report findings may be required.

G-5. PCA encourages efforts to ensure that building collapse does not result due to fire exposure. It appears that fire, with the exception of wildland interface fires, are generally considered local disasters. Therefore, they do not qualify for national disaster assistance, and do not receive the same attention from Federal agencies as other disasters such as high wind and seismic events even though more life and property losses occur annually in these isolated incidences than in most events that may be classified as national disasters. There are higher priorities by Federal agencies on flood, wildland fires, high-wind, and seismic disasters, than for local structure fires. This is likely attributed to major flood, wildland-fire, high-wind and seismic disaster areas being made national disaster areas which are eligible for Federal financial assistance for disaster mitigation and recovery. These priorities may have resulted in a lack of Federal programs for disaster prevention and recovery due to structure fires. It is disappointing that Federal assistance programs for improving life safety and property protection from isolated fire incidents are almost nonexistence when compared with Federal assistance programs than for high wind and seismic mitigation and recovery, especially when structure fires (excluding fires in one and two-family dwellings) annually result in more deaths, injuries, loss of property, and loss of business.

G-6. Consistent units should be used throughout the document. The document currently contains a combination of in-pound and metric units. In the in-pound system temperatures are expressed in °F not °C. If metric units need to be shown, it might be best to place them in parentheses behind the in-pound units.

Specific Comments

Summary of Findings:

S-1. *Page xliv, Objective 2, fourth bullet:*
Inadequacies of the structures to accommodate evacuation in a timely fashion are discussed. There should be provisions in section 9.2.5 "Group 5 Improved Building Evacuation" for the development of models used to predict building evacuation.

S-2. *Page xlv, Objective 2, last bullet:*
The time required for emergency responders to reach destinations within the damaged structures is discussed. The provisions in section 9.2.6 "Group 6 Improved Emergency Response" should include the development of models to predict the response time for emergency responders to reach destinations to perform tasks including time to assist others to evacuate.

S-3. *Page xlix, Table E-1:*
This table calls for New Methods for Fire Resistant Design of Structures to achieve burnout without local or global structural collapse in uncontrolled building fires. Buildings surrounding the WTC towers experienced burnout and did not collapse. The robustness of building elements and the ability of building elements to assist in transferring loads and limiting deflections appear to have played a significant role in allowing such buildings as 90 West Street to be reoccupied. The approach throughout this document appears to focus on individual components consistent with the recent and current trends in model building code and reference standard development. The use of individual building elements for multiple purposes and the use of multiple structural elements within buildings do not appear to be adequately addressed in the recommendations of this report. For example, when masonry walls are placed between structural elements, they are providing compartmentation in addition to limiting deflections at high temperatures, providing additional protection to structural elements, and may be transferring loads to other structural elements. The report does not appear to provide adequate recommendations for combining various structural systems. For example, comprehensive designs of buildings with steel exterior structural elements and concrete or masonry cores are not addressed. In addition, the report does not provide adequate recommendations for providing built-in redundancies by combining active and passive fire protection.
Also, when fire resistance requirements were first developed for building construction, the majority of the fire protection was provided by robust concrete and masonry elements that provided additional benefits to the structure including increased robustness and structural integrity. These benefits appear to have been jeopardized with recent trends in design which focused on developing the least expensive and lightest weight systems to satisfy the fire endurance requirements of the standard fire test, ASTM E 119. A robustness component for all passive fire protection, including sprayed-on fire resistive materials (SFRM), may be needed.

Chapter 1

S-4. *Page 10, line 8:*
Editorial – Change "bending loads" to "floor loads" or "bending moments."

Chapter 5

S-5. *Page 53, Section 5.2.2 "Pertinent Construction Provisions:"*
This section provides a comparison of three building codes in place elsewhere in the United States at the time the twin towers were designed and erected. However, the comparisons appear to be limited to structural design loads. The fire protection provisions of these codes also differed. For example the 1967 Municipal Code of Chicago would have classified this structure as an E occupancy and would have required Type I-A construction due to the building's unlimited floor area and height. The use of Type 1-B construction would have limited the building to 12 stories. In this 1967 code for Type 1-A construction, all columns, interior and exterior, except those supporting the roof, required a 4-hr rating. Similarly, beams and girders, except those supporting the roof, required a 3-hour rating.

S-6. *Page 68: Section 5.6 "Passive Fire Protection:"*
The title of this section should be revised. The discussions are limited to the fire protection of steel columns which do not address other passive fire protection. This may lead to unintended misinterpretations that passive fire protection in general may be inadequate. To be consistent with the terminology of ASCE 29, it is suggested that "Passive Fire Protection" be replaced with "Fire Protection of Structural Steel." Discussion in this section might also include statements that SFRM was selected for this project in lieu of other fire protection methods such as encasing structural steel in concrete or masonry. Substantiation for such discussion may have been discovered if the scope of the report on the performance of buildings impacted by the events of September 11, 2001 included the buildings that did not collapse, such as 90 West Street.

S-7. *Page 74: Section 5.7 "Concrete:"*
This section should emphasize that the weakened steel floor trusses resulted in excessive sagging in the floor system. Since trusses were quite deep, the thin 4" concrete floor remained in compression and likely prevented the trusses from complete collapse. Without such clarification, it may be interpreted by readers that structural concrete floor members failed.

Chapter 6 – Reconstruction of Collapse

S-8. *Page 101, Line 2, "Phase 2: Major Subsystem Analyses:"*
There is discussion about "insulation damage due to shock and subsequent vibrations as a result of aircraft impact or concrete slab cracking and spalling..." The latter may be of importance in existing fire test standards and reporting. During the NIST floor system fire tests at Underwriters Laboratories a comment was made by an unidentified researcher (not with UL) suggesting that some SFRM manufacturers specify a concrete with aggregates and water contents to minimize shock and vibration at elevated temperatures. This is done to minimize the amount of SFRM that is dislodged during tests. Such test results of the steel systems with SFRM, based on fire testing with concrete designed to produce minimal shocks, might be inappropriately applied for steel floor systems regardless of the type of concrete actually used for a specific project.

S-9. Page *119: Section 6.10.2 "Modeling Approach:"*
The modeling approach includes the influence of debris from wallboard, concrete, ceiling tile and other non-combustibles. It is not clear if the 4 lb/ft^2 tenant fuel load in section 6.10.3 "The Four Cases" included the effects of the debris on ignition and combustion of building contents, altering the fire load.

Chapter 8 – Principal Findings

S-10. *Page 179: Section 8.3.4 "Reconstruction of the Fires"*
In the fifth bullet there is discussion of the fire load at 4 lb/ft^2. It is unclear if this load includes the effects of non-combustible dust and debris described in the comment above.

Chapter 9 – Recommendations

S-11. *Page 197: Section 9.1 "Building Standards and Codes: Who Is In Charge?"*
Discussion in the third paragraph is misleading. While 45 states plus the District of Columbia have adopted the International Building Code (IBC), the IBC is not applied to all buildings in these 45 states. Only seventeen states have a state-mandated building code covering all buildings and occupancy classifications. One of these seventeen is California, which has not adopted the IBC. Eighteen states do not have a state-mandated building code covering residential and commercial building other than one and two-family dwellings. Twelve of these eighteen states are listed as having adopted the IBC on the International Code Council web-site. Several states have adopted the IBC only for state-owned buildings, state-funded buildings, or for special occupancies, which in some states may be limited to multi-family construction. The statement without clarification overstates the trend toward a national building code, suggesting that 45 of 50 states have adopted the IBC. In fact some state legislation clearly states that if a jurisdiction adopts a building code it must be the state code based on the IBC, but there are no requirements for a jurisdiction to have a building code. It is also noteworthy that only 10 states do not allow amendments to their building code. According to the Institute of Business and Home Safety, 14 states allow local amendments that are more stringent then the state-mandated code and 4 allow amendments that are less stringent than the state-mandated code. Furthermore, local jurisdictions may adopt ordinances, not part of the building code, to further regulate building design and construction. PCA believes these local variations are extremely important for local jurisdictions to adequately provide life safety, property protection, and welfare of the general public in a fashion that best suits the needs of the community. There may be building height restrictions due to limitations in the equipment of fire services. There may be restrictions due to inadequate water resources. There may be amendments because of the differences in volunteer fire services versus paid fire

services. Another variation that might warrant amendments is the distance from fire stations to community boundaries. Amendments might be warranted due to variations in local geologic, topographic and climatic conditions. Each jurisdiction needs to be able to amend the model building codes to appropriately address these local conditions. PCA continues to work with both the ICC and NFPA for the development of minimum model codes to be used as the base requirements for their state or local building code adoption. PCA encourages amendments to model building codes at the state and local levels when the minimum provisions of a model code do not adequately satisfy the requirements of a community to function in a safe and productive manner due to resource and/or equipment limitations or economic, geologic, topographic, climatic, or other considerations.

S-12. Page *198, Line 20, Section 9.1 "Building Standards and Codes: Who Is In Charge?"* This section contains a statement "Due to limited participation of the general public and building occupants, NIST has a responsibility to represent the public's interest." Is this statement accurate? If this statement is accurate, what process does NIST have in place to assure its actions and activities are representing the public's interest?

S-13. *Page 200, Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders," Item 2:*
This section needs to be expanded to include an evaluation of the performance criteria of typical construction historically tested in ASTM E 119 tests. Through such an evaluation, fire endurance tests may be found to be adequate. Whereas, the more significant aspect might be related to robustness or other criteria which may not be adequately addressed in the current ASTM E 119 test methods.
Discussion of "structural frame" is limited to girders, beams, trusses and spandrels. This excludes some concrete and most masonry components. Composite structures of concrete, steel, and/or masonry should be addressed for all buildings, especially those 20 stories or more in height. Concrete or masonry shear walls or masonry infill between structural members intended to serve primarily as fire protection or for compartmentation may limit deformations of, reduce temperatures of, and transfer loads from girders, beams, trusses, spandrels, and columns which are subjected to excessive loads. It may be more practical to transfer loads through elements primarily intended for fire safety than to incorporate other redundancies into the structural design of the building.
If existing fire resistance test methods are discovered to warrant revision, provisions should be incorporated into the recommendations that call for developing a methodology that can demonstrate compliance using test results obtained from existing test standards. Without such a tool, the costs to industry for retesting all assemblies would be more than each industry segment can bear. PCA recognizes that several aspects of the existing standard fire test method (ASTM E 119) may warrant revision. Examples include standardized design, construction, and operation of the furnace; and replacing the time-temperature curve with fuel load which would isolate the fuel load of the test specimen. To date, any significant revisions to the fire test standard have been slow, primarily because of the potential cost of re-testing thousands of materials, assemblies, and configurations.
Collection of data regarding the fire performance of building construction after actual structure fires would be useful in determining if priorities should be placed on revision of existing fire endurance test procedures themselves or the development of additional test methods to determine the robustness of passive fire protection.

S-14. *Page 200, Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders," Item 3:*
PCA strongly supports the design of structures to resist collapse after complete burnout. Such structures exist, as documented by the re-occupancy of 90 West Street.

S-15. *Page 200, Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders," Items 3 and 4:*
There is a need for further evaluation and development of provisions to address balanced design for fire safety with appropriate redundancies not only for structural elements and systems and for active fire suppression systems, but also for combining active fire suppression and passive fire protection.

S-16. *Page 200, Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders," Item 5:*
Improved building evacuation will benefit from more robust egress routes including corridors, stairways, and elevator shafts.

S-17. *Page 200 Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders," Item 6:*
Improved building emergency response access will benefit from more robust egress routes including corridors, stairways, and elevator shafts.

S-18. *Page 200 Section 9.2 "NIST's Recommendations for Improving the Safety of Buildings, Occupants, and Emergency Responders:"*
This section is lacking any discussion regarding the potential impact of a building or building system collapse on adjacent buildings. Recommendations may be needed for developing a method to determine if impact on or from other buildings warrants consideration in a building design and what if any provisions might be incorporated into model building codes and standards. The collapse of WTC 1 and 2 had a significant impact on WTC 3, 4, 5, 6, and 7 and several other surrounding buildings. If all the buildings surrounding the twin towers were of similar construction as WTC 7 and not of more robust construction like 90 West Street, there might have been more building collapses as a result of the collapse of the twin towers and additional collapses from the collapse of neighboring buildings – a house of cards effect.

S-19. *Page 202, Section 9.2.1 Group 1. "Increased Structural Integrity:"*
PCA strongly encourages NIST to modify its discussion to encourage design that considers the benefits of other building components in increasing the fire endurance and structural integrity of individual components or structural systems. As previously mentioned, a properly designed fire separation partition may perform as an element to resist deflections and/or transfer loads to other structural elements when the failure conditions of a particular structural component are reached. An approach combining design of structural elements and design of fire protection features should consider the use of appropriately designed fire protection features such as elements that are used to resist collapse.

S-20. *Page 204, Section 9.2.2 Group 2. "Enhanced Fire Resistance of Structures:"*
Consider expanding this section to include identifying building construction features of interest to emergency responders. Information about the construction type, maximum compartment size, window systems, construction of egress routes and elevator shafts, and the type of fire protection (concrete or masonry versus spray-applied fire resistive materials (SFRM) would be extremely useful to emergency responders. This and related information could be maintained in the fire control room and/or in a database accessible to emergency responders.

S-21. *Page 205, Section 9.2.2 Group 2. "Enhanced Fire Resistance of Structures," Recommendation 5:*
Consider adding item "d. Develop methods for predicting the performance of assemblies tested under the existing fire test methods as if tested under any revision to the existing fire tests."

S-22. *Page 206, Section 9.2.2 Group 2. "Enhanced Fire Resistance of Structures," Recommendation 6:*
Consider adding provisions for the development of test criteria for SFRM to appropriately resist external vibrations and shock as well as vibration and shock inherent in the system as specified.

S-23. *Page 207, Section 9.2.3 Group 3. "New Methods for Fire Resistance Design of Structures," Recommendation 8:*
Consider expanding the scope of this section to buildings not defined as tall (20 stories). Prevention of collapse is important for many other buildings depending on the occupancy classification. Collapse resistance is also appropriate for buildings in close proximity to other buildings. Further collapse prevention is appropriate for any building over one story in height that is occupied by persons with physical disabilities or other impairments that restrict mobility.

S-24. *Page 207, Section 9.2.3 Group 3. "New Methods For Fire Resistance Design of Structures," Recommendation 8.*
We strongly support this recommendation for burnout without local or global collapse. Re-occupying structures after burnout is desirable and achievable, as was demonstrated by buildings surrounding the WTC site, especially 90 West Street, and more recently the LaSalle Bank Building in Chicago where the fire was confined to several floors. In the latter case there were no sprinklers. Concrete and masonry provided adequate fire protection and compartmentation, no deaths occurred and the damaged areas of the building are being retrofitted for future use.

S-25. *Page 210, Section 9.2.5 Group 5. "Improved Building Evacuation," Recommendation 16:*
There is a need for occupancy evacuation modeling procedures to determine the appropriate time requirements to assure minimum life safety. Development of work described in this section should be coordinated with Recommendation 4 on fire rating requirements.

S-26. *Page 211, Section 9.2.5 Group 5. "Improved Building Evacuation," Recommendation 17:*
There is a need for emergency responders to have access to evacuation modeling to determine the appropriate time requirements to assure that responders reach their destinations and are able to perform duties including assisting evacuation. Evacuation models should include emergency responders entering the structure while occupants are evacuating. Development of work described in this section should be coordinated with Recommendation 4 on fire rating requirements.

S-27. *Page 212, Section 9.2.5 Group 5. "Improved Building Evacuation," Recommendation 17, Item c:*
The use of scissor stairs (when credited as a single exit could) should serve as a means to physically separate first responders who are entering the building from building occupants exiting the building facilitate access.

S-28. Page 214, Section 9.2.6 Group 6. "Improved Emergency Response," Recommendation 21:
Improved and hardened egress and access routes should be included in this recommendation and Recommendation 18. Hardened passageways will help assure that routes to hardened elevators are not obstructed by debris, and if properly designed and ventilated may serve as safe havens until assistance arrives.

S-29. *Page 214, Section 9.2.6 Group 6. "Improved Emergency Response," Recommendation 21:*
Consideration should be given to the development of models for predicting access times for emergency responders. The results of such model would be useful in determining criteria in Recommendation 4. This section should be developed with Recommendation 4 on fire rating requirements.

S-30. *Page 220, Table 9.1, "Enhanced Fire Resistance of Structures:"*
Recommendations 4, 5, and 6 should be appropriate for "Selected Other Buildings." Construction classification and fire rating requirements are more appropriate for some building occupancies under 20 stories than for other building occupancies over 20 stories. Recommendation 5 on fire standards would also be applicable to buildings under 20 stories tall. The recommendations for SFRM should also be appropriate for buildings of any height.

S-31. *Page 220, Table 9.1, "Improved Building Evacuation:"*
Public education in Recommendation 16 is appropriate for "Other Select Buildings" depending on occupancy and mobility of occupants. Recommendation 18 on egress systems should be considered for all buildings regardless of height.

S-32. *Page 221, Table 9.1, "Improved Emergency Response:"*
Hardened egress routes are appropriate for "Selected Other Buildings" as well as buildings over 20 stories in height. Recommendation 24 retaining an effective uninterrupted operation of a command and control center should also be applicable to "Selected Other Buildings."

S-33. *Page 222, Table 9.2a, "Standards Affected by the Recommendations:"*
Add American Concrete Institute ACI/The Masonry Society (TMS) 216.1 – Standard Method for Determining Fire Resistance of Concrete and Masonry Construction Assemblies. This standard addresses group numbers 1, 2, and 3 and is applicable to recommendations 1, 3, 8, 9, and 11.

S-34. *Page 224, Table 9.2a, "Standards Affected by the Recommendations:"*
Add The Masonry Society (TMS): ACI 530/ASCE 5/TMS 402 Building Code Requirements for Masonry Structures. This would be applicable to group numbers 1, 2, 3, and recommendations 1, 2, 3, 8, 9, and 11.

S-35. *Page 225, Table 9-2c, "Organizations Affected by the Recommendations:"*
Add The Masonry Society (TMS) for group 8, education and training, with recommendations 29 and 30.

S-36. *Page 225, Table 9-2c, "Organizations Affected by the Recommendations:"*
Add Portland Cement Association (PCA) for group 8, education and training, with recommendations 29 and 30.

In

From: Peter Szerlag <zerg90@gmail.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-8

Information Submitted on: 7/18/2005.

Name : Peter Szerlag
Affiliation :
Email Address : zerg90@gmail.com
Phone : 781-648-2329
Report Number : NCSTAR1-8
Page Number : ?
Paragraph : ?
Comment : This is message # 16172 from 25 March 2005 at
http://www.yahoogroups.com/group/privatewirelessforum

I need to correct a few things, the port authority radiax system at the WTC which looped through the basement and up the towers and had more than 3 miles of radiax had only PA licensed UHF & 800 MHZ frequencies on it plus the FDNY repeaters that the PA bought & installed but were licensed by the city. There were no commercial carriers on the radiax. Concourse Communications ran a carrier neutral fiber based RF distribution system on the concourse level where the stores were and on the truck dock and this carried Verizon, AT&T and other commercial carriers.

There was only one cell site at the WTC and it was on the roof of 5 WTC, a 9 story building. It was AT&T and it was part of a deal after 93 bombing to install it and spray the towers so fire wardens walking down could use AT&T cells, which we originally provided to them before cells became common.

There was a major Verizon switching office in 2 WTC and Teleport Communications later purchased and became AT&T Local Communications had a a major switching office in the lowest level (b6) of 2 WTC. The verizon building at 140 West st was severely damaged by the collapse of 1 WTC and flooded and knocked out of service. I don't know what went through the Verizon office on that day but in 1993, we raced to restore power to it after the phone people told us that all the FAA circuits for the 3 NY metropolitan airports were routed through it and the batteries were down to 40 VDC.

I know my cell worked on 9/1 while I was answering emergency calls at the PAPD WTC police desk in 5 WTC until the collapse of 2 WTC when it was lost as we tried to escape after being trapped by rubble. I eventually got that VZW qualcomm back from the rubble after they charged it up and my name and phone number came up on the display. Came back in a sealed evidence bag.

Comment Reason : I did not see any mention of the coax system in the NIST

In

report.

The NIST report also seems to be confused about the FDNY 800 Mhz trunked administrative radios versus the FDNY 482 Mhz UHF tactical radios.

Revision Suggestion : Investigate the possibility that the 154.43 mhz FDNY repeater system was only half functioning - perhaps the repeater on top of WTC 5 was still functioning, but it could only cover 2 sides of each of the Towers. Perhaps the FDNY repeater was not operating in the below ground areas. This situation would have presented the FDNY with partial building coverage where full building coverage was normally experienced.

You are presenting information that is very incomplete.

Why is there no means of making a copy of this submission?

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

THE PORT AUTHORITY OF NY & NJ

July 20, 2005

Francis J. Lombardi, P.E.
Chief Engineer

Dr. Shyam Sunder
Acting Deputy Director
Building and Fire Research Laboratory
National Institute of Standards and Technology
100 Bureau Drive, Stop 100
Gaithersburg, MD 20899-1000

SUBJECT: NIST Draft Report of WTC Collapse – 4th Stair Issue for Places of Assembly

Dear Dr. Sunder:

The draft report prepared by NIST has the following incorrect and misleading statement, in the 4th paragraph on page 58 of NCSTAR1, regarding code interpretation and the need for a 4th exit from Windows on the World and Top of the World that is not factual:

> "Subsequently, NIST communications in 2005 with the Port Authority and the NYC Department of Buildings identified a difference of interpretation regarding the number of exits required to serve these floors. The Port Authority stated that a 4th exit was not required since the assembly use space in question constituted less than 20 percent of the area of principal use, with principal use area defined as the entire building."

The statement does not represent the Port Authority's written response to questions from NIST regarding the applicability of the concept of areas of refuge and the need for a 4th stair, as evidenced in the attached copy of the communication.

The fact remains that the Port Authority reached out to the NYC Department of Buildings for code interpretation and requirements with respect to egress from Windows on the World. The Registered Architect of Record interpreted the code; the PA did not. The egress from Windows was presented to the Department of Buildings and they concurred with the design.

The statement in the draft report should be corrected in the final report to accurately represent the facts.

I would like to commend NIST's National Construction Safety Team for the extensive technical work and in-depth analysis done in the investigation of the World Trade Center collapse. The draft final report presents unprecedented technical details and demonstrates the high level of technical expertise of the Investigation Team.

The Port Authority is presently going through the draft of the complete report and any further comments will be forwarded to you before the August 4th deadline.

Sincerely,

Francis J. Lombardi, P. E.
Chief Engineer

Attachment

233 Park Avenue South, 7th floor
New York, NY 10003
T: 212-435-7449 F: 212-435-6689

Bhol, Saroj

From: Shyam Sunder [sunder@nist.gov]
Sent: Friday, May 06, 2005 10:32 AM
To: Bhol, Saroj
Subject: Re: Exits for Assembly Use Spaces

Saroj: Thanks. Shyam

At 09:02 AM 5/6/2005, you wrote:

Shyam,
Here's the response to the questions in the attachment.
Thanks
Saroj

(The numbers relate to the questions)

1. PA reaches out to the NYC Department of Buildings (DOB) for code clarifications and interpretations. Based on PA's meeting on exits from the Windows on the World with the DOB on December 6, 1994, it's PA's understanding that "20% of the floor area" in section 27-367 is intended to be the total floor area in the building occupied by the principal use.

2. There are no other section in the code on exit reduction beside section 27-367.

3. During the meeting with the DOB, the need for a fourth stair did not arise.

-----Original Message-----
From: Shyam Sunder [mailto:sunder@nist.gov]
Sent: Monday, May 02, 2005 1:19 PM
To: Bhol, Saroj
Cc: rbukowski@nist.gov; jason.averill@nist.gov; james.lawson@nist.gov; cauffman@nist.gov; cheri.Sawyer@nist.gov
Subject: Exits for Assembly Use Spaces

Saroj,

Attached is a request for information/clarification regarding the numbers of exist required for the assembly use spaces at the top of the WTC towers. Please be advised that NIST has not made a determination whether the WTC towers required four stairwells as a result of these spaces. We would appreciate your response in the near future.

Shyam

Dr. S. Shyam Sunder
Acting Deputy Director
Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899-8600
Tel.: 301-975-6850; Fax: 301-975-4032

Number of Exits Required in the Assembly Use Areas of the WTC Towers
All of the building codes examined in this study contain nearly identical requirements for Means of Egress, so this discussion will focus on the (1968) New York City Building Code (NYCBC). The building code (27-366) requires that every floor shall have "*... at least two independent exits, remote from each other ...*" except for one and two family dwellings and certain group J (multifamily residential) buildings. Subparagraph 3 of this section states further that,

"Notwithstanding any other provision of this section, when, within a building, any place of assembly has an occupant load between five hundred and nine hundred ninety-nine persons, there shall be provided at least three independent exits, remote from each other, from each floor; ***any such place of assembly with an occupant load of one thousand or more persons shall be provided with at least four independent exits, remote from each other, from each floor*** *(emphasis added)."*

However the next section provides for reductions in the number of exits required as follows:

*"**27-367 Exit reduction** - When a floor area has access to areas of refuge that comply with the requirements of section 27-372 of article five of this subchapter, the number of persons for whom vertical exits are to be provided may be reduced to fifty percent of the occupant load of the floor area when one area of refuge is provided, and may be reduced to thirty-three percent of the floor area when two areas of refuge are provided. This section shall not be applicable to any new or altered place of assembly, except for such places of assembly in fully sprinklered office buildings* ***which occupy less than twenty percent of the floor area occupied by the principal use*** *(emphasis added)."*

For the office floors the occupant load was no more than 390 and only two exits (providing a minimum of 6 ½ units of exit width, total) were required. Three exits providing a total of 6 ½ units of exit width were present.

For Windows on the World (floors 106 and 107 in WTC 1), however, the occupant loads were 1,013 and 1,130 respectively and the capacity of the stairs was increased to 1,170 by the creation of three areas of refuge, arranged in accordance with the requirements of section 27-372. Similarly for Top of the World (floor 107 in WTC 2) the occupant load calculated by the code required method was 1,751, but was limited to the 1,170 stair capacity (permitted by the creation of three areas of refuge) by order of The Port Authority and enforced by the tenant.

Applying the NYCBC provisions to Windows on the World and Top of the World:

- 27-366 (3) calls for four independent exits, except as modified by the next section.
- 27-367 does not appear to be applicable since all three floors were altered places of assembly (they had been renovated after the 1993 bombing) and:
    - The buildings do not appear to have been fully sprinklered in 1995.

- It appears the buildings were fully sprinklered by September 11, 2001 (as late as 1999 the sprinkler system being installed on the skylobby floors). However, the places of assembly occupied more than twenty percent of the floor area occupied by the principal use on those floors (which was assembly use).

Questions for the Port Authority of New York and New Jersey:

1. How does the PANYNJ interpret above sections 27-366 and 27-367 of the New York City Building Code?

2. Are there other sections of the New York City Building Code that would have allowed a different interpretation regarding the number of exits required?

3. On what basis does the PANYNJ conclude that a fourth exit was not required?

X-Sieve: CMU Sieve 2.2
X-Sender: sunder@email.nist.gov
X-Mailer: QUALCOMM Windows Eudora Version 6.1.2.0
Date: Mon, 01 Aug 2005 10:51:31 -0400
To: wtc@nist.gov
From: Shyam Sunder <sunder@nist.gov>
Subject: Fwd: Comments on WTC final report (draft)
Cc: rgann@nist.gov, hsl@nist.gov, rbukowski@nist.gov, wgrosshandler@nist.gov, jason.averill@nist.gov, james.lawson@nist.gov, fahim.sadek@nist.gov, frank.gayle@nist.gov, jgross@nist.gov, terri@nist.gov, cauffman@nist.gov, cheri.Sawyer@nist.gov
X-NIST-MailScanner: Found to be clean
X-NIST-MailScanner-From: sunder@nist.gov

> X-Sieve: CMU Sieve 2.2
> Subject: Comments on WTC final report (draft)
> Date: Mon, 1 Aug 2005 10:29:40 -0400
> X-MS-Has-Attach: yes
> X-MS-TNEF-Correlator:
> Thread-Topic: Comments on WTC final report (draft)
> Thread-Index: AcWWpSAngJJk6gplQz6+ordq8Q1zkg==
> From: "Bhol, Saroj" <sbhol@panynj.gov>
> To: "Shyam Sunder \(E-mail\)" <sunder@nist.gov>
> Cc: "Begley, James" <jbegley@panynj.gov>, "Fadavi, Ali" <afadavi@panynj.gov>, "Lin, C. John" <jlin@panynj.gov>, "Lombardi, Frank" <flombard@panynj.gov>, "Reiss, Alan" <areiss@panynj.gov>
> X-NIST-MailScanner-Information: Please contact the ISP for more information
> X-MailScanner:
> X-MailScanner-From: sbhol@panynj.gov
>
> Sam,
> Please see the attachment for PA's comments on the final draft report.
> Thanks
> Saroj
>
> <<Comments on NIST Report.doc>>

===
Dr. S. Shyam Sunder
Deputy Director
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===

Comments on NIST Report.doc

THE PORT AUTHORITY OF NY & NJ

<u>Comments on NIST Draft Reports</u>

NCSTAR 1

- Section 5.2.3(Page 54): The "Architectural and Structural Design Guidelines, Specifications, and Standard Details" document was not issued as a replacement for the "Tenant Construction Review Manual". Instead, it contained additional guidelines and standards that were to be complied with for any alterations in the WTC towers.

- Section 5.3.2 footnote 8(Page 55): Saroj Bhol's designation should read "Engineering Department, PANYNJ", and not "Design and Engineering".

- Section 5.3.5, Page 59: "Section 1.1.2" is described as referring to stairwell improvements, however there is no such section in the actual report. Regarding stairwell improvements, the Port Authority installed photo-luminescent paint and emergency power in the stairwells.

NCSTAR 1-1

- Executive Summary, Sections E.6 and E.8; and Chapter 7, Title and Section 7.5: Suggest replacing the word "variance" with "deviation" in order to avoid confusion with code variances.

- Executive Summary, Section E.10, Specifications for the original Buildings, 2nd paragraph; and Section 10.4.2: Business Occupancy in NYC Building Code is Occupancy Group 'E', not 'B.'

- Introduction, Section 1.3, last paragraph: The "Architectural and Structural Design Guidelines, Specifications, and Standard Details" document was not issued as a replacement for the "Tenant Construction Review Manual. Instead, it contained additional guidelines and standards that were to be complied with for any alterations in the WTC towers.

- Section 5.1.4, footnote 22: Same as second bullet for NCSTAR 1, Section 5.3.2 footnote.

NCSTAR 1-1C

- Section E3.2: Ongoing patch work of elevator fireproofing was done by Turner or Barney labors who were WTC GC. Please note that elevator 6/7A were abated and re-fireproofed post 93. Elevators 12/13/14/15A were also re-fireproofed.

NCSTAR 1-1H

- Page 47, Executive Summary: "Emergency lighting and exit sign enhancement" mentions post-1993 use of battery packs but omits mention of photo-luminescent paint in stairs and signage.

NCSTAR 1-4

- Page 42, 3rd paragraph states, "No information was found that indicated that the generator/fuel day-tank enclosures in WTC 7 were protected by automatic sprinklers or other special hazards protection." This is incorrect.

  7 WTC was fully protected by automatic sprinklers. The enclosure for the fuel tank on the 1st floor (where the Mayor's Emergency Management Office was located) was 4-hr fire rated and had clean agent (Inergen) extinguishing system protection. PA provided NIST with complete design and construction documents.

- Page 44,1st paragraph: The original fire alarm system was developed and supplied by the "American Multiplex System Company", not "American Multiple System Company".

NCSTAR 1-7

- Page iii, Acknowledgements, 5th paragraph: Alan Reiss, who was the Director of World Trade Department on 9/11/2001 should be included for his extraordinary effort in providing valuable information from his own and former WTD staff's personal records and facilitating access to PA personnel who were involved in the operation and maintenance of World Trade center.

- Page 12, Table 2-1: 110 in 1 WTC were TV transmitter rooms, and not studios; the 44th floor of 1 WTC was not the cafeteria, but rather the kitchen for the cafeteria. The cafeteria in 1 WTC was located on the 43rd floor. The 43rd floor of 2 WTC contained the Dean Witter cafeteria.

- Page 17: Fig 2-7 is a picture of the commodity trading floor in 4 WTC, 7th floor. However, it is NOT typical of trading floors in towers, which were rows of desks with complex phone systems and multiple monitors per position. Traders generally sat at their desks; 4 WTC was an exception.

- Page 28: 2nd paragraph says the Port Authority treated the plaza as an underground street. This is not accurate. The plaza was not underground; it was an open space at the street level. The concourse level was treated as an underground street during original design (the plaza was treated as a street).

  The PA added bridges from the mezzanine and additional exit doors after original construction so that occupants exiting stairs by West Street did not have to traverse the entire mezzanine to get to 1 WTC's east side plaza. Instead, they could exit north or south directly over the stairs, which descended to street level and placed them on the plaza right away. The same changes were made in 2 WTC.

- Page 28, Transfer Hallways: The paragraph states that there were horizontal transfers in stairwells at floors 66 & 68. This deviation only occurred in one stairwell (i.e., A) in one building (i.e., 1 WTC) as opposed to the areas between 42-48 and 76-82 which jutted out in the A & C stairwells in both towers. It should also be noted that the horizontal deviation between floors 66-68 was a much more minimal one, (i.e., with the continuation of the stairwell in view and no smoke doors or other obstructions) than the other "transfer" areas mentioned. The distinction should be made. Also, in discussing the horizontal transfers, it should be mentioned that there were smoke doors in the transfer hallways (in the 42-48 and 76-82 areas) that were kept closed but not locked.

- Page 30: Stairway doors leading in and out of tenant spaces were not integrated into the computerized access system controlled remotely from SCC on the 22nd floor; the only stairwell doors on this system were those leading into spaces such as mechanical equipment rooms on 41, 42, 75, 76, and doors leading from stairwells A & C to the 110th floor (necessary to pass through to access the roof). The system also controlled the two doors leading from the 110th floor to the roof. Doors leading in and out of tenant spaces had manual locksets to allow access into the stairs.

- Page 34: Elevators 6 & 7 served Windows or Observation deck. Note that Elevator 6 was a dual-use car, pax or freight during off hours.

- Page 39, Section 2.3.2: Bullets relating to the sky lobby deputy fire safety director should be deleted. There were no deputy fire safety directors stationed in the sky lobbies on the 44th and 78th floors as of September 11, 2001.These stations were eliminated when the backbone of the new fire alarm system was installed in the mid-90s. After this time, only elevator starters were posted in the lobby.

- Page 42, Section 2.4: The cost for the life safety upgrade was close to $250 million.

- Page 98, Section 6.2.4, 2nd Paragraph; Executive Summary, page xxxiv, 2nd paragraph: The Port Authority is not aware of substantiation to support a specific time for the "first" public-address announcement, (which we believe occurred before 9:00 AM) or whether there were simply two discrete announcements. Please verify.

- Page 111, Section 8.5, 2nd Paragraph: <u>See bullet 5 of this section</u>, p. 30; Doors leading from tenant space into the stairwells were not controlled by the SCC. As noted, these doors were always kept unlocked from the floors into the stairwells, with re-entry possible on at least every 4th floor. The inoperable tenant stairwell doors and/or smoke doors in the transfer hallways (reported in some cases as "locked" were likely jammed by shifting caused by the impact of the plane or otherwise blocked by debris. Issues with the SCC's computerized access system were not relevant to the ability of these doors to open.

- Page 123: The express elevator that eventually returned to the lobby may have been on slow-speed run. The elevators were wired to come to an emergency stop if a safety circuit was triggered (such as manual emergency stop button or opening of door interlock). During the 1980s, as a means of preventing extended entrapments (especially during off-hours), Otis Elevator modified the circuitry so that if the circuit was restored, the elevator continued towards its destination at inspection speed, typically around 50 FPM. The safety switch circuit was a series circuit. If people on a crowded elevator leaned on the interior car door and it moved about 1/4", the safety circuit would be tripped. Some switches, such as those on the follower or sheave in pit, were manual reset safety switches.

- Page 143, etc.: Please spell out "PA" as "public address"; reader may confuse with Port Authority.

- Page 148: Port Authority purchased evacuation chairs and provided them free to tenants after the 1993 bombing.

NCSTAR 1-8

- Page xxxv, Acknowledgement: Alan Reiss, who was the Director of World Trade Department on 9/11/2001 should be included for his extraordinary effort in providing valuable information on Emergency Response Operations from his and former WTD staff's personal records and experience n the operation and maintenance of World Trade center.

- Page xl of Executive Summary, Section E.2, 5th bullet: Controls for repeater operation were moved to the Fire Command Desks inside the lobby of each of the two towers at the FDNY's request.

- Page xlii, In the section "Initial 'Size-up' and Impact of Aircraft Damage to WTC 1", it should read, "Upon entering WTC 1 and going to the fire command desk to set up the Lobby Command Post, he met with the building's former Fire Safety Director…"The person who was the WTC Fire Safety Director before SPI took over was no longer the Fire safety Director for the WTC under SPI management. The new fire safety director under SPI management died on September 11, 2001.

- Page l of Exec Summary, 2nd bullet says Buildings were not clearly marked, and many emergency responders did not know one building from the other. This resulted in units being assigned to one building and reporting to the other building without knowing that it was the wrong building. While the PA acknowledges the confusion depicted in the radio transcripts, it disagrees on the notion that the towers were not clearly marked. Both 1 & 2 WTC were marked with approximately 12-foot high pylon type signs with large red text on black background, along with smaller text indicating Windows on the World and the observation deck. These signs were located on West & Liberty Street entrances to the towers and were installed post-1993. Both towers' lobbies contained large black & white overhead signs indicating the building number and the locations of the proper elevator banks.

- Page 1 of Executive Summary under Emergency Communications reads," Lack of rigorous pre-emergency inspection and testing of radio communications systems within high-rise buildings to identify performance gaps and inadequacies." The system installed at the World Trade center was fully tested and checked out by FDNY before being placed into service to verify expected performance both above & below grade. Please refer to the letter from FDNY that was previously transmitted to NIST by the Port Authority. Please note that PA's criteria for the design of the system was 95-98% coverage.

- Page 48, section 5.4 "Roof Rescue and Aviation Procedures", 2nd Para ("Roof Access…"), sentence beginning "No fire safety procedures…": At end of sentence (after "key run"), please indicate that on September 11, 2001, the SCC attempted to release all locks controlled by the computerized access system but was unable to do so because of damage to the system sustained during the impact of the plane.

- Page 128 contains numerous references to FDNY's new 800 MHz radios. These radios were not 800 MHz trunked radios but were UHF radios in the 480Mhz range. They were capable of both analog and digital modes of operation. These radios are completely different from the 800 MHz radios issued to chiefs for inter-agency communication. Please check details with FDNY. This trade journal editorial contains additional details regarding FDNY radios:

  <http://mrtmag.com/mag/radio_fixed/>

In

Subject: comment NCSTAR 1-8
From: "Reiss, Alan" <areiss@panynj.gov>
To: <wtc@nist.gov>
Cc: "Bhol, Saroj" <sbhol@panynj.gov>

Good morning,

On page 1 of NCSTAR 1-8 exec. summary under emergency communications it says "**Lack of rigorous pre-emergency inspection and testing of radio communications systems within high-rise buildings to identify performance gaps and inadequacies.**" The system I had installed at the world trade center was fully tested and checked out by FDNY before being placed into service to verify expected performance both above & below grade. I am attaching a letter from FDNY to myself that was previously transmitted to NIST by our engineering department.

Alan Reiss
former dir. World Trade Center
Port Authority of NY & NJ
212 435 -3701
<<ltr - FDNY to A Reiss 011994.pdf>>

ltr - FDNY to A Reiss 011994.pdf

X-Sieve: CMU Sieve 2.2
X-Mailer: Handspring Mail (1.0)
From: S. Shyam Sunder <sunder@nist.gov>
To: wtc@nist.gov, rgann@nist.gov, fahim.sadek@nist.gov, james.lawson@nist.gov, cauffman@nist.gov, cheri.sawyer@nist.gov
Subject: FW: Black Boxes at WTC
Date: 26 Jul 2005 16:08:27 -0400
X-MailScanner:
X-MailScanner-From: sunder@nist.gov

-----Original Message-----
From: dorshkind
Date: 7/26/05 2:48 pm
To: sivaraj.shyam-sunder@nist.gov
Subj: Black Boxes at WTC

Dr. Sunder:

Has your investigation covered the reasons that the aircraft Black Boxes were apparently not recovered? According to my internet research, 3 of the 4 Black Boxes were recovered, but the FBI quashed this information. My source for this is the attached article.

Larry Dorshkind
Redwood City, CA

BlackBoxCoverUp.doc

BLACK BOX COVER-UP

Rescue Workers Silenced After Exposing 9-11 Whitewash

By Greg Szymanski

A 9-11 rescue worker recently came forward to say he was told by FBI agents to "keep my mouth shut" about one of the "black boxes" a fellow firefighter helped locate at ground zero, contradicting the official story that none of the flight and cockpit data recorders were ever recovered in the wreckage of the World Trade Center (WTC) towers.

Honorary firefighter Mike Bellone claims he was approached by unknown bureau agents a short time after he and his partner, Nicholas DeMasi, a retired New York firefighter, found three of the four "black boxes" among the WTC rubble before January 2002.

The pair first claimed in an August 2003 book entitled Behind the Scene: Ground Zero to have found the data recorders.

DeMasi said the "black boxes" were found while he traversed "ground zero" in his all-terrain vehicle (ATV) with three federal agents.

FBI and New York fire officials have denied ever finding the voice and data recorders.

Now Bellone claims agents were adamant about keeping the discovery a secret.

"They confronted me and told me to not to say anything," recalled Bellone, referring to one of three reddish-orange boxes with two white stripes he saw in the back of DeMasi's ATV. "I said, 'Give me a good reason.' When they couldn't, I told them I wouldn't shut up about it.

"Why should I? I have nothing to hide and nothing to gain. It's the truth, and Nick and I are sticking to our story as we always have."

Bellone said he and DeMasi were not the only 9-11 rescue workers to see the "black boxes." He said there were several other witnesses and said he knows they have been silenced by federal agents.

"I know two or three others saw what went down, but they are not talking," said Bellone. "They got to those guys after they talked to me. The only reason I can figure they are trying to hide the truth is that the government knows it screwed up, and the recorders would prove it."

Asked to give names of the other witnesses, he said he wouldn't break a fellow worker's confidence by revealing his identity.

"I can tell you this, though, it was all very strange. I worked on the spaceship Columbia cleanup, and you know when something important is found and when something is not," he said.

The day the "black boxes" were secretly carted away, agents acted like "something big was going down," he added.

Bellone said he never learned the FBI agents' names as this type of personal contact and information wasn't exchanged between the civilian workers and government officials working side-by-side at ground zero.

"They had on their FBI jackets, but I'm sure I could pick them out of a lineup or recognize their pictures," said Bellone.

The pair's bombshell accusations blow a big hole in the official story as well as the findings in the recent 9-11 commission report."

In Chapter 1, footnote 76, there is the sole but definitive reference to the airline "black boxes": "The CVR's and the FDR's [voice and flight data recorders] from American 11 and United 175 were not found."

Asked if DeMasi and Bellone were questioned or subpoenaed, commission spokesman Al Felzenberg said: "I can't tell you now if he was one of the 1,200 people we interviewed or if the book was one of the countless ones we researched. We explored every lead, but I will try to find out if we talked with him and get back to you."

Bellone said commission members never contacted him or DeMasi and never asked the two to appear before the group even though the book was published well before the hearings commenced.

"I have been contacted by only one newspaper reporter, from The Philadelphia Daily News," said Bellone, referring to an October 2004 story by reporter William Bunch, who recapped DeMasi's statements as well as the usual official denials.

Those close to the 9-11 investigation said the recovery of the "black boxes" is important because they may hold vital clues about what really happened on the morning of Sept. 11, 2001.

The cockpit voice recorder uses a pair of microphones to capture all cockpit sounds for the last 30 minutes of a doomed flight. The flight data recorder is also significant since it records altitude, heading and airspeed.

Both recorders are designed to withstand enormous impact and heat. National Transportation Safety Board (NTSB) officials said they should have withstood the conditions at the WTC.

And finding the boxes after a crash seems to be standard procedure, according to the NTSB.

"It's extremely rare that we don't get the recorders back,' said NTSB spokesman Ted Lopatkiewicz. "I can't remember another case which we did not recover the recorders."

Bellone is retired and was made an honorary New York fireman for his efforts after 9-11. DeMasi has recently retired from Engine Co. 261, nicknamed the "Flaming Skulls."

X-Sieve: CMU Sieve 2.2
X-Mailer: Handspring Mail (1.0)
From: S. Shyam Sunder <sunder@nist.gov>
To: wtc@nist.gov
Cc: rgann@nist.gov, jason.averill@nist.gov, james.lawson@nist.gov,
jgross@nist.gov, terri@nist.gov, fahim.sadek@nist.gov, cauffman@nist.gov,
cheri.sawyer@nist.gov
Date: 26 Jul 2005 16:08:23 -0400
X-MailScanner:
X-MailScanner-From: sunder@nist.gov
Subject: FW: Explosions Experienced in the Sub-Basements of WTC 1 &

-----Original Message-----
From: dorshkind
Date: 7/26/05 3:02 pm
To: sivaraj.shyam-sunder@nist.gov
Subj: Explosions Experienced in the Sub-Basements of WTC 1 & Connection to Impact Floors

Dr. Sunder:

Has your investigation covered the explosions experienced by William Rodriguez and other maintenance staff in the sub-basements of WTC 1? In particular, what is the connection between these explosions experienced in the sub-basement levels and the floors involving the aircraft impact? My sources are indicated below.

Has your investigation covered reports of explosions heard and experienced by firefighters and survivors throughout the WTC buildings on floors other than the impact floors.

http://www.arcticbeacon.citymaker.com/articles/article/1518131/28031.htm

http://www.chiefengineer.org/article.cfm?seqnum1=1029

Larry Dorshkind
Redwood City, CA

From: "dorshkind" <mail@dorshkind.com>
To: <wtc@nist.gov>
Subject: WTC Collapses

Does anyone care that the book "The New Pearl Harbor" by David Ray Griffin (available at alibris.com) documents a myriad of evidence that the towers were most likely brought down by "controlled explosions" – not from the heat from 1300-1400 degree hydrocarbon fires?

In addition, there is an article that was written about William Rodriguez, a 20-year veteran janitor, who said there were explosions below the basement level office he was in and these explosions were felt by him seconds before the plane hit the tower above him. William Rodriguez said he led a fellow janitor, David Felipe, to safety after Mr. Felipe burst into his office badly burned and yelling "explosion!, explosion!, explosion!". After leading Mr. Felipe to safety, William Rodriguez returned to help two other men trapped and drowning in the basement elevator shaft as well as doing many other heroic acts.

The book, "The New Pearl Harbor", also reported that firemen and others heard explosions in the building at various levels of the towers. To my knowledge, there were no investigations by FEMA, NIST or the 911 Commission of these explosion reports (except that William Rodriguez says he was interviewed by the 911 Commission behind closed doors and by NBC News). The steel, according to the book, could have been inspected for explosive residue but was quickly hauled off (to foil a proper investigation) and quickly sent to China and Korea.

The book goes into a lot more regarding fire temperatures, materials science, etc., and is worthy of someone's review for either confirmation of presented facts or refutation of those presented facts.

Larry Dorshkind

In

From: Reijo Yli-Karjanmaa <reijo.yli-karjanmaa@pp.inet.fi>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6

Information Submitted on: 7/13/2005.

Name : Reijo Yli-Karjanmaa
Affiliation :
Email Address : reijo.yli-karjanmaa@pp.inet.fi
Phone :
Report Number : NCSTAR1-6
Page Number : lxiii
Paragraph : Paragraphs 1 and 5, last sentences
Comment : The phrase "Global collapse then ensued" occurs frequently in the reports of Project 6. But it is a mere proposition with no kind of supportive momentum calculations to back it, the real question being: how did the collapse on one floor (which I don't say is impossible) turn into a progressive collapse that destroyed the whole buildings -- despite the fact that the towers were mostly in the normal temperature and the structures were sound? It must be shown that such a total collapse was indeed possible in such an immensely short time without external energy. Not even the
word 'momentum' is mentioned except in an annexe to one of the supporting technical reports (and even there only a one-floor drop is examined).

There is no kind of examination of how the potential energy of the buildings could have possibly been sufficient for all the phenomena seen.

The report does not even so much as mention, let alone explain, the features that are alien to a gravitation-driven collapse, such as the almost complete pulverization of concrete and other non-metallic substances and the extremely hot spots in the rubble.

Comment Reason :

Revision Suggestion : Fullfill the report with the missing calculations and explanations.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

To: wtc@nist.gov
Cc: TBrown@rjagroup.com ...snip... AVaughn@rjagroup.com
Subject: Comments on WTC Report
From: RTucker@rjagroup.com

Attached are our comments on the WTC report. Please contact me if you have any questions.

============================

Randolph W. Tucker, P.E.
Executive Vice President
The RJA Group, Inc.
13831 Northwest Freeway, Suite 330
Houston, TX 77040 USA
+1-713-462-1840
Fax +1-713-462-0812
Cell +1-713-213-7355
http://www.rjagroup.com

Comment on Recommendation 4.pdf

Comment on Recommendation 8.pdf

Comment on Recommendation 12.pdf

Comment on Recommendation 17.pdf

Comment on Recommendation 27.pdf

Comment on Threshold Height.pdf

Name: Randolph W. Tucker, P.E.

Affiliation: The RJA Group, Inc.

Contact: rtucker@rjagroup.com

Report Number: NCSTAR 1

Page Number: 204

Paragraph/Sentence: Recommendation 4

Comment:

This recommendation is an overreaction to an extreme incident.

Reason for Comment:

Statistically, the life safety performance of commercial buildings in the U.S. has been quite good based upon the current model codes. The improbable scenario of the WTC event should not cause such major rewrites of our codes which until now have generally provided a level of fire safety which meets societal acceptance of risk. The US codes and standards organizations are regularly reviewing and modifying their requirements based on analysis of fire records, changing design styles, new materials, and new technology.

This recommendation for more stringent prescriptive requirements appears to not account for the benefits gained by improvements in performance-based engineering approaches noted in Recommendation 9.

Suggestion for Revision:

The recommendation should be to continue to evaluate the appropriateness of building and fire code requirements to improve overall building safety and security performance. The application of performance-based design should be applied to unusual buildings (very tall, unique configuration, large occupancy, etc) rather having the codes and standards develop mandatory prescriptive requirements for all buildings over a certain height or area.

Name: Randolph W. Tucker, P.E.

Affiliation: The RJA Group, Inc.

Contact: rtucker@rjagroup.com

Report Number: NCSTAR 1

Page Number: 207

Paragraph/Sentence: Recommendation 8

Comment:

Although an interesting suggestion, such requirement would be difficult to enforce.

Reason for Comment:

The recommendation assumes that a designer can fully predict the fuel loading, maintenance of structural integrity (penetrations, removal of protective coatings or materials, maintenance of fire rated separations, etc) over the life of a building. The fire record in tall buildings in the US has not indicated that the current code requirements, if properly followed and maintained, are not sufficient for the types of fires that have occurred in buildings. The only examples where total or local structural collapse from a fire in tall buildings have occurred have been in extreme cases (WTC). The only incidents we are aware of where fire caused significant structural failure were in unsprinklered high rise buildings where retrofit sprinklering was is progress, but not completed (Meridian Plaza – Philadelphia; First Interstate – Los Angeles).

Should such a requirement be in a building code, there would be no reasonable way for a designer to assure compliance over the life of the building.

Suggestion for Revision:

Delete the comment.

Name: Randolph W. Tucker, P.E.

Affiliation: The RJA Group, Inc.

Contact: rtucker@rjagroup.com

Report Number: NCSTAR 1

Page Number: 209

Paragraph/Sentence: Recommendation 12

Comment:

Reliability of system performance is currently addressed in existing fire safety system design and installation standards and reinforced through requirements in building and fire codes.

Reason for Comment:

Each of the fire safety system standards committees regularly reviews available information on system performance as well as system failures. The standards set minimum levels of performance and reliability requirements for these systems for application in a broad range of applications. It is incumbent on system designers to determine when additional reliability may be necessary based on unique building characteristics or operational needs.

System performance and reliability comes form proper design, installation, commissioning, maintenance, and periodic testing. All of these considerations are currently in the IBC, NFPA 5000, IFC, and UFC. Where improvement may be necessary is in the enforcement of what is currently required not from adding more requirements.

Suggestion for Revision:

Designers, installers, building managers, and AHJ's should do a better job of analysis of reliability factors in unusual design and use buildings to match the system fire safety systems' design and reliability to the needs of the building.

Name: Randolph W. Tucker, P.E.

Affiliation: The RJA Group, Inc.

Contact: rtucker@rjagroup.com

Report Number: NCSTAR 1

Page Number: 211

Paragraph/Sentence: Recommendation 17

Comment:

This requirement is not justified by US fire history for code compliant buildings.

Reason for Comment:

By their very nature and definition, high rise buildings take a great deal of time to exit. Based on this fact, the design of tall buildings has evolved to a concept of staged egress while protecting occupants by active fire and life safety systems. Even in the WTC event, NIST's review indicated that nearly all of the occupants below the impact levels were able to use the stairs to get out of the building. While the considerations presented in Recommendation 17 (and Recommendation 21) may have some merit, attempting to establish a "timely full evacuation" of very tall buildings is at best infeasible.

The life safety in tall buildings may be enhanced by increased stair width and the ability to use elevators for emergency use, however, an analysis of credible building threats and how to design to mitigate such threats may offer a better cost/benefit return than by increasing the number of stairs or elevators.

Suggestion for Revision:

Develop data on emergency evacuations that have occurred in buildings that demonstrates whether the existing building code requirements are sufficient to meet emergency egress and emergency responders' needs.

Name: Randolph W. Tucker, P.E.

Affiliation: The RJA Group, Inc.

Contact: rtucker@rjagroup.com

Report Number: NCSTAR 1

Page Number: 217

Paragraph/Sentence: Recommendation 27

Comment:

Installation standards currently have requirements for on-site copies of life safety systems. Unfortunately, when these systems are modified or upgraded, such changes are not generally added to the original documents.

Reason for Comment:

While it would be beneficial to have up-to-date documents on the property, it is a difficult enforcement issue. Further, attempting to also keep an off-site set of documents would prove even more difficult. Where off-site should they be? Who is to be their custodian? Who can verify that the off-site documents are current? Who will assure that these documents are secure from access by unauthorized persons?

Suggestion for Revision:

Establish where the off-site repository is to address the security issue while also assuring the proper updating of the documents will occur.

Name: Randolph W. Tucker, P.E.

Affiliation: The RJA Group, Inc.

Contact: rtucker@rjagroup.com

Report Number: NCSTAR 1

Page Number: 201

Paragraph/Sentence: Second bulleted paragraph (starting "Affected...")

Comment:

Although we agree with the concept of thresholds for tall building requirements, the selected threshold of 20 stories for the majority of the items addressed in the recommendations may be inappropriate.

Reason for Comment:

Currently the IBC and NFPA 5000 define a high rise building as one having occupied floors at a height of over 75 feet above fire department vehicle access. Certainly, as building heights reach other thresholds, such as the 20 storey height NIST suggests, other reliability issues come into play. The requirements and redundant features that may be appropriate for a 100+ story building may not be necessary for a 20, 40, or 60 story building.

Suggestion for Revision:

Each of the recommendations that deal with building design requirements should be reevaluated for appropriateness at the 20 story threshold.

SCHIRMER ENGINEERING CORPORATION

707 LAKE COOK ROAD ▲ DEERFIELD, ILLINOIS 60015-4997 ▲ PHONE (847) 272-8340 ▲ FAX (847) 272-2639

WRITER'S EXTENSION: 280

WRITER'S EMAIL: james_hurst@schirmereng.com

August 4, 2005

Via E-mail
wtc@nist.gov

S. Shyam Sunder, Ph.D.
NIST
WTC Technical Information Repository
Gaithersburg, MD 20899-8610

Re: Review Comments to NIST NCSTAR 1 (Draft)

Dear Dr. Sunder:

Enclosed are review comments related to the referenced draft report. The comments focus on NIST's 30 recommendations, since these encompass the thoughts and findings presented throughout the report. Since there wasn't time for a company peer review, please consider this response submission as that from an individual in the field of fire protection engineering rather than those of Schirmer Engineering.

Recommendation 4 – Replace the word "construction" with "building" with reference to determination of an appropriate classification. The codes already have established construction type classifications based on a much different set of criteria. The criteria that are being proposed go much beyond just construction considerations by also including building systems.

Recommendation 5 – I agree in principle with the recommendation, however, this is a lofty goal requiring extensive research for years to come. There is also the politics of the standardization process that will have to be overcome for implementation.

Footnote 25 references text recommending that construction classifications and fire rating requirements need examination. The footnote seems to favor increasing structural fire resistance in high-rise buildings, but then talks about buildings 420 feet and higher having a 4-hour requirement. The question is, how much higher could fire resistance ratings expect to go?

Recommendation 11 – It is first necessary to study and establish the behavior of the referenced high-performance materials under standard fire conditions before they can be evaluated under conditions expected in building fires. Part of the process may include establishing a correlation between standard fire test conditions and those of actual building fires.

Recommendation 12 – The enhancement of the performance and redundancy of active fire protection systems could be equated to better design layout. This could include, for example, double feed sprinkler systems with remoteness of supply risers.

Recommendation 13 – Suggest exploring the possibility of wireless technologies for some communication devices to eliminate the damage potential of hard-wired systems.

Recommendation 14 – The general concept is desirable, but information returned to the Command Panel on water flow rates and pressures would not seem to be very useful in a fire situation. Room temperatures at various floor locations would appear to be more useful.

Recommendation 15 – Off-site collection and storage of data is more suited for after-the-event usage. Relying on signals from an off-site location during the event adds one more degree of failure into the equation. If the on-site equipment cannot adequately perform during the fire or disaster event due to damaged systems, then off-site data collection and transmission will also be ineffective.

Recommendation 16 – None of the referenced activities will overcome the physical challenges of a person being able to descend numerous stories through a stairway during an evacuation process of these ultra-high-rise buildings. It was mentioned the NYC doesn't permit full building evacuation training during drills. The rigors of navigating down numerous flights of stairs is a problem that must be addressed.

Recommendation 17 – Additional exit capacity for emergency responders is a good idea. Hardened side-by-side stairs with rated sight glass could be used in the separation wall to permit occupants and firefighters get first-hand knowledge of conditions in each of the stairs. Also, subsection b addresses mobility-challenged occupants. Whatever techniques are available that will increase the effectiveness of the evacuation process should be extended to all occupants, not just those who are physically challenged. The use of elevators should be increased during the disaster event through a more robust design of elevators and their shafts. (I see that Recommendation 21 addresses this consideration).

Recommendation 18 – Item c – If the construction of the scissor stairs is sufficiently robust and penetrations are adequately firestopped, then the stairs should get counted as two stairs.

Recommendation 26 – This recommendation involves increasing egress and sprinkler requirements for existing buildings and seems to suggest that these measures be taken irregardless of significant renovation work being done. If this is the case, the implementation is likely to be cost prohibitive. Existing high-rise buildings should be considered for upgrading of life-safety features on a case-by-case basis such as iconic buildings, for example. This shouldn't be expected to be done over a broad scale.

All in all, I thought the report was a very impressive body of work.

Very truly yours,

James P. Hurst

James P. Hurst, P.E.

SCHIRMER ENGINEERING CORPORATION

Fire Protection Engineering ▲ Code Consulting ▲ Risk Control ▲ Security Consulting

Writer's Extension: 222

August 2, 2005

VIA FAX
301.975.6122

WTC Technical Information Repository
Attention: Mr. Stephen Cauffman
National Institute of Standards and Technology
Stop 8610
Gaithersburg, MD 20899-8610

Re: NIST NCSTAR 1 (Draft)
Public comments

Gentlemen:

Schirmer Engineering Corporation is recognized as the nation's first private fire protection engineering consulting firm, founded in 1939, and today consists of more than 220 professionals working to make the built environment safe from fire. We are pleased to have this opportunity to provide comments on the NIST NCSTAR Draft report on the collapses of the World Trade Center Towers. NIST is to be commended on the comprehensive nature of the investigation and the analytical tools developed in response to the assignment.

A thorough review of the report was not possible during the limited time frame for public comments; an additional comment period would be appreciated. Nevertheless, we are providing comments for consideration in a number of subject areas, as follows.

Recommendation 4. NIST recommends evaluating, and where needing improving, the technical basis for determining appropriate construction classification and fire rating requirements (especially for tall buildings greater than 20 stories in height) – and making related code changes now as much as possible – by explicitly considering factors including:

- **timely access by emergency responders and full evacuation of occupants, or the time required for burnout without local collapse;**
- **the extent to which redundancy in active fire protection (sprinkler and standpipe, fire alarm, and smoke management) systems should be credited for occupant life safety;**
- **the need for redundancy in fire protection systems that are critical to structural integrity;**

- **the ability of the structure and local floor systems to withstand a maximum credible fire scenario without collapse, recognizing that sprinklers could be compromised, not operational, or non-existent;**

- **compartmentation requirements (e.g., 12,000 ft^2) to protect the structure, including fire rated doors and automatic enclosures, and limiting air supply (e.g., thermally resistant window assemblies) to retard fire spread in buildings with large, open floor plans;**

- **the impact of spaces containing unusually large fuel concentrations for the expected occupancy of the building; and**

- **the extent to which fire control systems, including suppression by automatic or manual means, should be credited as part of the prevention of fire spread.**

This recommendation includes many issues which warrant commentary. However, due to the limited comment period, we wish to focus on one important portion of this recommendation, compartmentation. Many buildings – both high-rise and low-rise – employ large, open areas in order to fulfill the desired function of the space and/or to fulfill that function in an economical manner. For years, these large building areas were recognized as being able to fulfill the functional and economic goals by limiting potential fire spread by means of active suppression systems. Indeed, as the fire protection community realized after initially allowing a compartmentation "option" for high-rise buildings in the 1970s and 1980s, automatic sprinkler protection was considered more effective and reliable when compared to the compartmentation option which has since been eliminated.

Building owners and operators must be given an option to conduct operations in a safe, cost-effective manner as has been demonstrated to occur in properly designed and operated buildings employing other fire protection strategies such as automatic sprinkler protection. We agree, however, that as building height increases such that building evacuation becomes more difficult or even impossible, the reliability of the active fire suppression systems becomes more important and should be improved by methods such as redundant water supplies, redundant risers, redundant fire pumps and associated power supplies, electrical supervision of the system and off-site monitoring. Such reviews are considered part of the design process employed by professional fire protection engineers who may be engaged on such projects and are subject to a number of project-specific variables.

The recommendation to limit compartment sizes in tall buildings is not supported by technical information or historical data, other than the extreme events of 9/11 and, therefore, should be removed from the report.

Recommendation 12. **NIST recommends that the performance and redundancy of active fire protection systems (sprinklers, standpipes/hoses, fire alarms, and smoke management systems) in buildings should be enhanced to accommodate the greater risks associated with increasing building height and population, increased use of open spaces, available compartmentation, high-risk building activities, fire department response limits, transient fuel loads, and higher threat profile.** The performance attributes should deal realistically with the system design basis, reliability of automatic/manual operations, redundancy, and reduction of vulnerabilities due to single point failures. *Affected National Standards:* NFPA 1, NFPA 13, NFPA 72, NFPA 90A, and NFPA 101. *National Model Building Codes:* The performance standards should be adopted in national model building codes by mandatory reference to, or incorporation of, the latest edition of the standard.

Schirmer Engineering Corporation recommends that the wording, "be enhanced to accommodate the greater risks," be changed to "evaluated and possibly enhanced to accommodate the potentially increased risks." The current NIST recommendation appears to be vague and without technical substantiation.

With respect to the sprinkler systems, the report indicates that the systems were designed to produce densities significantly greater than NFPA 13. It also concludes that the system could not be expected to provide protection to the extreme conditions that occurred on September 11, 2001. The water supply also had several secondary and back-up conditions. As the report indicates that the sprinkler systems could not be expected to protect against the extreme conditions and that the New York City Fire Department (FDNY) decided against fighting the fire, the water supply would appear "adequate." In actuality, the building's water supply had several redundant features that exceeded codes. Although manual operation of some secondary pumps was noted in the report, we agree that automatic operation is preferred. For this item, it is suggested that automatic operation would be designed in the 2000s, where manual was acceptable in the 1960s and 1970s. For water supply, we therefore do not see any significant code changes.

The report indicates that the fire alarm system included manual operation of the occupant notification system. Apparently, occupancy notification alarms occurred 12 minutes after impact. The current code, NPFA 72 suggests shorter periods with specific limitations for reliability. In essence, the current code does address this condition.

The report also suggests that the use of the smoke control system would not have provided added protection to change the outcome. It also indicated that the system was manual and that smoke dampers were not provided at duct openings to shafts. Currently, the International Building Code (IBC) requires smoke dampers at shafts. The technical committee of NFPA 90A recently approved a code change to include smoke dampers at shafts. The IBC indicates that operation of smoke control is to be automatic. We therefore do not see any significant code changes.

The term "risk" should be carefully used. Currently, there is a perceived higher risk level by the general public with respect to high-rise buildings. Although protection should be consistent with the risk level, higher protection levels based on a perceived risk should be avoided. It is also recognized that under some conditions, any level of risk is unacceptable.

In lieu of a broad, code-mandated increase in system performance and redundancy, we suggest that a performance-based analysis be required for unique or iconic structures consistent with the "greater risks" noted in the NIST recommendations.

<u>Recommendation 13.</u> **NIST recommends that fire alarm and communications systems in buildings should be developed to provide continuous, reliable, and accurate information on the status of life safety conditions at a level of detail sufficient to manage the evacuation process in building fire emergencies, and that standards for their performance be developed.** This should include means to maintain communications with evacuating occupants that can both reassure them and redirect them if conditions change. While pre-installed fire warden telephone system in buildings can serve a useful purpose and may be installed in buildings, they should be made available for use by emergency responders. Pre-installed dedicated firefighter telephone systems in buildings are of limited use and effectiveness, and their installation is not encouraged. *Affected National Standards:* NFPA 1, NFPA 72, and NFPA 101. *National Model Building and Fire Codes:* The performance standards should be adopted in national model building and fire codes by mandatory reference to, or incorporation of, the latest edition of the standard.

It is agreed that fire alarm and communication systems should provide continuous, reliable, and accurate information on the status of life safety conditions at a level of detail sufficient to manage the evacuation process.

Improved communications with existing technology can be as simple as proper zoning of communication system. NFPA 72 does not include zoning requirements. In general this has been a design issue related to the building specifics and fire department requirements. Standards would assist to unify zoning requirements. It is recommended that such requirements be performance based.

Two-way communication systems should be further evaluated on an overall basis by all stakeholders. Although firefighters in one of the Towers were given headsets, the report indicates that the firefighter's two-way system was not used. Handheld walkie-talkies were used by firefighters with mixed results even though a repeater had been installed after the 1993 incident. The fire warden telephone system was apparently not used. Based on the above information, it is not clear why Recommendation 13 includes information that fire warden telephone systems in buildings can serve as a useful purpose and that firefighter telephone systems are not encouraged. Technologies, including the allocation of appropriate radio frequencies, should be explored that allow better communications in steel and concrete tall buildings

<u>Recommendation 14.</u> **NIST recommends that control panels at fire/emergency command stations in buildings should be adapted to accept and interpret a larger quantity of more reliable information from the active fire protection systems that provide tactical decision aides to fireground commanders, including water flow rates from pressure and flow measurement devices, and that standards for their performance be developed.** *Affected National Standards:* NFPA 1, NFPA 72, and NFPA 101. *National Model Building and Fire Codes:* The performance standards should be adopted in national model building and fire codes by mandatory reference to, or incorporation of, the latest edition of the standard.

It is agreed that some additional information from active fire protection systems may be helpful. However, it is suggested that "waterflow rates from pressure and flow measurement devices" may not be helpful and that this level of detailed information could be more negative than positive. Information at this level would require a detailed knowledge of the building and its systems for it to be useful. Although the "waterflow" rate could suggest a hose is being operated from standpipe, this information can be obtained from the firefighting unit. In large complicated buildings, sometimes making it simple is best of all.

Recommendation 15. NIST recommends that systems should be developed and implemented for: (1) real-time off-site secure transmission of valuable information from fire alarm and other monitored building systems for use by emergency responders, at any location, to enhance situational awareness and response decisions and maintain safe and efficient operations; and (2) preservation of that information either off-site or in a black box that will survive a fire or other building failure for purposes of subsequent investigations and analysis. Standards for the performance of such systems should be developed, and their use should be required. *Affected National Standards:* NFPA 1, NFPA 72, and NFPA 101. *National Model Building and Fire Code:* The performance standards should be adopted in national model building and fire codes by mandatory reference to, or incorporation of, the latest edition of the standard.

Schirmer Engineering Corporation believes that additional information should be provided to emergency responses during their responses, if possible. This would require additional equipment from other building owners, emergency dispatch, and emergency responders.

Preservation of information via black box or off-site is not considered necessary at this time. Although this information is helpful in an investigation, resources should be spent in areas where preservation of life and property is more direct.

General Comment on Improved Active Fire Protection

For the most part, active fire protection systems were adequate and were not a major part in the outcome of September 11, 2001. The NIST recommendations are very generic.

The major single theme is for improved communications. This would include improved reliability of communication system along with the systems providing other information. As technology improves, it is hopeful that better information can be provided in a cost-effective manner. The benefits of additional hardware must be tangible, measurable, or else the requirements will simply add a cost burden to construction. Caution must be also be exercised to assure that information communicated to building occupants is meaningful and useful towards evacuation of occupants, conservation of property, and safety of emergency responders. The building included a two-way communication system for firefighters and, apparently, this system was not used. NIST concludes that the installation of these systems "is not encouraged." Providing additional information or equipment, which is not used, is of no value.

Recommendation 16. **NIST recommends that public agencies, non-profit organizations concerned with building and fire safety, and building owners and managers should develop and carry out public education campaigns, jointly and on a nationwide scale, to improve building occupants' preparedness for evacuation in case of building emergencies. This effort should include better training and self-preparation of occupants, an effectively implemented system of floor wardens and building safety personnel, and needed improvements to standards.**

We support this recommendation for training and occupant preparedness, since training and drills that provide proper instruction on the evacuation options will help occupants make correct evacuation decisions (e.g., use stairs or use elevators, etc.).

Recommendation 17. NIST recommends that tall buildings should be designed to accommodate timely full building evacuation of occupants due to building-specific or large-scale emergencies such as widespread power outages, major earthquakes, tornadoes, hurricanes without sufficient advanced warning, fires, accidental explosions, and terrorist attack. Building size, population, function, and iconic status should be taken into account in designing the egress system. Stairwell and exit capacity should be adequate to accommodate counterflow due to emergency access by responders.

Recommendation 17 is noted per Table 9-1 to be both related and unrelated to 9/11 outcome and applicable to all tall buildings and other structures. We find this recommendation to be overreaching and inconsistent with philosophy taken on structural recommendations. First, it is clear that the structural recommendations for the design of buildings do not require that tall buildings be designed to resist or accommodate the direct hit of a jet airliner by terrorists, yet Recommendation 17 requires that a terrorist attack, which could be any one of a number of possible scenarios for any given building, be the basis upon which to design the egress system. Designing, or attempting to design, an egress system for a given scenario can provide owners and occupants a false sense of security because of the myriad number of types and scenarios of extreme events, i.e., a design for "Event A" may not be adequate for an "Event B" that was not contemplated. Clearly, the design of a building's egress system for all possible events is not possible.

Also, for other large-scale emergencies such as hurricane, tornado, earthquake, it is not clear in the report how full-scale evacuation is necessary or the rationally appropriate action to be taken and, in fact, may be inappropriate for many types of occupancies (e.g., hospitals and senior residential living). For many buildings, the evacuation strategy and building design features need to consider the needs of the occupants without utilizing full building evacuation.

The last sentence of Recommendation 17 states, "Stairwell and exit capacity should be adequate to accommodate counterflow due to emergency access by responders." The data and details of the NIST NCSTAR documents do not support this as a final recommendation. While counterflow was noted between responders on the occupants in the stairwells, the data and analysis in no way supports or provides a basis for the definitive and broad recommendation as cited in Recommendation 17 for counterflow.

In NIST NCSTAR 1-7, the document states that few building occupants felt that counterflow on the stairways had much effect on their evacuation. Also, on page 8 of NIST NCSTAR 1-8, "In contrast, many emergency responders suggested that counterflow on the stairways in WTC 1 generally had a negative impact on the emergency responder operations." Further, analysis is needed to validate if the perceptions of the emergency responders was in fact evidence of a problem and whether or the 9/11 events equates to a problem for credible, non-terroristic emergency events.

From the standpoint of occupant egress, the recommendation is not supported. From the perspective of emergency responders, the negative conditions reported by emergency responders were a direct function of the magnitude of the terrorist attack which eliminated elevator usage, compromised stairways and forced a large-scale evacuation as opposed to a partial or phased evacuation. The events of 9/11 did not represent credible egress expectations for credible fires, but rather an extreme terrorist event in tall buildings. As the recommendation to accommodate counterflow is related to the 9/11 outcome, it is too broad to be considered applicable to other buildings (as noted per Table 9-1) without consideration for the nature of the occupancy, nature of building height, area fire separations, architectural arrangement, evacuation procedures, elevator service arrangement, and the credible fire scenarios for any given building.

We recommend that this recommendation be eliminated or modified to read that the potential for full building evacuation should simply be considered and take into account factors such as a building's iconic status, its geo-political environment, its susceptibility to earthquakes, hurricanes and other natural hazards, etc.

Again, thank you for this opportunity. We look forward to reviewing the final report.

Very truly yours,

SCHIRMER ENGINEERING CORPORATION

Carl F. Baldassarra, P.E.
President
cb(r/d|o)

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Vice President-Engineering

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In

From: FPESCHULTE@aol.com
Subject: September Plumbing Engineer Column
To: WTC@NIST.GOV

Ladies and Gentlemen-

Attached is a pdf file of the fire protection column which will appear in the September issue of Plumbing Engineer. The column addresses the NIST recommendations contained in the NIST draft final report on the WTC investigation.

Rich Schulte

COLUMN 149.00.pdf

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THE NIST INVESTIGATION RECOMMENDATIONS FOR CHANGES TO BUILDING CODES

by Richard C. Schulte
Schulte & Associates

If you examine both the International Building Code (IBC) published by the International Code Council (ICC) and the Building Construction and Safety Code (NFPA 5000) published by the National Fire Protection Association (NFPA), you will note that the provisions which relate to fire safety and fire protection are very similar, and certainly the intent of both of these model codes is the same. Given that NFPA 5000 provides a more in-depth explanation of the intent of the code than does the IBC, a review of the general provisions contained in NFPA 5000 can be useful in developing not only a better understanding of NFPA 5000, but also of the International Building Code. Hence, a review of the general provisions contained in NFPA 5000 should be of interest to anyone involved with code development or making recommendations for changes (such as NIST).

Code Fire Safety Goals

Section 1.2 in NFPA 5000 provides a general purpose statement for the code and reads as follows:

> "***Purpose.*** *The purpose of the Code is to provide minimum design regulations to safeguard life, health, property, and public welfare and to minimize injuries by regulating and controlling . . . .all buildings and structures. . .* "

Sections 4.1.3 provides further elaboration of the general purpose statement of the code and reads as follows:

> "***Safety.*** *The intent of the safety goal of this Code is to reduce the probability of injury or death from fire, structural failure and building use.*"

> "***Safety from Fire Goal.*** *The fire safety goal of this Code is as follows:*

(1) *To provide an environment for the occupants inside or near a building that is reasonably safe from fire and similar emergencies.*

(2) *To provide reasonable safety for fire fighters and emergency responders during search and rescue operations."*

"Buildings shall be designed and constructed to protect occupants not intimate with the initial fire development for the time needed to evacuate, relocate, or defend in place."

"Buildings shall be designed and constructed to provide reasonable safety for fire fighters and emergency responders during search and rescue operations."

"Buildings shall be designed and constructed to reasonably protect adjacent persons and buildings from injury, death, or substantial damage as a result of a fire."

"Buildings shall be designed and constructed to provide reasonable access to the building for emergency responders."

Section 4.2 in NFPA 5000 addresses the basic assumption of the code with respect to the fire safety provisions contained in the code:

"***Assumption-Single Fire Source.*** *The fire protection methods of this Code assumed that multiple simultaneous fire incidents will not occur."*

Section 4.4.1 in NFPA 5000 states a guiding principle of the code in the following excerpt:

"***Multiple Safeguards.*** *The design of every building or structure intended for human occupancy shall be such that reliance for property protection and safety to life does not depend solely on any single safeguard. An additional safeguard(s) shall be provided for property protection and life safety in case any single safeguard is ineffective due to inappropriate human actions, building failure or system failure."*

Various sections in the chapter titled "Performance-Based Options", Chapter 5, in NFPA 5000 also outline concepts which should be incorporated into a performance design. Section 5.2.2 in NFPA 5000 include the following provisions:

"Building shall be designed and constructed to reasonably prevent the spread of fire beyond the compartment of fire origin."

"Buildings shall be designed and constructed to reasonably prevent structural failure under fire conditions for a time sufficient to protect the occupants."

"*Means shall be provided to evacuate, relocate, or defend in place occupants of buildings for a time sufficient to prevent them from exposure to instantaneous or cumulative untenable conditions from smoke, heat, or flames.*"

"*Buildings shall be designed and constructed to reasonablely prevent structural failure under fire conditions for a time sufficient to enable fire fighters and emergency responders to conduct search and rescue operations.*"

It is important to note that the provisions of section 4.1.3 in the Code only speak to reducing "*the probability of injury or death from fire*", but not totally eliminating "*the probability of injury or death*". Further, it is also important to note that many of the provisions addressing fire safety goals excerpted above use the adjectives "*reasonable*" or "*reasonably*" when referring to fire safety. In other words, NFPA 5000 recognizes that the goal of completely eliminating the probability of death in a building fire is neither possible, nor cost effective. With this background regarding the fire safety goals and objectives of NFPA 5000 (and the International Building Code), the changes to building codes recommended by NIST can be discussed against the framework of the intent of the codes.

The NIST Recommendations

The portion of the draft final report released by NIST on June 23, 2005 includes 30 recommendations for changes to building codes and building construction procedures and practices in the United States. The following is a brief summary of the issues addressed in the NIST's recommendations:

Recommendations 1-3. Recommendations 1 through 3 address structural issues pertaining to progressive collapse provisions, wind loads and building sway.

Recommendations 4-7. Recommendations 4 through 7 address structural fire resistance issues for high rise buildings exceeding 20 stories in height, propose a review of ASTM E119, propose a study of the performance of spray-applied fireproofing materials and propose that codes address the structural fire protection requirements for the"structural frame" of a building, rather than for vertical and horizontal structural members separately. In addition, and perhaps most importantly, Recommendation 4 proposes that high rise buildings exceeding 20 stories in height be both protected by a sprinkler system and be compartmented into floor areas of 12,000 square feet or less in floor area.

Recommendations 8-11. Recommendations 8 through 11 address the development of mathematical models which can be used to predict the actual performance of a building structure to various fires, the development and testing of new fireproofing coatings for structural steel and basic structural materials which have improved structural properties at high temperatures. Recommendation 8 proposes that building structures be designed with sufficient structural fire resistance to prevent building collapse in the event that an uncontrolled fire spreads throughout the building.

Recommendations 12-15. Recommendations 12 through 15 address modifications to the design of sprinkler, standpipe, fire alarm/communications and smoke control systems used in high rise buildings to increase reliability of these systems and modifications to fire alarm and communications systems which will enhance decision-making capabilities of incident commanders.

Recommendations 16-20. Recommendations 16 through 20 address the design of egress facilities for high rise buildings and building evacuation drills. Recommendation 17 proposes that the egress system serving high rise buildings be designed for total evacuation.

Recommendations 21-24. Recommendations 21 through 24 address first responder operations at large-scale incidents. Recommendation 21 proposes that an elevator specifically designed to operate under fire conditions for fire department use be provided in high rise buildings and that further research into the use of elevators for evacuation purposes be conducted.

Recommendations 25-28. Recommendations 25 through 28 address code compliance in government-owned and operated buildings, code enforcement in existing buildings, the retention of construction documents and the involvement of fire protection engineers in the design of innovative structures.

Recommendations 29 and 30. Recommendations 29 and 30 address additional education in building fire safety design for architects, structural engineer and fire protection engineers.

Analysis

Considered as a package, NIST's 27 recommendations which address building fire safety represent what can only be described as a radical agenda of change in the way we protect high rise buildings (exceeding 20 stories in height) from fire. Unfortunately, NIST did not bother to include any technical justification for its recommendations in the draft final report despite working on the investigation and report for almost 34 months. Given the better than excellent fire safety record of high rise buildings since special provisions for high rise buildings were introduced in the model building codes used in the United States 30 years ago, not providing a technical justification for each of the recommendations in the report has to be considered to be a serious omission.

An in-depth review of each of the recommendations pertaining to high rise building fire safety is not possible given the constraints on space in this column , so let me focus on just a few of NIST's recommendations.

Recommendation 8 in the report indicates that the structural systems of a high rise building (exceeding 20 stories in height) should be protected by fireproofing materials so that the building structure can withstand a fire which spreads throughout the building. In addition, Recommendation 4 proposes that floors in high rise buildings be divided into compartments not exceeding 12,000 square feet in area. The purpose of the floor compartmentation (as stated in Finding 22, NIST NCSTAR 1-1, WTC Investigation) is to limit fire spread to a relatively small floor area so that the fire department can extinguish a fire using the standpipe system in the event of sprinkler system failure. Obviously, NIST's recommendation that the structural elements of a high rise building be sufficiently fire resistive to prevent a collapse in a building "burn-out" anticipates both the failure of the sprinkler protection and the recommended compartmentation of each floor. All of this is on top of the recommendations that the reliability of both sprinkler and standpipe systems be improved (Recommendation 12) and that the egress system serving the building be designed for total building evacuation, rather than a partial evacuation (Recommendation 17).

It seems obvious, based upon the above, that NIST doesn't seem to have very much confidence in sprinkler protection or, for that matter, compartmentation. Given the performance of high rise buildings protected throughout by sprinklers over the last 30 years, it is difficult to understand why NIST believes that the combination of both sprinkler protection and compartmentation is necessary, particularly when NIST is also recommending improvements in the reliability of sprinkler protection provided in high rise buildings. It would seem logical that there should be no reason to also recommend compartmentation if the reliability of sprinkler systems will be increased further by the implementation of Recommendation 12.

Just an observation, but the federal government presently permits aircraft carrying passengers (an assembly occupancy located 35,000 feet in the air) to fly over oceans without sprinkler protection, compartmentation or exits. Certainly, if none of the protection recommended by NIST is considered to be an acceptable level of safety for aircraft carrying passengers flying over oceans, it would seem that fire resistive high rise buildings protected by highly reliable sprinkler systems ought to be considered "reasonably safe" for a building which is only 1,400 feet tall.

Conclusion

Without technical justification for NIST's proposals for improvements in the fire safety of high rise buildings (which should include a loss history and an extensive cost/benefit analysis for each recommendation), NIST's recommendations are merely opinions. Can NIST's opinions be justified? NIST has promised to provide the technical justifications for its recommendations at a NIST technical conference in Gaithersburg, Maryland on September 13-15, conveniently 40 days after the 6 week period for public comment on the draft final report has ended.

President Bush's State of the Union address on February 2, 2005 included the following excerpt:

> *"The principle here is clear: Taxpayer dollars must be spent wisely, or not at all."*

In effect, the implementation of NIST's recommendations are "stealth" tax increases which will eventually "trickle down" to every citizen of the United States (in the form of higher costs for goods and services). Will the implementation of NIST's recommendations be a wise use of the dollars which we devote to safety, or could those dollars be spent more wisely, as the President suggested in his State of the Union address, say in fire safety in 1- and 2-family dwellings or highway traffic safety?

The NFPA fire statistics on fire fatalities in high rise buildings and 1- and 2-family dwellings and the National Highway Transportation Safety Administration (NHTSA) statistics on highway fatalities provide a clear and concise answer to that question which can easily be understood by the general public. Just a recommendation, but perhaps NIST should lay out the NFPA statistics on fire fatalities in high rise buildings and 1- and 2-family dwellings next to the NHTSA statistics on highway fatalities and then let President Bush decide whether or not we should spend additional dollars on high rise building fire safety or invest those dollars on fire safety in 1- and 2-family dwellings or in highway safety. Better not to spend our dollars on additional high rise building fire safety than to spend our dollars unwisely on additional high rise building fire safety.

* * * * *

Note: The full text of NIST's recommendations can be found in section 9.2 of the draft final report designated as NIST NCSTAR 1, WTC Investigation. The report is available on the NIST website, wtc.nist.gov.

From: FPESCHULTE@aol.com
Subject: NIST Draft Final Report Comment
To: wtc@nist.gov

Public Comment-NIST WTC Collapse Investigation

Name: Richard Schulte

Affiliation: Schulte & Associates

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Report Number: General Comment

Page Number:

Paragraph/Sentence:

Comment: Neither the Executive Summary or the Recommendations section of the report define the problem that NIST is attempting to address with its recommendations. Based upon a conversation with Dr. Sunder at the AIA convention in Las Vegas, it is my understanding that the recommendations have not been written to mitigate another terrorist attack similar to that which occurred on 9/11. The report should clearly state that this is the case and then clearly define the need to make changes in how we design our buildings.

Reason for Comment: It is my opinion that high rise buildings as presently constructed are "safe" buildings. The basis for my opinion is the fire record of U.S. high rise buildings as outlined in the NFPA report on high rise buildings issued in September 2001. From the portions of the report which I have read, I see no justification for the recommendations, nor have I seen any statements regarding what will be accomplished if NIST's recommendations are implemented. NIST's stated goal is to make buildings "safer", but the question needs to be answered-"safer than what"? High rise buildings, office buildings in particular, are already the safest buildings which we construct. In fact, the NFPA report on high rise buildings indicates that the taller the building, the safer the building from a fire perspective.

Suggestion for Revision: Include a justification for each recommendation which includes a loss history, an estimated cost to accomplish the recommendation on a per building basis (i.e. cost for a 20 story, 30 story, 40 story, 50 story etc.) and the expected benefits of implementing each recommendation. Given the loss history, I don't believe that NIST can justify any of its recommendations.

From: FPESCHULTE@aol.com
Subject: NIST Draft Final Report Comment
To: WTC@nist.gov

Public Comment-NIST WTC Collapse Investigation

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Report Number: NIST NCSTAR 1
Page Number: 197

Paragraph/Sentence: Paragraph 2, 2nd sentence
This sentence reads as follows:

"In the United States, the private sector develops such codes and standards."

Comment: This statement is in error. The private sector does not the develop codes and standards used in the United States. Codes and standards are developed by "quasi-public" organizations, such as the International Code Council and the National Fire Protection Association, with input from both public and private entities, including trade associations.

The present statement implies that the process by which codes and standards are developed in the United States is defective because there is a "conflict of interest". In other words, the statement implies that the codes and standards are written by the same people and organizations which are regulated by the codes and standards. This implication is entirely incorrect.

Suggestion for Revision: The sentence should be revised to reflect the actual development process of codes and standards used in the United States. The process by which codes and standards are developed is designed to eliminate the "conflict of interest" which NIST implies exists in the present development process of codes and standards.

From: FPESCHULTE@aol.com
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Report Number: NIST NCSTAR 1

Page Number: 198

Paragraph/Sentence: 1st and 2nd paragraphs

This sentence reads as follows:

"Very few members of the general public and building occupants participate in this process."

"Due to limited participation of the general public and building occupants, NIST has a responsibility to represent the public's interest. As an objective and impartial technical entity, NIST recommendations are given serious consideration by private sector organizations that develop national standards and model codes, which provide minimum requirements for public welfare and safety."

Comment: It is my opinion that NIST is <u>not</u>, in fact, an impartial technical entity. BFRL is an agency which is involved in research. Like any government agency, NIST seeks to increase its budget and increase the size of the agency. Given this, the fact that NIST recommends additional research and greater involvement by NIST in the writing of building codes and standards and involvement in the dissemination of structural and fire safety information to the construction industry may be considered to be a conflict of interest.

(It should also be noted that a number of researchers at BFRL are now employed in the private sector and making extraordinarily high incomes doing work for BFRL. This is also gives the appearance of a conflict of interest.)

If NIST truly represented the public interest, NIST would have told the Congressional Science Committee (CSC) prior to the appropriation for the WTC study that the most likely reason for the collapse of the WTC towers was the fact that the aircraft impact damaged the fireproofing for the building structures, along with all of the other fire safety systems in the towers. NIST would have also told the CSC about the excellent fire safety record of high rise buildings. Instead, NIST chose to emphasize the dangers of high rise buildings at the March 6, 2002 CSC hearing. To date, it appears that NIST has yet to tell the American public about the excellent fire safety record of high rise buildings.

(It should also be noted that, in my conversations with the public about the collapse of the WTC towers, the reasons for the collapse of the towers was obvious. The typical reaction by people with whom I discuss my work on the WTC towers is laughter and disbelief that the federal government is still studying this event.)

The above statement by NIST also implies that the National Fire Protection Association (NFPA) and the International Code Council (ICC) do not represent the public interest. I strongly disagree with this implication. Both the NFPA and the ICC (and its predecessors, the three regional model building code groups) have been in the forefront of developing code regulations in the public interest for decades. To imply that these organizations do not represent the public interest is a "slap in the face" to these organizations and to all of the people who participate in the development of code organizations. Yes, many who participate in the code development process do so for financial gain, however, others including code enforcement officials and the fire service (and me) work tirelessly in the public interest and most certainly represent the public interest. The fact that codes and standards do not already include many of the recommendations proposed by NIST is more of an indication that NIST proposals are unnecessary, than an indication that the NFPA and ICC do not represent the public interest.

The statements excerpted above are an indication of NIST's arrogance about its abilities and capabilities. The entire section 9.1 is a misrepresentation of the code and standards development process and, as such, misleads the public. Obviously, this is not in the public interest.

Suggestion for Revisions: The entire section 9.1 should be rewritten to better reflect how code and standards are actually developed in the United States.

From: FPESCHULTE@aol.com
Subject: Re: The Public's Interest
To: WTC@nist.gov

Ladies and Gentlemen-

Attached is a draft of an article discussing section 9.1 of the draft final report of NIST WTC investigation. The article is titled "The Public's Interest".

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COLUMN1948.pdf

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DRAFT

"THE PUBLIC'S INTEREST"

By Richard C. Schulte
Schulte & Associates

The National Institute of Standards and Technology (NIST) released a portion of the draft final report on the investigation into the collapse of the World Trade Center (WTC) towers (and WTC 7) on April 5, 2005 and released the remaining portion of the draft final report on June 23, 2005. Based upon information provided in press releases issued by NIST, the report is roughly 10,000 pages in length. If you are a regular reader of this column, you already know quite a bit about the NIST's opinions regarding the "how and why" the WTC towers collapsed. Rather than discuss the reasons for the collapse, or NIST's recommendations included in the report, a section of the report on the development of building codes and standards, Section 9.1 of Chapter 9 of NCSTAR 1, caught my attention.

Section 9.1 is titled "*Building Standards and Codes: Who Is in Charge?*" and includes the following excerpts:

> "*Codes and standards for the design, construction, operation, and maintenance of buildings are the documents by which a society states its intent to provide public safety and functionality . . . . The United States has a unique approach to such codes and standards. In virtually all other developed countries the national government has a primary role in the development of national model codes. In the United States, the private sector develops such codes and standards.*"

"In addition to standards and codes organizations, there are other key stakeholder groups that either are responsible for or influence the practices used in the design, construction, operation, and maintenance of buildings in the United States. These typically include organizations representing building owners and managers (e.g., Building Owners and Managers Association, Construction Industry Institute), real estate developers (e.g., Real Estate Board of New York), contractors (e.g., Associated General Contractors, Associated Builders and Contractors), architects (e.g., American Institute of Architects), engineers (e.g., National Society of Professional Engineers, Society of Fire Protection Engineers, Structural Engineering Institute, National Council of Structural Engineering Associations), suppliers, and insurers. . . . Very few members of the general public and building occupants participate in this process."

"The National Institute of Standards and Technology (NIST) is a non-regulatory agency of the U.S. Department of Commerce. NIST does not set building codes or standards, but provides technical support to the private sector and to other government agencies in the development of U.S. building and fire practice, standards and codes. NIST provides this support by: conducting research which helps to form the technical basis for such practice, standards, and codes; disseminating research results to practicing professionals; having its staff participate on technical and standards committees; and, providing technical assistance to the building and fire safety communities. Due to limited participation of the general public and building occupants, NIST has a responsibility to represent the public's interest. As an objective and impartial technical entity, NIST recommendations are given serious consideration by private sector organizations that develop national standards and model codes, which provide minimum requirements for public welfare and safety."

Very few members of the general public and building occupants participate in this process.

Due to limited participation of the general public and building occupants, NIST has a responsibility to represent the public's interest.

As an objective and impartial technical entity, NIST . . . . .

Although the report states that NIST considers itself to be *"an objective and impartial technical entity"*, the excerpts from section 9.1 above are cause enough to question whether or not this actually the case.

According to NIST, *"the private sector develops such codes and standards"* in the United States, however, the two primary developers of building codes and fire safety standards in the United States, the National Fire Protection Association (NFPA) and the International Code Council (ICC), are both non-profit "quasi-public" entities. The NFPA has been developing fire safety standards used in the United States for more than 100 years, while the ICC and its predecessors, the three regional model building code groups, have been developing model construction codes for more than five decades. While it is true that the NFPA was dominated by property insurance interests early in its history, the influence of insurers on NFPA standards began to wane in the early 1970's and, for the last 25 years or so, has been almost non-existent. (Of course, there was nothing wrong with the property insurer domination of the NFPA-it was the property insurers who first developed a building code in the United States and promoted the adoption of building codes throughout the United States.) Given NIST's participation in the codes and standards development process in the United States, NIST should be well aware that building codes and standards are not developed by the private sector in United States. Why then would NIST make such a statement? Good question.

In the second paragraph excerpted above, NIST lists a few of the many organizations which are involved in the development, design, construction and maintenance of buildings, as well as the development of building codes and standards. First on NIST's list of these organizations is the Building Owners and Management Association (BOMA). Just a coincidence, or is NIST trying to suggest that some of these organizations, particularly BOMA, have undue influence on the development of building codes and standards in the United States? If that's what NIST is implying, NIST is incorrect.

After characterizing the organizations which develop codes and standards as part of the "private sector", and suggesting that organizations with financial interests perhaps exert undue influence on how buildings are designed, constructed and maintained, the report writers for NIST state that they are a "white knight" in this process and, given this, their opinions for changes to building codes and standards should carry more weight than others. Of course, when anyone goes out of their way to suggest that others have an interest in the results of an investigation and shouldn't be trusted, while their motives are "pure", it's time to be at least a little suspicious.

From: FPESCHULTE@aol.com
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Report Number: NIST NCSTAR 1-1

Page Number: Pages 152, 153, 154, 155, 156 and 157

Paragraph/Sentence: Sections 10.1.1 and 10.1.2

Comment: Section 10.1.1 and 10.1.2 have been interpreted by some (Glenn Corbett and The New York Times) to mean that all floors in the building would have been required to be provided with access to a 4th stair. This interpretation is incorrect. Only the top floors used for assembly purposes would have been required to be provided with access to a fourth stair. Although this stair would have been required to run through the entire height of the building, access to this stair would not have been required on the office floors in the WTC towers. In other words, any doors between the 4th stair and the office floors would have been permitted to be locked from the office side of the doors and no exit or exit directional signs would have been required to direct occupants of the office floors to this 4th stair.

Since I am not acquainted with the 1968 NYC Building Code (NYCBC), I do not know whether or not the NYCBC would have permitted a "blind" stair to run the height of the building, but per the egress provisions contained in the 2003 edition of the Life Safety Code, doors would only be required at every fifth floor in the stairs. These doors would be required to provide access from the stairs back into the building, but could be locked on the building side to prohibit access into the stair.

Suggestion for Revisions: It is suggested that section 10.1.1 and 10.1.2 be revised to reflect the comments above. That way the families of the victims will know that a 4th stair would not have have aided their relatives, unless the relatives happened to be on the 2 highest floors on the building.

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"THE PUBLIC'S INTEREST"

By Richard C. Schulte
Schulte & Associates

The National Institute of Standards and Technology (NIST) released a portion of the draft final report on the investigation into the collapse of the World Trade Center (WTC) towers (and WTC 7) on April 5, 2005 and released the remaining portion of the draft final report on June 23, 2005. Based upon information provided in press releases issued by NIST, the report is roughly 10,000 pages in length. If you are a regular reader of this column, you already know quite a bit about the NIST's opinions regarding the "how and why" the WTC towers collapsed. Rather than discuss the reasons for the collapse, or NIST's recommendations included in the report, a section of the report on the development of building codes and standards, Section 9.1 of Chapter 9 of NCSTAR 1, caught my attention.

Section 9.1 is titled "*Building Standards and Codes: Who Is in Charge?*" and includes the following excerpts:

> "*Codes and standards for the design, construction, operation, and maintenance of buildings are the documents by which a society states its intent to provide public safety and functionality . . . . The United States has a unique approach to such codes and standards. In virtually all other developed countries the national government has a primary role in the development of national model codes. In the United States, the private sector develops such codes and standards.*"

"In addition to standards and codes organizations, there are other key stakeholder groups that either are responsible for or influence the practices used in the design, construction, operation, and maintenance of buildings in the United States. These typically include organizations representing building owners and managers (e.g., Building Owners and Managers Association, Construction Industry Institute), real estate developers (e.g., Real Estate Board of New York), contractors (e.g., Associated General Contractors, Associated Builders and Contractors), architects (e.g., American Institute of Architects), engineers (e.g., National Society of Professional Engineers, Society of Fire Protection Engineers, Structural Engineering Institute, National Council of Structural Engineering Associations), suppliers, and insurers. . . . Very few members of the general public and building occupants participate in this process."

"The National Institute of Standards and Technology (NIST) is a non-regulatory agency of the U.S. Department of Commerce. NIST does not set building codes or standards, but provides technical support to the private sector and to other government agencies in the development of U.S. building and fire practice, standards and codes. NIST provides this support by: conducting research which helps to form the technical basis for such practice, standards, and codes; disseminating research results to practicing professionals; having its staff participate on technical and standards committees; and, providing technical assistance to the building and fire safety communities. Due to limited participation of the general public and building occupants, NIST has a responsibility to represent the public's interest. As an objective and impartial technical entity, NIST recommendations are given serious consideration by private sector organizations that develop national standards and model codes, which provide minimum requirements for public welfare and safety."

Very few members of the general public and building occupants participate in this process.

Due to limited participation of the general public and building occupants, NIST has a responsibility to represent the public's interest.

As an objective and impartial technical entity, NIST . . . . .

Although the report states that NIST considers itself to be *"an objective and impartial technical entity"*, the excerpts from section 9.1 above are cause enough to question whether or not this actually the case.

According to NIST, *"the private sector develops such codes and standards"* in the United States, however, the two primary developers of building codes and fire safety standards in the United States, the National Fire Protection Association (NFPA) and the International Code Council (ICC), are both non-profit "quasi-public" entities. The NFPA has been developing fire safety standards for more than 100 years, while the ICC and its predecessors, the three regional model building code groups, have been developing model construction codes for more than five decades. While it is true that the NFPA was dominated by property insurance interests early in its history, the influence of insurers on NFPA standards began to wane in the early 1970's and, for the last 25 years or so, has been negligible. (Of course, there was nothing wrong with the property insurer domination of the NFPA-it was property insurers who first developed a model building code in the United States, promoted the adoption of building codes throughout the United States and championed the cause of building fire safety for much of the twentieth century.) Given NIST's participation in the codes and standards development process in the United States, NIST should be well aware that building codes and standards are not developed by the private sector in United States. Why then would NIST make such a statement? Good question.

Also in section 9.1, NIST lists a few of the many organizations which are involved in the development, design, construction and maintenance of buildings, as well as the development of building codes and standards. First on NIST's list of these organizations is the Building Owners and Management Association (BOMA). Just a coincidence, or is NIST implying that BOMA, in particular, has undue influence on the development of building codes and standards in the United States? If that's what NIST is suggesting, NIST is simply incorrect.

After NIST's inaccurate characterization of the NFPA and the ICC as "private sector" entities and suggesting that organizations with financial interests perhaps exert undue influence on the safety requirements which apply to buildings, the report writers for NIST then suggest that NIST is a "white knight" in the whole process of codes and standards development. Given NIST's inaccurate statements in section 9.1, there is certainly reason to be skeptical about NIST's "white knight" status. Of course, there's more evidence to make one skeptical of NIST's intentions than simply a few statements included in section 9.1.

Roughly 6 months after September 11th, on March 6, 2002, the Congressional Science Committee (CSC) held a public hearing on the collapse the World Trade Center towers. The purpose of the hearing was to discuss the need for an investigation into the collapse and to authorize the investigation by NIST.

The following are excerpts from remarks made by the chairman of the CSC, Congressman Sherwood Boehlert (R-NY), at March 6 hearing:

> *"The* [Congressional Science] *Committee decided to move forward . . . . . to ensure that such a catastrophic building failure, and the resulting loss of life, never happen again."*

> *"Another significant lesson of the Trade Center collapse is that we need to understand a lot more about the behavior of skyscrapers and about fire, if we are going to prevent future tragedies."*

> *"But this hearing is not so much about the past, as it is about ensuring that we protect lives in the future."*

Following a number of other witnesses, the director of NIST, Dr. Arden L. Bement, Jr., provided testimony at the hearings. Excerpts from Dr. Bement's remarks include the following:

> *"The tragedy that the United States experienced on September 11, 2001, was unprecedented when compared with any prior accident, natural disaster, or terrorist/war attack. The collapse of the twin World Trade Center towers was the worst building disaster in human history . . ."*

> *"The implementation of the results of such an investigation would be critical to restore public confidence in the safety of tall buildings nationwide, enhance the safety of fire and emergency responders, and better protect people and property in the future."*

> *"Fourth, to study procedures and practices used to provide adequate structural reserve capacity to resist abnormal loads (e.g. blast, explosion, impact due to aircraft or flying debris from tornadoes, accidental fires, and faulty design and construction), especially those that can be anticipated prior to construction (e.g. impact of a Boeing 707). . ."*

"In short, NIST would provide the technical basis and guidance for fire safety design and retrofit of structures, the predictive tools and test methods for fire resistance determination, and the performance criteria for fireproofing materials. In addition, NIST proposes to develop guidance and retrofit technologies to enhance building egress in emergencies, practical tools and guidance to enhance the safety and effectiveness of fire and emergency responders, and improved models of occupant behavior and response to enhance evacuation and communication in emergencies."

"In conclusion, I believe it is imperative for the U.S. to learn from the worst-ever building disasters in human history and take aggressive remedial action to minimize future losses."

Unfortunately, the director of NIST never corrected Congressman Boehlert's impression that we can somehow *"ensure that such a catastrophic building failure, and the resulting loss of life, never happen again."* Dr. Bement even went so far as to suggest in his testimony before the Science Committee that buildings could, and perhaps should, be designed to resist the impact of a Boeing 707 aircraft. Nor did the director of NIST inform the Science Committee of the excellent fire record of high rise buildings at any time during his public testimony. Was the director of NIST actually acting in the public's interest during his testimony on March 6, 2002, or was the director just trying to "wring" money out of Congress for a high-profile research project by hyping the results of a NIST study?

Three years after the Congress Science Committee hearing, the NIST study is almost completed and a draft of the final report has been released. Notably absent from the draft report are any recommendations on how NIST believes the issue of terrorism should be addressed in codes and standards and in building design and the lead investigator for NIST, Dr. Sunder, has stated publicly (at the American Institute of Architects convention in Las Vegas in May of this year) that the NIST study will not include any recommendations for making buildings "terrorist-proof". Also, notably absent from the draft final report are any reference to the excellent fire safety record of high rise buildings over the last 30 years. This, of course, raises the obvious question - what happened to all Dr. Bement's promises to the Congressional Science Committee on March 6, 2002? I guess NIST thought that we would all forget about Bement's testimony.

Broken promises about the results of the study, hidden facts about the excellent fire safety record of high rise buildings (and commercial buildings in general), and NIST wants us to believe that NIST is an "*an objective and impartial technical entity*". Let's be honest, NIST has an agenda too. While NIST's investigative work into the collapse of the World Trade Center towers is impressive and appears to be "top-notch", the findings and recommendations portion of the NIST report is a reflection of NIST's agenda-more research and a bigger budget for NIST. Pardon me if I disagree with NIST assertion that NIST is acting in the public's interest. The Congressional Science Committee needs to recall Dr. Bement and ask him to justify his prior testimony to the Committee. The Congressional Science Committee also needs to ask NIST for a justification of each and every one of the recommendations contained in the draft final report. Building fire safety and homeland security are simply too important to allow a government agency to shade the truth in order to secure increases in its budget. An agency acting in the public's interest certainly would not have done that.

* * * * *

WTC 1

Area of Refuge 1:	234 occupants
Area of Refuge 2:	579 occupants
Area of Refuge 3:	200 occupants

Total Occupant Load: **1,013 occupants**

Stair #1:	44 inches ÷ 0.3 inches/person = 146 people
Stair #2:	44 inches ÷ 0.3 inches/person = 146 people
Stair #3:	56 inches ÷ 0.3 inches/person = 186 people

Total Exit Capacity (LSC): **478 people**

Stair #1:	44 inches ÷ 0.2 inches/person = 220 people
Stair #2:	44 inches ÷ 0.2 inches/person = 220 people
Stair #3:	56 inches ÷ 0.2 inches/person = 280 people

Total Exit Capacity (IBC): **720 people**

From: FPESCHULTE@aol.com
Subject: The Public's Interest
To: WTC@nist.gov

Ladies and Gentlemen-

Attached is an article titled "The Public's Interest" which addresses section 9.1 of Chapter 9 of NCSTAR 1 in the NIST draft final report on the WTC investigation. Also attached are two articles on Dr. Arden L. Bement, Jr.'s testimony at the Congressional Science Committee hearing on the collapse of the World Trade Center towers on March 6, 2002. You may find these articles of interest.

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COLUMN148a.pdf

Congressional Testimony-Part 1 (February 2003).pdf

Congressional Testimony-Part 2 (March 2003).pdf

Fire Protection

By Richard G. Schulte, Schulte & Associates, Evanston, IL

The World Trade Center Collapse: Congressional Testimony

The fire protection column published in the January, 2003 *Plumbing Engineer* concluded with a question:

"... is the World Trade Center collapse incident simply being used by "experts" to 'wring' more research funding out of the Federal Treasury?"

Rather than provide an answer to this question, the January column referred readers to the testimony of the director of the National Institute of Standards and Technology (NIST), Dr. Arden L. Bement, Jr., at the Congressional Science Committee hearings on the collapse of the World Trade Center towers on March 6, 2002. (A transcript of Dr. Bement's testimony can be found on the NIST Web site at *www.nist.gov/testimony/2002/abwtc.html.*)

The Congressional hearings on the collapse of the World Trade Center held on March 6, 2002 opened with a statement from the chairman of the committee, Congressman Sherwood Boehlert (R-N.Y.), followed by the testimony from five witnesses. Congressman Boehlert's opening statement included the following excerpts:

"The Committee decided to move forward for two fundamental reasons. First, we believe that we owe it to the victims and their families to learn everything possible about what happened in those horrifying first hours of September 11th—not just to satisfy their immediate needs and yearnings, but to ensure that such a catastrophic building failure, and the resulting loss of life, never happen again.

"Another significant lesson of the Trade Center collapse is that we need to understand a lot more about the behavior of skyscrapers and about fire, if we are going to prevent future tragedies.

"But this hearing is not so much about the past, as it is about ensuring that we protect lives in the future."

The first witness before the committee was Robert F. Shea, Acting Administrator, Federal Insurance and Mitigation Administration of the Federal Emergency Management Agency (FEMA). Mr. Shea's testimony included the following:

"... its conclusions and recommendations [referring to the FEMA study issued May, 2002] will help guide future investigative and research efforts connected primarily to understanding the performance of buildings when subjected to extreme conditions.

"This study [again referring to the FEMA study issued May, 2002] represents an important first step in suggesting how the technical resources of the nation can be brought to bear on protection of lives and property."

The next witness before the committee was Glenn P. Corbett, an assistant professor of fire science at John Jay College in New York City. Professor Corbett is also a member of the advisory panel of the Skyscraper Safety Campaign, a group advocating more restrictive code requirements for high rise buildings. His testimony included the following:

"For example, our model building codes treat a 15-story building exactly the same as a 100-story building in terms of fire protection—we apply the same level of structural fire resistance, the same fire protection systems, the same everything. We place heavy reliance on automatic sprinkler systems, with little redundancy in terms of structural fire resistance to ensure that the building will stay up long enough to allow for firefighters to reach the fire area, rescue trapped inhabitants, and generally deal with the situation. Automatic sprinklers are the best protection against fire, but we need to have a backup when we are 1,000 feet high in a building on fire. We need a proper balance of passive and active protection in larger high-rise structures.

"This test, commonly known as A.S.T.M. E-119, was developed to provide assurance that the fire protection coating/encasement provided for beams and columns would allow them to be subjected to high temperatures and not collapse. This test, however, dates back to the 1920's and is based upon the temperatures recorded when a set of buildings were burned back then for study purposes. Today, we basically still use the same test with the same 'fire' temperature and exposure conditions developed over 75 years ago. I would argue that the fires of the 1920's are different than those of today, and that this nationally accepted test needs to be thoroughly reexamined in light of what happened on 9-11."

The final witness before the committee was Dr. Bement, the director of NIST. Dr. Bement's testimony included the following:

"The tragedy that the United States experienced on September 11, 2001, was unprecedented when compared with any prior accident, natural disaster, or terrorist/war

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attack. The collapse of the twin World Trade Center towers was the worst building disaster in human history...

"The implementation of the results of such an investigation would be critical to restore public confidence in the safety of tall buildings nationwide, enhance the safety of fire and emergency responders, and better protect people and property in the future. To cite one example, the February 4th issue of 'Crain's New York Business' reports that an increasing number of tenants are leaving the Empire State Building, which is again the tallest building in New York City, because of fears of another terrorist attack. Anecdotal evidence also suggests that building vacancy rates have doubled in Manhattan, despite the 15 million square feet of space that was lost on September 11th.

"The Building and Fire Research Laboratory is the foremost fire research laboratory in the United States, and through the National Earthquake Hazards Reduction Program (NEHRP) NISTis the principal agency for research and development to improve building codes and standards...

"Fourth, to study procedures and practices used to provide adequate structural reserve capacity to resist abnormal loads (e.g. blast, explosion, impact due to aircraft or flying debris from tornadoes, accidental fires, and faulty design and construction), especially those that can be anticipated prior to construction (e.g. impact of a Boeing 707)...

"This broader program would address critically and urgently needed improvements to national building and fire standards, codes, and practices that have begun to be recognized in recent years. The events of September 11th have brought even more focus and priority to this already important issue.

"The goal of this broader program would be to produce cost-effective retrofit and design measures and operational guidance for building owners and emergency responders.

"Current building design practice does not consider fire as a design condition. Instead, structural fire endurance ratings are prescribed in building codes using standard tests on individual components. The current testing standards are based on work carried out at NIST in the 1920s. They do not represent real fire hazards in modern buildings. They also do not consider the fire performance of structural connections or of the structural system as a whole, or the multiple performance demands on fire proofing materials.

"In short, NIST would provide the technical basis and guidance for fire safety design and retrofit of structures, the predictive tools and test methods for fire resistance determination, and the performance criteria for fireproofing materials. In addition, NIST proposes to develop guidance and retrofit technologies to enhance building egress in emergencies, practical tools and guidance to enhance the safety and effectiveness of fire and emergency responders, and improved models of occupant behavior and response to enhance evacuation and communication in emergencies.

"Yet, the United States has not developed standards, codes, and practices to assess and reduce this vulnerability. Adding to the problem for modern structures is their smaller margin of safety—and the reserve capacity to accommodate abnormal loads—due to increased efficiency in the use of building materials and refinements in analysis techniques...

"The overwhelming majority of buildings in public use today are vulnerable to terrorist attack on a number of fronts...

"The final program element supports a construction-industry-led roadmapping effort to reflect changed priorities for development and deployment of safety and security standards, technology, and practices.

"The effort would complement and support parallel efforts of technical organizations to improve standards, codes, and practices.

"In conclusion, I believe it is imperative for the U.S. to learn from the worst-ever building disasters in human history and take aggressive remedial action to minimize future losses.

"In the wake of September 11th, the private sector's willingness to take necessary corrective action to strengthen building codes and standards is extraordinarily strong."

Perhaps if the Science Committee had heard from a more diverse group of "experts," the committee would have developed a far different perspective on the relative importance of a study of collapse of the World Trade Center Towers.

Following the March 6 hearings, members of the Science Committee issued a press release containing some of the members' reactions to the testimony which the committee heard. The reaction of one committee member, Representative Connie Morella (R-Md.) was as follows:

"The importance of this work can't be overstated. Research into this disaster is the only way we have any chance of preventing the next one and Congress needs to move swiftly to formalize the way we evaluate catastrophic building collapse. Fortunately, we have an advanced federal laboratory dedicated to such research. The National Institute of Standards and Technology is uniquely position[ed] to conduct extensive

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investigations into the structural failures of the World Trade Center and suggest appropriate new standards and potential retrofits..."

As a result of the hearings, the House Committee on Science drafted a letter to Mr. Mitchell Daniels, the director of the Office of Management and Budget (OMB), regarding funding for a federal government study of the collapse of the World Trade Center. The opening paragraph of the letter reads as follows:

"We are writing to you as a result of today's House Science Committee hearing on the collapse of the World Trade Center buildings. There was unanimity among the witnesses on the need for a comprehensive assessment and research agenda to address evacuation procedures, emergency response, and structural analysis of the site's buildings. The goal of such a study would be to improve the safety of both the public and the emergency responders in the event of another building collapse."

The letter to the director of OMB also includes the following excerpt:

"... the Federal Emergency Man-agement Agency's (FEMA) Building Performance Assessment Team (BPAT) has estimated that $40 million would be required to fund a comprehensive study of an event of this magnitude and complexity."

From the standpoint of the overall federal budget, a proposal to spend $40 million for a study of the collapse of the World Trade Center is "chicken feed," but certainly any decision to devote this amount of taxpayer money (or the $16 million which was actually allocated for the study) to studying a single disaster should be based upon credible testimony by witnesses before a Congressional committee. Unfortunately, the testimony from some of the experts at the March 6 hearing of the House Science Committee was less than factually accurate. Perhaps if the Science Committee had heard from a more diverse group of "experts," the committee would have developed a far different perspective on the relative importance of a study of collapse of the World Trade Center Towers.

Next month we will continue this series by presenting an analysis of the various statements presented on these pages. □

About the Author

Richard Schulte is a 1976 graduate of the fire protection engineering program at the Illinois Institute of Technology. After working in various positions within the fire protection field, he formed Schulte & Associates in 1988. His consulting experience includes work on the Sears Tower and numerous other notable structures. He has also acted as an expert witness in the litigation involving the fire at the New Orleans Distribution Center. He can be contacted by sending email to rschulte@plumbingengineer.com

Next month:

Analysis of Congressional Testimony on the WTC Collapse

Fire Protection

By Richard G. Schulte, Schulte & Associates, Evanston, IL

Analysis of Congressional Testimony on the World Trade Center Collapse

Last month in this column we offered a compendium of testimony presented before the House Science Committee of the United States Congress. (See March 2003 *Plumbing Engineer*, page 8.) This month we provide an analysis of those remarks.

To begin his testimony, the director of NIST, Dr. Bement, stated that the terrorist attack on September 11 was "... unprecedented when compared with any prior accident, natural disaster, or terrorist/war attack." Dr. Bement further stated that "the collapse of the twin World Trade Center towers was the worst building disaster in human history." Obviously, these statements are an exaggeration. Without thinking very hard, several other major building disasters which were far greater in magnitude and impact come to mind, for instance, the Great Chicago Fire in 1871, the San Francisco earthquake and fire in 1906, the destruction of Dresden by Allied bombers in 1945 and the destruction of Hiroshima and Nagasaki using atomic weapons also in 1945. The destruction of the World Trade Center towers pales in comparison to these events. The difference between these events and the collapse of the World Trade Center towers is that the collapse of the towers was recorded on film and played ad nauseam on television, while the Great Chicago Fire, the San Francisco earthquake and fire and the destruction of German and Japanese cities in World War II are "ancient" history. Although these other events are "ancient" history, one would have expected that the director of NISTcould have put the destruction of the World Trade Center towers into proper perspective for a Congressional committee.

The inaccurate historical perspective on the magnitude of the collapse of the World Trade Center towers was not the only major distortion of facts contained in Dr. Bement's testimony. As one justification for a major investigation into the collapse of the World Trade Center, Dr. Bement stated that "an investigation would be critical to restore public confidence in the safety of tall buildings nationwide ..." Dr. Bement further stated that "anecdotal evidence also suggests that building vacancy rates have doubled in Manhattan, despite the 15 million square feet of space that was lost on September 11th." Of course, one way to restore the public's confidence in the safety of high rise buildings would be to conduct an expensive research study by NIST. Another, far more immediate, and far less expensive way of restoring the American public's confidence in the safety of our tall buildings would be for "experts" to simply stop scaring the public and cite the actual facts about high rise building safety.

The truth is that the fire record of American high rise buildings has been excellent over the last 20 years. This statement is supported by statistics published in a report written by Dr. John Hall, Jr. of the Fire Analysis and Research Division of the National Fire Protection Association (NFPA). Dr. Hall's report titled "High-Rise Building Fires" was published (coincidentally) in September, 2001. (A summary of some of the statistics presented in Dr. Hall's paper appeared in the fire protection column in the January, 2003 issue of *Plumbing Engineer*, along with other fire statistics published by the NFPA.) It is unfortunate that Dr. Bement did not provide the Congressional Science Committee with Dr. Hall's report, along with a summary of the statistics contained in the report. Dr. Bement missed an excellent opportunity to reassure the American public about the "dangers" of fires in high rise buildings.

Dr. Bement's reference to the fact that the (commercial) building vacancy rate in Manhattan has doubled since September 11 as an indication that the American public has developed an aversion to living or working in high rise buildings is a rather curious statement. Dr. Bement seems to have totally neglected the impact of the events of September 11 on the economy in New York City and the rest of the nation. Was the increase in the vacancy rate in Manhattan due to the fact that companies were fearful that other high rise buildings would be attacked by terrorists as suggested by Dr. Bement or could it be that the increase in the vacancy rate was mainly due to the impact that the September 11 attacks had on the economy? Common sense tells us that the impact of the September 11th events on the local economy had far more to do with rise in the vacancy rate in Manhattan than the fear of another terrorist attack.

Dr. Bement's testimony also included a statement that improvements in building and fire codes used in the United States are "urgently needed" and that the deficiencies in the codes "have begun to be recognized in recent years." Dr. Bement's testimony also stated that "the events of September 11th have brought even more focus and priority to this already important issue." If it is NIST's opinion that improvements in the building and fire codes used in the United States are so "urgently needed," why was NISTno where to be found when the two newest model building codes in the United States, the 2000 edition of the *International Building Code* and the 2003 edition of *NFPA Building Code*, were being developed? (It

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should be noted that Mr. Richard Bukowski of the Fire Research Division of the Building and Fire Research Laboratory of NIST did participate in the development of the first edition of the *International Performance Code* published by the International Code Council.)

A review of the fire statistics in the United States (published annually by the NFPA) indicates that the number of fire fatalities in the United States has steadily declined over the last quarter century, despite the fact that the population of the United States has continued to grow. The NFPA statistics for 2001 indicate only 80 Americans died as a result of fires in U.S. commercial (non-residential) buildings (excluding the fatalities which occurred as the result of the September 11 terrorist attack). These same statistics indicate that roughly 83 percent of the fire fatalities which occurred in the United States in 2001 occurred in residential occupancies (excluding the fatalities which occurred on September 11) with 70.7 percent of the fatalities occurring in one- and two-family dwellings. (That means that more American civilians died as a result of fires in one- and two-family dwelling in 2001 than died as a result of the collapse of the World Trade Center towers.) Given these statistics, just what are these "urgently needed" improvements in our fire codes? If there are any "urgently needed" improvements in our fire codes, the NFPAstatistics seem to suggest the need to address the fire problem in the smallest buildings that we construct, one- and two-family dwellings, not high rise buildings.

Dr. Bement's testimony also included a statement that "current building design practice does not consider fire as a [structural] design condition." Along these same lines, Dr. Bement's further stated that "the current testing standards are based on work carried out at NIST in the 1920s" and that the test standards "do not represent real fire hazards in modern buildings." Dr. Bement's statements regarding structural engineering design practice is correct, as is his statement regarding the fire resistance test (ASTM E119), but his inference that somehow these are major problems is another distortion of the facts. The reason that fire conditions are not presently considered in structural engineering design is that our "real world" experience with building fires indicates it simply isn't necessary. While the fire exposure (the time-temperature curve) required to be used by ASTM E119 may not represent time-temperature curves derived from real fires, more than 50 years of experience with the ASTM E119 fire test indicates that the results derived from this test are adequate. Based upon fire testing, we are aware that the temperatures developed in a fire vary with the type of fuel, the quantity of fuel, the fuel configuration and the ventilation available to the fire. Hence, any standardized test using a single time-temperature curve will necessarily be a compromise.

It is assumed by many in the fire protection field that hourly fire resistance ratings assigned to structural assemblies represent the actual fire resistance of a structural assembly in a real fire. This assumption is erroneous, however. The variable with the greatest impact on the fire resistance of a structural assembly is the fire itself. If a structural assembly is exposed to a fire which is more severe than the ASTM E119 time-temperature curve, the actual fire resistance of the assembly will be less than indicated by the fire rating assigned to the assembly by testing per ASTM E119, while if the fire exposure is less severe than the ASTM E119 time-temperature curve, the actual fire resistance of the assembly will be greater than indicated by the fire rating assigned to the assembly. If you have an actual understanding of the E119 test standard, the above is obvious.

The issue of the actual structural fire resistance, versus the severity of the fire exposure, has implications in the collapse of the World Trade Center towers because the fire to which the structural systems in the towers were exposed was far more severe than the fire exposure utilized in the ASTM E119 fire test standard. (The severity of a massive flammable liquids fire will far exceed the

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Fire Protection

Continued from page 10

severity of the ASTM E119 time-temperature curve.) Hence, it should be obvious that the actual fire resistance of the structural systems in the World Trade Center towers would have been less than indicated by the hourly ratings assigned to the structural systems assuming that all of the structural fire protection provided for the structural systems in the building was intact. Of course, the impact of the aircraft damaged the structural fire protection provided for the towers reducing the actual fire resistance of the overall structure. (The damage to the building structural systems caused by the impact of aircraft also would have reduced the actual fire resistance of the structure by increasing the stress in some of the undamaged structural members.)

In Professor Corbett's testimony, he in essence attacked the model building codes because the code requirements that apply to high rise buildings "treat a 15-story building exactly the same as a 100-story building in terms of fire protection." Professor Corbett further stated that the model building codes "place heavy reliance on automatic sprinklers, with little redundancy in terms of structural fire resistance ..." The professor's testimony also included the statement that "we need a proper balance of passive and active [fire] protection in larger high-rise structures." As with some of Dr. Bement's testimony, Professor Corbett's statements regarding the high rise building provisions contained in the model building codes lack an historical perspective.

The high rise provisions presently included in the *International Building Code* and the *NFPA Building Code* (NFPA5000) were originally developed in the early 1970s and first included in the regional model building codes in the middle 1970s. The issue of whether sprinkler protection should be mandated in high rise buildings was the subject of much debate in the early 1970s and the first set of high rise building provisions included in the three regional model building codes contained two alternatives for protecting high rise buildings. One alternative was to "compartment" the building, while the other was to provide sprinkler protection in lieu of "compartmentation."

At that time, it was acknowledged that providing sprinkler protection in a high rise building would provide superior protection for the occupants of the building, however, there were concerns about the cost of installing sprinkler protection. To encourage the installation of sprinkler protection in high rise buildings, the high rise provisions included a number of "trade-offs" in the passive fire protection normally required. The purpose of allowing these "trade-offs" in passive protection was to at least partially offset the cost of installing sprinkler protection. Among the "trade-offs" allowed in the high rise provisions were reductions in the structural fire protection required, the elimination of fire dampers and the substitution of pressurized stair enclosures for smokeproof (exit stair) enclosures. It was not until the 1980s that the high rise provisions included in the three regional model building codes were revised to mandate the installation of sprinkler protection in high rise buildings.

Since the inclusion of the high rise provisions in the three regional model building codes, there has not been a major fire disaster in an American high rise building protected throughout by a sprinkler system (with the exception of the World Trade Center towers). Based upon the experience of the last 25 years, many, if not most, code professionals have accepted the con-

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Fire Protection

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cept of "trade-offs" in passive fire protection when sprinkler protection is installed. In recent years, however, manufacturers of passive fire protection products have begun to attack the concept of "trade-offs" for the installation of sprinkler protection and have developed a concept which is referred to as "balanced" fire protection. The implication is that allowing "trade-offs" in passive fire protection when sprinkler protection is installed is somehow "unbalanced" fire protection. One of the problems with the "balanced" fire protection concept as it applies to high rise buildings is that it neglects the history of the development of the high rise building provisions (and the fire record of sprinklered high rise buildings in the last 25 years). Unfortunately, Professor Corbett's testimony before the Congressional Committee implied that the concept of "balanced" fire protection is generally accepted in the fire protection field.

Common sense tells us the impact of the September 11th events on the local economy had far more to do with rise in the vacancy rate in Manhattan than the fear of another terrorist attack.

Does the fact that both of the World Trade Center towers collapsed on the morning of September 11 validate the concept of "balanced" fire protection and does the World Trade Center towers collapse indicate that additional fire protection should be required in 100 story high rise buildings? The answer to both of these questions might be affirmative if the fires in the World Trade Center towers were typical fires which occur in high rise buildings, but the fires in the World Trade Center towers were anything but typical. The key question which must be answered in this debate is not whether the high rise building provisions contained in our model building codes are adequate, but what are our expectations regarding the structural stability of high rise buildings? It appears that the witnesses before the Congressional Committee have assumed that there is a consensus that buildings should remain stable, regardless of the magnitude of damage done to the building by terrorists (or the cost to construct such buildings).

Professor Corbett's testimony also addressed "inadequacies" in ASTM E119 stating that "today, we basically use the same test with the same 'fire' temperature and exposure conditions developed over 75 year ago. I would argue that the fires in the 1920s are different than those of today, and that this nationally accepted test needs to be thoroughly reexamined in light of what happened on 9-11." Are fires really different today, from fires which occurred in the 1920s? Obviously, the physics of fire is the same today as in the 1920s, but what Professor Corbett appears to be referring to is the increased use of petrochemical products (plastics) in modern American society. What

Professor Corbett has neglected in his assessment that the contents of buildings are different today than they were in the 1920s are the advancements made in material science over the last 80 years. In the early part of the 20th century, furniture and wall and ceiling finishes were combustible. Today, much of our furniture in commercial occupancies is constructed with noncombustible materials with only minor quantities of plastic finishes, and wall and ceiling finishes are mostly noncombustible. Astrong argument can be made that the contents of a modern building are far less combustible and safer today than the contents of buildings in the 1920s. The fire safety statistics collected and published by the NFPAsupport this point of view, rather than Professor Corbett's viewpoint. The number of structure fires continues to decrease each year, as do the number of civilian and firefighter fatalities caused by fire, despite the fact that the population of the United States continues to grow. Over the past quarter century, we have, in essence, conquered the hazard of fire. Given this, is it really absolutely essential to address some of the "well-known" deficiencies in ASTM E119 test standard?

Closing comments

This column offers a far different perspective on the hazard of fire in the United States than that presented by Dr. Bement and Professor Corbett. Although the money to fund the NIST study of the World Trade Center towers collapse has already been appropriated and the study is under way, the Congressional Science Committee should be aware that some of the testimony before the committee provided a less than objective assessment of the importance of the World Trade Center collapse to our understanding of the hazard of fire in high rise buildings. It is likely that the staff of NIST wrote Dr. Bement's remarks for him. If this is the case, Dr. Bement can, perhaps, be excused for some of his misstatements.

Finally, back to my original question. Is the World Trade Center collapse incident simply being used by "experts" to "wring" more research funding out of the federal treasury? Why else would witnesses before the Congressional Committee exaggerate the magnitude of the World Trade Center collapse in comparison to other major building disasters and "cover up" the excellent fire record of American high rise buildings? Did the Congressional Science Committee get "rolled" by the "experts" who testified at the March 6, 2002, hearing? It certainly appears that the answer to this question is yes. □

About the Author

Richard Schulte is a 1976 graduate of the fire protection engineering program at the Illinois Institute of Technology. After working in various positions within the fire protection field, he formed Schulte & Associates in 1988. His consulting experience includes work on the Sears Tower and numerous other notable structures. He has also acted as an expert witness in the litigation involving the fire at the New Orleans Distribution Center. He can be contacted by sending email to rschulte@plumbingengineer.com

This and Mr. Schulte's several previous columns comprising a series on the World Trade Center collapse can be downloaded (in PDF format) from the Plumbing Engineer Web site, www.plumbingengineer.com. They are located in the "Resources" section.

From: FPESCHULTE@aol.com
Subject: Finding 10
To: WTC@nist.gov

Finding 10: Although not required to conform to NYC codes, the PANYNJ adopted the provisions of the proposed 1968 edition of the NYC Building Code, more than three years before it went into effect. The 1968 edition allowed the PANYNJ to take advantage of less restrictive provisions compared with the 1938 edition that was in effect when design began for the WTC towers in 1962. The 1968 code:
? Eliminated a fire tower53 as a required means off fire department access;
? Reduced the number of required stairwells frrom 6 to 3 and the size of doors leading to the stairs from 44 in. to 36 in. (by increasing stairway and door capacity allowances);
? Reduced the required fire rating of the shaft walls in the building core from 3 h to 2 h; and
? Permitted a 1 h reduction in fire rating for all structural components (columns from 4 h to 3 h and floor framing members from 3 h to 2 h) by allowing the owner/architect to select Class 1B construction for business occupancy and unlimited building height.
Many of these newer requirements, instituted in the 1968 NYC Building Code, are contained in current codes.
Finding 11: In 199

From: FPESCHULTE@aol.com
Subject: Finding 18
To: WTC@nist.gov

Finding 18: Detailed procedures to select appropriate design-basis fire scenarios to be considered in the performance-based design of the sprinkler system, compartmentation, and passive protection of the structure are needed. The standard fire in current prescriptive fire resistance tests is not adequate for use in performance-based design. While the NFPA 5000 model building code contains general guidance on design fire scenarios (the IBC Performance Code contains no such guidance), the details of the scenarios are left to the fire engineer and regulatory official. The three major scenarios that are not considered adequately are: frequent but low severity events (for design of sprinkler system), moderate but less
frequent events (for design of compartmentation), and a maximum credible fire (for design of passive fire protection on the structure). The maximum credible fire scenario for passive protection of structures would assume that the sprinkler system is compromised or overwhelmed and that there is no active firefighting, as is explicitly considered for US Department of Energy facilities. These building-specific representative fire scenarios are similar in concept, though not identical, to the approach used in building design where the performance objectives and design-basis of the hazard are better defined (e.g., a two level design that includes an operational event with a 10 percent probability of occurrence in 50 years and a life safety event with a 2 percent probability of occurrence in 50 years). The design-basis fire hazards for the WTC towers and WTC 7 are unknown, and it is difficult to evaluate the performance of the fire protection systems in these buildings under specific fire scenarios.

From: FPESCHULTE@aol.com
Subject: Finding 22
To: WTC@nist.gov

Finding 22: Building fire protection is based on a four-level hierarchical strategy comprising detection, suppression (sprinklers and firefighting), compartmentation, and passive protection of the structure.

? Detectors are typically used to activate fire alaarms and notify building occupants and emergency services.

? Sprinklers are designed to control small and mediium fires and to prevent fire spread beyond the typical water supply design area of about 1,500 ft2.

? Compartmentation mitigates the horizontal spread of more severe but less frequent fires and typically requires fire-rated partitions for areas of about 7,500 ft2. Active firefighting measures also cover up to about 5,000 ft2 to 7,500 ft2.
? Passive protection of the structure seeks to ensure tthat a maximum credible fire scenario, with sprinklers compromised or overwhelmed and no active firefighting, results in burnout, not overall building collapse. The intent of building codes is also for the building to withstand

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Subject: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1-1

Page Number: 2
Paragraph/Sentence: Comparison of the structural provisions in the 1968 New York City (NYC) Building Code with other contemporaneous code provisions:
- Differences between the 1968 NYC Building Code and the contemporaneous building codes of New York State, Chicago, and Building Officials Conference of America (BOCA), and the 2001 NYC Building Code.

Comment: It is not clear why the code comparison is limited to building codes used in the 1960's and the 2001 NYC Code. It would seem that a comparison of present day codes would also be of interest (i.e. International Building Code and NFPA 5000). Including the International Building Code and NFPA 5000 in the comparison would perhaps allow the reader to judge whether the provisions contained in building codes presently being used are adequate.

Suggestion for Revision: The comparison should be revised to include the 2003 International Building Code and NFPA 5000.

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Report Number: NIST NCSTAR 1-1

Page Number: 3

Paragraph/Sentence: Comparison of the fire safety provisions in the 1968 New York City (NYC) Building Code with other contemporaneous code provisions:
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Comment: It is <u>not</u> clear why the code comparison is limited to building codes used in the 1960's and the 2001 NYC Code. It would seem that a comparison of present day codes would also be of interest (i.e. International Building Code and NFPA 5000). Including the International Building Code and NFPA 5000 in the comparison would perhaps allow the reader to judge whether the provisions contained in building codes presently being used are adequate.

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Page Number: 4

Paragraph/Sentence:

"***By adopting the draft versions of the new NYC Building Code, the Port Authority had an option of classifying WTC 1 and WTC 2 as Type 1-B Construction instead of Type 1-A Construction (see Sec. 9.1.3 for definition and fire protection requirements of Construction Type), and several architectural features related to egress were modified in the final design (see Sec. 10.1). This relaxation of code requirements allowed the Port Authority to gain economic advantage.5 The new NYC Building Code (NYC BC 1968) was enacted by the City Council on October 22, 1968, approved by the Mayor on November 6, 1968, and became effective on December 6, 1968.***"

Comment: The two sentences above are written to make it appear that there was something "sleazy" about utilizing the 1968 code, rather than the 1938 code. The purpose of utilizing the 1968 code, rather than the 1938 code was to reduce the cost of constructing the buildings, while at the same time designing and constructing the building in an acceptable ("safe") manner. Since the Port Authority is a government agency which is supported by taxpayer funding, it would have been wasteful of taxpayer funds for the Port Authority to utilize the 1938 Code when an updated version of the code which was significantly different was being prepared. In other words, the Port Authority was acting in the taxpayer's best interests in utilizing the 1968 code, rather than the 1938 code.

It should also be noted that this paragraph does not indicate when the construction of the towers actually began. It is common for enforcing authorities to allow a code which will be adopted in the future to be used as the basis for a design if the adoption will occur during design or during construction.

Suggestion for Revision: Rather than indicate that the Port Authority had an "option" to use Type 1-B construction, rather than Type 1-A construction, it is proposed that the words "permitted to use" Type 1-B construction, rather than Type 1-A construction be used.

It is also recommended that the sentence *"This relaxation of code requirements allowed the Port Authority to gain economic advantage."* be changed to read:

"The use of the 1968 edition of the NYC Code permitted to Port Authority to reduce the cost of constructing the towers."

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Report Number: NIST NCSTAR 1-1

Page Number: 12

Paragraph/Sentence:

Pared trusses, spaced at 6 ft 8 in. on center, were supported at every other exterior column. The metal deck which spanned parallel to the main trusses was directly supported by transverse bridging trusses spaced at 13 ft 4 in. and intermediate deck support angles spaced at 6 ft 8 in. from the transverse bridging trusses.

Comment: Spelling error?

Suggestion for Revision: Substitute the word "paired, rather than "pared", or, preferrably, revise to read "A pair of trusses. . . .

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Report Number: NIST NCSTAR 1-1

Page Number: 38
Paragraph/Sentence:

Local Laws are enacted by the NYC Council. Any member can introduce a bill to the Council for the purpose of amending the Building Code requirements. When passed by the Council and approved by the Mayor, the bill becomes a Local Law. The current Building Code was enacted on December 6, 1968. Through 2002, 79 Local Laws were adopted that modified the 1968 Building Code.

Comment: This paragraph is poorly written and needs to be revised.

Suggestion for Revisions: It's not my job to do editorial work.

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Report Number: NIST NCSTAR 1-1

Page Number: 38

Paragraph/Sentence:

To aid the implementation of and to clarify Building Code requirements, New York City issues "rules." Typically these rules are initiated by City Government offices such as the Department of Buildings and the Department of Environment, and issued by the Building Commissioner. The rules do not require enactment by the City Council, and new rules issued by the Building Commissioner can be put into effect expeditiously. The rules, although are not part of the Building code, are required to be complied with for design, construction, and maintenance of buildings.
The 1968 NYC Building Code includes "Reference Standards," including standard test methods published by the American Society for Testing and Materials (ASTM), and design standards published by other organizations such as the American Concrete Institute and the American Institute of Steel Construction. These reference standards may include modifications to the provisions in the published standards, or they may be stand-alone requirements developed by New York City.

At the time the WTC project was begun (early 1960s), the 1938 NYC Building Code, which was first adopted on January 1, 1938, was in effect and enforced throughout the five boroughs. In the late 1950s, it was noted that "great changes have occurred in all facets of the building industry" and that "As a result of these developments, and the failure in many instances, of the Code to keep pace, there had been a growing dissatisfaction with it" (Schaffner 1964). Thus, in 1960, the Building Commissioner requested the New York Building Congress to form a working committee to study the problem. The committee recommended that the Code should not be rewritten by a group of volunteers and that a local educational institution should conduct a study to develop an approach to solve the problem. The Polytechnic Institute of Brooklyn conducted the study, and in July 1961, the Institute made the following recommendations (Schaffner 1964):

Comment: These paragraphs are poorly written and need to be revised.

Suggestion for Revisions: It's not my job to do editorial work.

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Report Number: NIST NCSTAR 1-1

Page Number: 38 and 39

Paragraph/Sentence: Entire section 3.2

Comment: This entire section is poorly written and should be revised.

Suggestion for Revision: Editorial-not my job.

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Report Number: NIST NCSTAR 1-1

Page Number: 41

Paragraph/Sentence: ***While the Port Authority facilities, including the WTC buildings, were not required to undergo review or approval by the NYC Department of Buildings, a letter dated February 18, 1975, from Joseph Solomon of Emory Roth & Sons (the code architect for the towers) to Malcolm Levy, General Manager, World Trade***
Center Operations states, "The Building Department reviewed the tower drawings in 1968 and made six comments concerning the plans in relation to the old code.

Comment: What is a "code architect"?

Suggestion for Revision: Editorial-not my job.

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Report Number: NIST NCSTAR 1-1

Page Number: 141

Paragraph/Sentence:

The codes selected for comparison are laws or nationally or regionally recognized model regulations that reflect the standards of practice of the time. The 1964 New York State Building Construction Code was the governing building code outside the New York City limits. The 1965 BOCA Basic Building Code was typically adopted by local jurisdictions in the northeastern region of the United States. The 1968 NYC Building Code is compared with the 1967 Municipal Code of Chicago (MCC) to see whether there are any substantial differences in the fire safety requirements of the two codes. In the late 1960s and early 1970s, several tall buildings were built in Chicago including the Sears Tower (110 stories) and the John Hancock Tower (100 stories), both of which were classified as business use and incorporated innovative design features. In addition, the 2001 edition of the NYC Building Code was compared with the 1968 version to examine the extent to which Local Laws modified the code provisions, and in most cases, is only addressed in areas where changes occurred between the two versions.

Comment: The sentence "In the late 1960s and early 1970s, several tall buildings were built in Chicago including the Sears Tower (110 stories) and the John Hancock Tower (100 stories), both of which were classified as business use and incorporated innovative design features." doesn't fit in the paragraph. It is just a comment stuck in the middle of the paragraph, but doesn't relate to any of the rest of the paragraph.

Suggestion for Revision: Editorial-not my job.

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Report Number: NIST NCSTAR 1-1

Page Number: 144

Paragraph/Sentence:

"***The structural elements of a building are protected against failure in fire for a specified period, as determined in the ASTM E 119 test. The intent of the fire rating requirements is for the structure as a minimum to withstand design loads (including fire) without local structural collapse until occupants can escape and the fire service can complete search and rescue operations.***"

Comment: This sentence is poorly written and should be revised. The statement regarding "the intent of the fire rating requirements. . . . ." is technically incorrect. As written, this statement applies to all buildings including buildings which are permitted to be unprotected construction.

Suggestion for Revision: Editorial-not my job.

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Report Number: NIST NCSTAR 1-1

Page Number: 145

Paragraph/Sentence:

"***For example, the 1997 Uniform Building Code contains tables of prescribed ratings for specific materials and assemblies which may be depended on as an alternate to ASTM E 119 testing.***"

Comment: The tables of assemblies with fire resistance ratings contained in the 1997 Uniform Building Code referenced in the sentence above are based upon testing per ASTM E119. The statement made in this sentence is in error. (That's embarrassing.)

Suggestion for Revision: This statement should be deleted.

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Report Number: NIST NCSTAR 1-1

Page Number: 146

Paragraph/Sentence:

"***In traditional practice, the architect (sometimes different from the design architect, called the code architect) specifies the fire resistance ratings needed to comply with the building code. The required***
ratings are normally not shown on the architectural drawings (although the construction type may be); rather they are shown in the supporting material submitted to the building department for plans review."

Comment: This statement is factually incorrect. Building codes require that the required fire resistance ratings of various structural elements be shown on the drawings. In addition, building codes require the method to achieve the required ratings be shown on the drawings. Whoever wrote the above sentence apparently isn't involved in building design practice or in code enforcement.

Suggestion for Revision: The entire section 9.1.3 is poorly written and needs to be re-written by a professional actually involved with building code compliance.

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Report Number: NIST NCSTAR 1-1

Page Number: 147

Paragraph/Sentence:

"***There are no code requirements nor general practice by which spray applied fireproofing is inspected over the life of the building.***"

Comment: This sentence is factually inaccurate. Every model building code in use today requirements that all fire safety features required by the code be maintained. Hence, inspections of fireproofing which is required by a building code is required to be inspected to verify compliance with the general requirement that all required fire safety features be maintained.

Whoever wrote this statement appears not to have any experience with building codes.

Suggestion for Revision: The entire section 9.1.3 should be rewritten.

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Page Number: 148

Paragraph/Sentence:

"***The assembly use group includes any place used for the gathering of more than 50 people for civic, social, or religious functions, recreation, food and drink, or awaiting transportation.***"

Comment: This sentence is poorly written.

Suggestion for Revision: The word "place" should be replaced with the phrase "room or space" so that the sentence reads as follows:

"***The assembly use group includes any room or space used for the gathering of more than 50 people for civic, social, or religious functions, recreation, food and drink, or awaiting transportation.***"

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Report Number: NIST NCSTAR 1-1

Page Number: 149

Paragraph/Sentence:

"The requirement for exit stairs to discharge to a public way was the subject of ongoing discussion with respect to the A and C stairs in WTC 1 and WTC 2 terminating at the mezzanine level, which was not at street level but rather at the Plaza level. The Port Authority's position was that the Plaza was a street and the Concourse was an underground street, and that the arrangement met the intent of the Code. NIST found PANYNJ documents indicating that the NYC Department of Buildings agreed with this interpretation (e.g., Solomon 1975), but did not find any documents from the NYC Department of Buildings confirming this. Thus, the issue continued to come up as a variance with the Code as late as 1996 (see Section 11.4)."

Comment: This paragraph is poorly written and should be revised.

Suggestion for Revision: Editorial-not my job. It is suggested that the definition of the "level of exit discharge" contained in the Life Safety Code be discussed. Based upon the little information provided, it appears that the stairs discharge was at the exit discharge level.

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Report Number: NIST NCSTAR 1-1

Page Number: 149

Paragraph/Sentence:

"At the time of construction, sprinklers were primarily for property protection and were rare even in highrise buildings (except for underground spaces)."

Comment: This sentence is either in error or does not convey the meaning intended.

Suggestion for Revision:

"At the time the towers were constructed , sprinkler protection was primarily installed for property protection purposes and was rarely provided in high rise office and residential buildings (except in underground spaces)."

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Page Number: 149

Paragraph/Sentence:

"Requirements for voice systems first appeared in national standards in the mid-1980s (e.g., the 1985 edition of NFPA 72F), at the same time as New York City adopted LL 16-1984."

Comment: This sentence is either factually in error or does not convey the intended meaning. A requirement for the installation of a voice alarm system in high rise buildings was included in the 1975 edition of the BOCA Basic Building Code. It is assumed that the writer is referring to specific installation requirements, rather than requirements for the installation of a voice alarm system in high rise buildings.

Suggestion for Revision: The sentence should be revised to say exactly what the writer means.

From: FPESCHULTE@aol.com
Subject: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1-1

Page Number: 150

Paragraph/Sentence:

"***Prior to 1988 all building codes determined egress capacity by the (22 in.) Units of Exit Width method, which New York City still uses. In 1988, other codes changed to a method involving an allowance of***
width per person which provides credit for non-standard widths of corridors and doors, but for standard dimensioned components yields the same results."

Comment: This statement is factually inaccurate. The Uniform Building Code (UBC) did not use the concept of units of exit width. The UBC utilized a factor of 50 people per foot of egress width and, in actual practice, used inches to determine the required width of an egress component.

Suggestion for Revision: The statement should be revised so that it is factually accurate.

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Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1-1

Page Number: 151

Paragraph/Sentence: Section 10.1, Chapter 10

Comment: It is recommended that the term "smokeproof enclosure" or "smokeproof exit enclosure" be used rather that the term "fire tower".

Suggestion for Revision: Substitute the term "smokeproof enclosure" for the term "fire tower". Add a footnote to indicate that the NYC Code utilizes the term "fire tower".

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Subject: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1-1

Page Number: 152

Paragraph/Sentence:

"***Restaurants, bars, and function rooms are classified in building codes as assembly use, which carries a significant increase in occupant load and consequent provisions for egress. The design occupant load for assembly space is 15 ft2 per occupant as opposed to the 100 ft2 per occupant for the office use on most of the floors. Thus, while the design number of occupants on an office floor was 390, the design number of occupants for these floors was over 1,000 each (the exact number depends on the area of kitchens, dishwashing, and office space on the floor, all of which is at 100 ft2 per occupant).***"

Comment: Very sloppy writing. The paragraph should be revised to "clean up" the language.

Suggestion for Revision: Editorial. Not my job.

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Report Number: **NIST NCSTAR 1-1**

Page Number: **156**

Paragraph/Sentence:

"The concept of using horizontal exits to create areas of refuge was to provide a protected space in which occupants could wait to get into stairs that do not have adequate capacity for the numbers of people. In
the world of post-September 11, 2001, it is unclear whether people will be comfortable waiting in a large queue to enter an egress stair, and what the impact would be of such a large group of people moving
down the stairs on the orderly evacuation of lower floors. The decedent analysis in NIST NCSTAR 1-7 estimates the number of people in Windows on the World at 188. The early hour of the attacks saw much fewer patrons (such as the early arrivals for a breakfast meeting) that would have been expected later in the day. The occupant load would have permitted more than 2,000 people on these two floors, from which there were no survivors."

Comment: It should be noted that the issue of the use of horizontal exits is not addressed in either the recommendations or the findings. If the use of horizontal exits is questionable as indicated above, then the use of horizontal exits should be addressed in both the recommendations and the findings.

Suggestion for Revision: The issue of the use of horizontal exits should be address in both the recommendations and the findings.

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Report Number: NIST NCSTAR 1-1

Page Number: 157

Paragraph/Sentence:

"Fewer than ten people who were present on the observation level perished on September 11th. The number of perople who were present and managed to evaculate is unknown."

Comment: The terms "perople" and "evaculate" should be defined. Most word-processing programs have a "spell checking" program incorporated into the program. It is recommended that this spell checking program be used. I wonder how much this contractor was paid for this portion of the work.

Suggestion for Revision: Correct the misspellings.

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Report Number: NIST NCSTAR 1-1

Page Number: 152-157

Paragraph/Sentence: Sections 10.1.1 and 10.1.2

Comment: The egress analysis only includes an analysis per the NYC Building Code. It is recommended that an analysis per the International Building Code (IBC) and NFPA 5000 also be included. Based upon my calculations, the exit capacity provided by the 3 stairs is 720 people per the IBC and 478 people per NFPA 5000 (and the Life Safety Code).

Suggestion for Revision: Include an exit capacity analysis per the IBC and NFPA 5000.

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Report Number: NIST NCSTAR 1-1

Page Number: 151

Paragraph/Sentence: Section 10.1, Chapter 10

Comment: It is recommended that section 10.1 include an egress analysis for the office floors per the International Building Code (IBC) and NFPA 5000. Based upon my calculations, the 3 stairs serving office floors provided egress capacity for 720 people. The design occupant load of the office floors was only 429 people. Based upon this, the exit capacity of the 3 stairs was 167 percent of the design occupant load of the floors based upon the IBC.

Suggestion for Revision: Include an egress analysis for the office floors based upon the IBC and NFPA 5000.

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Report Number: NIST NCSTAR 1-1

Page Number: 161

Paragraph/Sentence:

"No contemporaneous documentation has been found that provides the rationale for the decision to select Class 1B for the WTC towers. This decision, however, appears to have been made by the architect-of-record on the basis of economics."

Comment: This is a silly statement. If Class 1B was an acceptable construction type, then the decision to utilize Class 1B construction was made because Class 1B construction complied with code requirements.

Suggestion for Revision: At present, the sentences are pointless. Revise the sentences to that they have a point.

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Report Number: NIST NCSTAR 1-1

Page Number: 172

Paragraph/Sentence:

"The 2 in. fuel lines were encased in a second pipe covered with 2 in. of calcium silicate to provide the required 2 h fire rating. Pipe supports were located approximately 10 ft apart, and inspection plugs were provided approximately 50 ft apart. Mechanical equipment rooms were sprinklered (ordinary hazard group I), and the fuel pump room was sprinklered (ordinary hazard group III). The generator area on floor 5 was not sprinklered."

Comment: The term "sprinklered" doesn't sound very professional for a formal report.

Suggestion for Revision: It is suggested that the term "were protected by a sprinkler system" or "were protected by sprinklers" be used in lieu of the term "sprinklered".

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Report Number: NIST NCSTAR 1-1

Page Number: 179

Paragraph/Sentence:

Finding 1: The NYC Department of Buildings reviewed the WTC tower drawings in 1968 and provided comments to the PANYNJ concerning the plans in relation to the 1938 NYC Building Code. The architect-of-record submitted to the PANYNJ responses to those comments, noting how the drawings conformed to the 1968 NYC Building Code. All six comments made by the NYC Department of Buildings dealt with egress issues, but none questioned the large occupant loads for Windows on the World in WTC 1 or Top of the World in WTC 2.

Comment: The above suggests that a review by the NYC Department of Buildings will not necessarily find all of the errors in a design. Hence, comments suggesting that the Port Authority's exemption from compliance with the NYC was a root cause of the collapse of the towers are not logical.

Suggestion for Revision: The above is just an observation. No suggested revisions.

From: FPESCHULTE@aol.com
Subject: Re: WTC Technical Conference
To: wtc@nist.gov

In a message dated 7/12/2005 4:07:56 PM Central Daylight Time, wtc@nist.gov writes:

<< The National Institute of Standards and Technology (NIST) is holding a technical conference on the federal building and fire safety investigation of the World Trade Center disaster on September 13-15, 2005, at its headquarters in Gaithersburg, Maryland.

The objectives are:
· Present the technical foundation for the NIST recommendations for improving building and fire codes, standards, and practices
· Provide a forum for the technical community outside of the investigation team to present their ideas and analyses, with an emphasis on spurring action on the recommendations >>

Ladies and Gentlemen-

"The technical foundation for the NIST recommendations for improving building and fire codes, standards, and practices" was not included in the draft final report releasted by NIST on June 23, 2005. Given this, the public will not have an oppurtunity to comment on the "technical foundation" which will be presented by NIST in its September 13-15 technical conference. It seems reasonable that the public comment period on NIST's draft final report should be extended for 6 weeks beyond September 13-15 conference, rather than terminating on August 4, so that the public has an oppurtunity to comment on the "technical foundation" for NIST's recommendations. Not including NIST's "technical foundation" for the recommendation was a major omission in the draft final report and was a blunder made by NIST, not the public. The public should not be penalized for NIST's blunder.

Richard Schulte
Schulte & Associates
Building Code Consultants
Evanston, Illinois
504/220-7475
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From: FPESCHULTE@aol.com
Subject: NIST Draft Final Report Comment
To: wtc@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1-4

Page Number: xxix

Paragraph/Sentence:

"In the event of a fire in a building, the safety of occupants and first responders and the protection of property is accomplished through a combination of passive and active means."

Comment: This sentence ignores the fact that the building egress system also plays a part in the safety of building occupants.

Suggestion for Revision: The sentence should be revised to include a reference to building egress systems.

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Report Number: NIST NCSTAR 1-4

Page Number: xxix

Paragraph/Sentence:

"A passive fire protection system is one which is an integral part of the building layout and materials of construction, such as partitions to confine the fire, a stairway to assist rapid evacuation, or spray-on fire proofing to increase the fire resistance of a load-bearing steel structure."

Comment: This sentence includes stairways as part of the passive fire protection systems provided in a building. A stairway is not a passive fire protection system. A stair is part of the egress system provided for a building.

Suggestion for Revision: The reference to stairways as part of passive fire protection should be deleted in this sentence.

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To: wtc@nist.gov

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Report Number: NIST NCSTAR 1-4

Page Number: xxix

Paragraph/Sentence:

"Active and passive fire protection systems work together to control the spread of the fire and maintain the integrity of the structure; however, the fire department is always relied upon to fully extinguish the fire and rescue occupants who may be immobilized."

Comment: The sentence suggests that passive fire protection is necessary to control the spread of fire and to maintain the integrity of the building structure in buildings which are protected by an active fire protection system (sprinkler protection). The sprinkler protection is capable of controlling the spread of fire without passive fire protection. Sprinkler protection is also capable of protecting the building structure without passive (structural) fire protection. In addition, sprinkler protection is capable of extinguishing a fire in many cases without the assistance of either passive fire protection or manual firefighting activity and also protecting building occupants in the room or space of fire origin.

Suggestion for Revision: It is suggested that the paragraph be revised to properly describe the capabilities of sprinkler protection.

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Report Number: NIST NCSTAR 1-4

Page Number: xxx

Paragraph/Sentence:

"The evaluation of the sprinklers, standpipes, and preconnected hose systems was performed by subject experts at Hughes Associates, Inc., under contract to NIST."

Comment: It is assumed that NIST retained the services of "subject" experts. Hence, there is no need to describe Hughes Associates, Inc. as "subject experts". (It should be noted that further comments on this section of the report cast some doubt on the expertise of Hughes Associates' personnel assigned to this project.)

Suggestion for Revision: Delete the words "subject experts at" from the sentence.

From: FPESCHULTE@aol.com
Subject: NIST Draft Final Report Comment
To: wtc@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1-4

Page Number: xxx

Paragraph/Sentence:

". . . . and estimated suppression system performance when challenged with design fire scenarios assumed in standard engineering practice as well as with a fire scenario similar to that which occurred on September 11, 2001."

Comment: The report actually addresses the performance of the sprinkler protection installed in the three buildings. Given this, it is suggested that the above sentence be revised to reflect that this is the case.

Suggestion for Revision: The words "suppression system" should be replaced with the word "sprinkler system" in the above sentence.

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Report Number: NIST NCSTAR 1-4

Page Number: xxx

Paragraph/Sentence:

"Flow capacity and duration of water supplies to the installed sprinkler systems were estimated using industry-accepted software."

Comment: It would be assumed by most readers that the hydraulic calculations were done using industry-accepted procedures, including software. Given this, there is no reason to make this statement. The only reason to make a statement similar to the one above is if the hydraulic calculations were done using other than industry-accepted software.

Suggestion for Revision: Delete the sentence.

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Report Number: NIST NCSTAR 1-4

Page Number: xxx

Paragraph/Sentence:

"Hydraulic calculations were performed with variations in primary and secondary water supplies, the number of sprinklers flowing, and floor level elevations."

Comment: The sentence indicates that the floor level elevations were varied. The floor level elevations are fixed by the building construction. What was actually varied was the floors levels.

Suggestion for Revision: The last word in the above sentence should be deleted.

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Report Number: NIST NCSTAR 1-4

Page Number: xxx

Paragraph/Sentence:

"Except for specific areas that were exempted from required sprinkler coverage, sprinklers were installed throughout WTC 1, 2, and 7 on September 11, 2001."

Comment: The above sentence is poorly written

Suggestion for Revision: It is suggested that the above sentence be revised to read:

"Sprinkler protection was installed throughout WTC 1, 2 and 7 on September 11, 2001, with the exception of specific rooms and spaces where sprinkler protection was permitted to be omitted by the NYCBC."

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Report Number: NIST NCSTAR 1-4

Page Number: xxxi

Paragraph/Sentence:

"According to the documentation examined, the fire suppression systems in WTC 1, 2, and 7 were installed, for the most part, in a manner consistent with state-of-the-art practices in existence at the time of their installation. The installations as documented, with several minor exceptions, would satisfy current best practices."

Comment: These sentences need work.

Suggestion for Revision: It is suggested that these sentences be revised to read as follows:

Based upon the documents examined, the fire suppression systems in WTC 1, 2 and 7 appear to have been installed in a manner consistent with accepted engineering practices at the time of their installation, with a few minor exceptions. The installations also appear to comply with current accepted engineering practices, again with a few minor exceptions.

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Report Number: NIST NCSTAR 1-4

Page Number: xxxi

Paragraph/Sentence:

"According to the documentation examined, the fire suppression systems in WTC 1, 2, and 7 were installed, for the most part, in a manner consistent with state-of-the-art practices in existence at the time of their installation. The installations as documented, with several minor exceptions, would satisfy current best practices."

Comment: It is Schulte & Associates' opinion that the use of manually started fire pumps, rather than automatic fire pumps, is a major deviation from accepted engineering practice both at the time of installation and currently. This should not be construed as a criticism of the installation, but rather a criticism of the NYCBC. Given that the Port Authority was not required to comply with the NYCBC, the engineers for the system should have designed the sprinkler and standpipe installations to comply with nationally accepted engineering practice and ignored the local practice.

Suggestion for Revision: The statements made above should be revised to reflect that the use of manually started pumps was not accepted engineering practice at the time of installation, nor currently.

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Report Number: NIST NCSTAR 1-4

Page Number: xxxi

Paragraph/Sentence:

"The installation of the supply piping from the storage tanks on the 110th floor in WTC 1 and WTC 2 resulted in restricted flow capacity to several floors. The flow capacity was sufficient to supply the suppression systems, but the installation was not consistent with current engineering best practices."

Comment:

The statement above makes reference to a flow restriction, but does not provide any explanation as to the nature of the restriction. Given that this section is an executive summary, the reader should not be forced to read throug the entire report for an explanation of the actual problem.

Suggestion for Revision:

It is suggested that the nature of the "restriction" in the piping system be briefly explained at this point in the report. A footnote could be used to provide the explanation.

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Report Number: NIST NCSTAR 1-4

Page Number: xxxi

Paragraph/Sentence:

"The installation of the supply piping from the storage tanks on the 110th floor in WTC 1 and WTC 2 resulted in restricted flow capacity to several floors. The flow capacity was sufficient to supply the suppression systems, but the installation was not consistent with current engineering best practices."

Comment:

The flow restriction referenced in the statement above is a length of 4 inch piping supplying 6 inch risers. It is Schulte & Associates' opinion that this arrangement, while not optimal, complies with accepted engineering practice since, as stated, the water supply to sprinkler/standpipe systems still complied with minimum requirements. Compliance with minimum code requirements in use today should not be considered to be a deficiency.

Suggestion for Revision:

Delete the phrase "but the installation was not consistent with current engineering best practices".

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Report Number: NIST NCSTAR 1-4

Page Number: xxxi

Paragraph/Sentence:

"The suppression systems in WTC 1, 2, and 7 required manual initiation of the electrical fire pumps in order to provide supplemental water."

Comment:

The sentence above makes reference to the "electrical fire pumps".

Suggestion for Revision:

It is suggested that the term "electrical fire pumps" be replaced with either the term "electric fire pumps" or the term "electric-driven fire pumps".

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Report Number: NIST NCSTAR 1-4

Page Number: xxxi

Paragraph/Sentence:

"An automatic supplemental water supply has been required by National Fire Protection Association (NFPA) 14 for some time and represents best practice."

Comment: The meaning of the phrase "for some time" is not clear. Does this mean days, weeks, months, years or decades? Given that the firm contracted by NIST to develop this section of the report is represented by NIST to be a "subject expert", it should be expected that the time frame referred to would have been researched and determined with more accuracy that "for some time".

Suggestion for Revision: This phrase "for some time" should be deleted and replaced with a more accurate time frame reference.

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Report Number: NIST NCSTAR 1-4

Page Number: xxxi

Paragraph/Sentence:

"The supply risers for automatic sprinkler systems in WTC 1, 2, and 7 were configured to provide redundant capabilities. However, the sprinkler floor level controls were installed with one connection to the sprinkler water riser. This represented a single point of failure location for the water supply to the sprinklers on that floor."

Comment: It is Schulte & Associates' understanding that the sprinkler systems in both WTC 1 and WTC 2 were supplied by a single riser (in each zone). Given this, it would be difficult to characterize the design of the risers supplying the piping on each floor as having redundant capabilities.

It should be noted that the vast majority of sprinkler systems (estimated to be in excess of 99%) in multi-story buildings are only provided with one connection to the sprinkler riser and that most sprinkler systems are only supplied by one connection to the municipal distribution system. Given this, the statement that there was only one connection to the riser and that this constituted "a single point of failure" is misleading in that it suggests that this was a deficiency in the installation. Most fire protection systems installed in buildings have a single point failure (i.e. each door which provides access to an exit stair is a potential failure point for the entire stair).

It is not clear why the term "sprinkler water riser" has been used in the statement above.

Suggestion for Revision: The statements above should be revised to be factually accurate and put the design of the system in proper context.

The term "sprinkler water riser" should be replaced with the term "sprinkler riser".

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Report Number: NIST NCSTAR 1-4

Page Number: xxxi

Paragraph/Sentence:

"The water flow capacities of the sprinkler systems installed in WTC 1, 2, and 7 were designed to provide densities considerably greater than typically provided for high-rise office buildings. Based on hydraulic calculations, it was estimated that the sprinkler systems could have controlled a typical fire at a coverage area up to two to three times the specific design area of 1,500 ft 2 . However, a coverage area of 4,500 ft 2 constitutes less than 15 percent of the area of a single floor."

Comment:

The last sentence in this paragraph is an irrelevant fact. (It is assumed that the percentage indicated refers to the floor area of WTC 1 and WTC 2, although this isn't stated.)

Sprinkler systems are designed to control a fire in its incipient stage. A sprinkler system protecting a light hazard occupancy (with relatively low ceilings) is capable of limiting the size of the fire to 100 square feet (or less) when standard sprinklers are utilized. There are no conditions (considered in design) where a fire in a light hazard occupancy should spread to the entire floor (if the sprinkler system has been properly designed and installed and is operating properly).

Suggestion for Revision:

Delete the last sentence in the paragraph above.

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Report Number: NIST NCSTAR 1-4

Page Number: xxxi

Paragraph/Sentence:

"The standpipe and preconnected hose systems were consistent with the applicable requirements in the Building Code of New York City (BCNYC). They were not consistent with the flow rates and durations specified by NFPA 13."

Comment:

The last sentence makes reference to the incorrect standard. The standard which addresses standpipe installations is NFPA 14, not NFPA 13 as indicated. (This error should have been caught by the "subject experts".)

Suggestion for Revision:

Replace the reference to NFPA 13 with a reference to NFPA 4.

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Report Number: NIST NCSTAR 1-4

Page Number: xxxii

Paragraph/Sentence:

"Due to the magnitude of the initial fires and the likely aircraft impact-induced damage sustained to the suppression systems infrastructures in WTC 1 and WTC 2, it is not unexpected that the suppression systems present in these buildings failed to control the fires on September 11, 2001."

Comment:

The term "suppression systems infrastructures" is a very "high-brow" way of referring to the supply piping for the sprinkler and standpipe systems. Using the term "suppression systems infrastructures" is a very pompous way of expressing oneself and appears to be an attempt by the "subject experts" of connoting superiority.

Suggestion for Revision:

The sentence should be revised to be written in a more straight forward and "down-to-earth" manner (so that less intelligent people in the Midwest and South (such as myself) know what the "subject experts" are actually talking about). The sentence could be revised to read as follows:

Due to the damage to the risers supplying the sprinkler and standpipe systems caused by the impact of the aircraft and the magnitude of the fires which occurred, ...

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Report Number: NIST NCSTAR 1-4

Page Number: xxxii

Paragraph/Sentence:

"The evaluation of the fire alarm systems, a review of applicable codes and standards, documentation of the normal operation of fully functional fire alarm systems, and their potential performance in WTC 1, 2, and 7 on September 11, 2001, were performed by subject experts at Rolf Jensen and Associates, Inc., under contract to NIST."

Comment:

Use of the term "subject experts" is a pompous way of expressing oneself.

Suggestion for Revision:

Delete the term "subject experts" from the sentence above.

From: FPESCHULTE@aol.com
Subject: NIST Draft Final Report Comment
To: wtc@nist.gov

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Report Number: NIST NCSTAR 1-4

Page Number: xxxiii and xxxiv

Paragraph/Sentence:

In order to more fully understand the potential impact of smoke management systems within high-rise buildings, multiple smoke management strategies, design fire scenarios, building configurations and weather conditions were analyzed. In total, a set of 180 simulations were performed, and results were evaluated.

The smoke management systems in WTC 1 and WTC 2 were not initiated on September 11, 2001.

Had the smoke purge sequence been initiated in WTC 1 or WTC 2, it is unlikely the system would have functioned as designed, due to damage caused by aircraft impacts.

Even if fully operational, none of the potential smoke management systems evaluated would have prevented smoke spread given the damage caused by aircraft impact.

Comment:

It is Schulte & Associates' understanding that the "smoke management" system installed in the building was designed to be utilized after a fire was extinguished. Given that the fires which occurred in WTC 1 and WTC 2 were never extinguished, the design basis for the "smoke management" systems installed in the towers was exceeded. Hence, it should have been obvious that the "smoke management" systems would not "have prevented smoke spread". Based upon this, there does not appear to a justification for conducting such a detailed analysis (180 simulations) for the "smoke management" portion of the report. It appears that the analysis of the "smoke management" system was really just a "make work" exercise designed to justify a fee, rather than an essential part of the investigation. The money which was used to pay for this exercise could have (and should have) been used to fund more essential fire safety research (e.g. minimum sprinkler densities for residential occupancies).

The portion of the work involving the "smoke management" system should be justified by both the contractor and by NIST.
It is my understanding that Hughes & Associates is involved in research on smoke control systems in high rise buildings for a trade association. It may be

more appropriate for the trade association to pay for Hughes & Associates' work discussed in this report, rather than NIST.

Suggestion for Revision:

None.

From: FPESCHULTE@aol.com
Subject: NIST Draft Final Report Comment
To: wtc@nist.gov

Affiliation: Schulte & Associates

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Report Number: NIST NCSTAR 1-4B

Page Number: 43

Paragraph/Sentence:

Design Bases and Associated Criteria

Comment:

"Bases" are used in baseball and "basis" is used in engineering. What was the hourly billing rate used by this consultant?

Suggestion for Revision:

The titled of this section should be "Design Basis and Associated Criteria".

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Report Number: NIST NCSTAR 1-4B

Page Number: 45

Paragraph/Sentence:

"A smoke curtain or draft stop was installed around the perimeter of the opening and closely spaced sprinklers, 6 ft on center were positioned 12 in. from the opening (PACO 2002)."

Comment:

The term is "smoke curtain" is not used in NFPA 13. A draftstop is used to prevent the movement of heat, not smoke, through a floor opening. (Sprinklers respond to heat, not smoke.)

The term "closely spaced sprinklers" refers to sprinklers spaced 6 feet on centers.

Suggestion for Revision:

Delete the term "smoke curtain".

It is suggested that the sentence be revised to read:

A draft stop was installed around the perimeter. . . . and closely spaced sprinklers (sprinklers spaced 6 ft on centers) were positioned 12 in. from the opening. (PACO 2002).

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Report Number: NIST NCSTAR 1-4B

Page Number: 49

Paragraph/Sentence:

"Swing type check valves where required for all sprinkler systems and were installed as follows:"

Comment:

The report states that swing type check valves where required, however, the drawings of the connection to the sprinkler risers do not show a check valve. Further explanation of the reference to the requirement for check valves at the connection to the sprinkler riser is required.

It should be noted that check valves are installed at the connections to sprinkler risers in multi-story buildings to prevent the floor piping systems in a zone from acting as water storage for systems on lower floors and then activating the water flow indicators when a fire pump starts and begins to refill the floor piping.

Suggestion for Revision:

Additional research and/or information is required.

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Report Number: NIST NCSTAR 1-4B

Page Number: 24

Paragraph/Sentence:

"In the BCNYC, the term "high-rise" refers to any structure over 75 ft in height (Razza and Grill 2005). Such buildings pose a unique challenge for fire suppression since firefighting and rescues for the upper floors must be staged from within the building without the use of aerial ladder or boom trucks for assistance."

Comment:

It should be verified that the definition of the term "high-rise" building is as stated above. Both the International Building Code and the NFPA 5000 define the term "high rise building" as a building where the elevation of the highest occupied floor exceeds 75 feet measured from the lowest level of fire department vehicle access.

It should be noted that as the term is defined in the sentence above, an antenna would be considered to be a high rise. Given this, it should be verified whether the definition of a high rise building makes reference to a "structure or to a "building".

The word "building" is missing after the term "high-rise" in the first sentence.

The term "boom trucks" is slang for the term "elevated platform".

Suggestion for Revision:

It is suggested that the word "building" be added after the word "high rise" in the first sentence above. This sentence should read as follows:

In the BCNYC, the term "high-rise" [building] refers to any building over 75 ft in height (Razza and Grill 2005).

The term "boom trucks" in the second sentence should be replaced with the term "elevated platform" truck or apparatus.

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Paragraph/Sentence:

"Additionally, many building codes have retroactive requirements for existing structures with either specified timelines for compliance or triggers built into the code provisions that require upgrades based on percentages of building construction, modifications, or cost. (High-rise buildings constructed today are required by building codes to have both standpipe and sprinkler systems installed throughout.) Limitations imposed by material costs and the working pressures of pipe, fittings, and equipment limit the ability to design a high-rise building using a single water supply zone. For this reason fire suppression systems for high-rise buildings are usually designed with multiple vertical water supply zones."

Comment:

This entire paragraph is poorly written and should be rewritten.

Suggestion for Revision:

It is suggested that the word "triggers" in the first sentence above be replaced with the word "thresholds".

It is suggested that the words "fire suppression systems" in the last sentence above be replaced with the words "sprinkler and standpipe systems".

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Report Number: NIST NCSTAR 1-4B

Page Number: iii

Paragraph/Sentence:

"The standpipe/pre-connected hose systems were consistent with the applicable requirements of the Building Code of the City of New York, but were not consistent with the minimum flow rates and durations required in National Fire Protection Association 14."

Comment:

The terminology used in this section of the report is inconsistent. The sentence above makes reference to "National Fire Protection Association 14", while in most cases, the report makes reference to NFPA 14.

Suggestion for Revision:

The report should either make reference to National Fire Protection Association 14 or NFPA 14 and be consistent throughout.

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Report Number: NIST NCSTAR 1-4B

Page Number: xxxiii and xxxiv

Paragraph/Sentence:

"This arrangement of the water distribution system provided a near constant pressure for all flows that are normally anticipated for fire protection system demands, with a residual pressure that was nearly identical to the static pressure. Standard practice in New York City was to flow 500 gpm to 750 gpm through the 12 in. and 20 in. mains, respectively. Such flows typically would not cause a recognizable drop in the system pressure."

Comment:

It is suggested that water supply test results actually be used. The sentence "This arrangement of the water distribution system provided a near constant pressure for all flows that are normally anticipated for fire protection systems . . . ." could be interpreted to mean flows of anywhere from 250 gpm to 2,500 gpm. It appears that the capacity of the municipal water supply far exceeded the supply suggested in this sentence.

The meaning of the sentence "Standard practice in New York City was to flow 500 gpm to 750 gpm through the 12 in. and 20 in. mains, respectively." is not clear. The capacity of 12 inch and 20 inch mains far exceeds 750 gpm with reasonable pressure drops, hence, an explanation of this statement should be provided.

Suggestion for Revision:

Clarifications of the statements made above should be added so that the meaning of these sentence is clear to the readers (with fire protection experience).

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Page Number: xxxiv

Paragraph/Sentence:

"In addition to automatic fire sprinkler systems, each building had vertical standpipe systems located in the stairwells. The standpipe systems were configured with four vertical water supply zones and included three standpipe risers in each zone. The standpipes provided fire suppression water to pre-connected hoses located in the stairwells at each floor. WTC 1 and WTC 2 were equipped with standpipe systems which included Class III pre-connected hose stations in all exit stair enclosures and in certain corridors and tenant spaces."

Comment:

The first sentence of this paragraph indicates that the standpipe systems were located in the stairs. This statement is factually in error-only the standpipe riser portion of the standpipe system were located within the stairs.

The paragraph does not indicate the size of the standpipe risers.

The sentence "The standpipes provided fire suppression water to pre-connected hoses . . . ." is rather obvious. The purpose of providing a standpipe system is to provide water used for manual firefighting purposes. Hence, there is no need to indicate that the standpipes "provided fire suppression water" to the hoses.

Suggestion for Revision:

It is suggested that the sentence be revised to read:

Each building was provided with a standpipe system configured with four vertical water supply zones. Each zone included a 6 inch riser in each of the three exit stairs serving the upper floors of the building. The standpipes supplied pre-connected hoses located at each stair landing. Additional pre-connected hose stations were provided in corridors and tenant spaces at various locations in the buildings.

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Report Number: NIST NCSTAR 1-4

Page Number: xxxiv

Paragraph/Sentence:

"Each hose station was equipped with a standpipe hose control valve, a 125 ft long fire hose and a nozzle for use by a trained fire brigade or The Fire Department of the City of New York (FDNY)."

Comment:

This sentence does not indicate the size of the hose connections provided. Nor does this sentence indicate the size and type of the nozzle provided.

Suggestion for Revision:

The sentence should be revised to indicate the size of the hose connections provided and the size and type of nozzles provided. It is also recommended that information regarding the minimum pressure required to operate the nozzle be provided. Information regarding the friction loss in the hose also would be of interest.

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Report Number: NIST NCSTAR 1-4B

Page Number: xxxv

Paragraph/Sentence:

"Fourteen fire department connection (FDC) stations were located at ground level for use by the FDNY to supplement the water supply and pressure to the fire suppression systems in the buildings. Any of the FDC stations could be used to supply the standpipe systems throughout the complex of sprinkler systems in WTC 1 and WTC 2 above the 32nd floor level. Isolation valves were installed between each consecutive FDC station. This provided independent supply and operation of the standpipe systems throughout the WTC complex. Two additional express FDC stations were provided to supply only the sprinkler systems in WTC 1 and WTC 2 above the 32nd floor level, and, two separate FDC stations were provided for the sprinkler systems in WTC 1 and WTC 2 below the 31st floor level."

Comment:

The paragraph above does not indicate the size of the pipe in the fire department connection, nor does the paragraph indicate the number and size of the fire department connection inlets provided.

Information regarding the location (distance away) of the fire department connections with respect to the towers would be of interest. Of interest, would be whether fire department equipment and firefighters supplying the fire department connections would have been damaged or crushed when the towers collapsed.

Suggestion for Revision:

The information should be added to the report.

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Page Number: xxxv

Paragraph/Sentence:

"Fourteen fire department connection (FDC) stations were located at ground level for use by the FDNY to supplement the water supply and pressure to the fire suppression systems in the buildings. Any of the FDC stations could be used to supply the standpipe systems throughout the complex of sprinkler systems in WTC 1 and WTC 2 above the 32nd floor level. Isolation valves were installed between each consecutive FDC station. This provided independent supply and operation of the standpipe systems throughout the WTC complex. Two additional express FDC stations were provided to supply only the sprinkler systems in WTC 1 and WTC 2 above the 32nd floor level, and, two separate FDC stations were provided for the sprinkler systems in WTC 1 and WTC 2 below the 31st floor level."

Comment:

The paragraph above does not indicate the size of the pipe in the fire department connection, nor does the paragraph indicate the number and size of the fire department connection inlets provided.

Information regarding the location (distance away) of the fire department connections with respect to the towers would be of interest. Of interest, would be whether fire department equipment and firefighters supplying the fire department connections would have been damaged or crushed when the towers collapsed.

Suggestion for Revision:

The information should be added to the report.

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Page Number: xxxvi

Paragraph/Sentence:

"An evaluation of the consistency of the system installations with applicable codes and standards provisions and state-of-the-art engineering "best practices" during the time of construction of the buildings was performed for WTC 1, 2, and 7."

Comment:

The above sentence infers that the sprinkler installations in the towers were evaluated based upon standards used during the time the towers were constructed, rather than evaluating the sprinkler installations based upon standards in effect at the time the sprinkler systems were installed.

Suggestion for Revision:

The sentence should be revised to clearly indicate that the portions of the sprinkler systems installed in the 1980's and 1990's were not evaluated based upon standards used in the late 1960's and early 1970's.

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Paragraph/Sentence:

"Current best practices involve demand calculations back to the water supply. This approach, while not required by code at the time of installation, would have identified the excessive friction loss associated with the extended length of horizontal supply pipe located directly under the supply tanks."

Comment:

The above statement is confusing at best and is most likely factually inaccurate. Hydraulic calculations required by NFPA 13 have always required that the sprinkler system demand and the available supply be compared.

Suggestion for Revision:

The sentence above should be revised to clearly indicate the intended meaning.

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Paragraph/Sentence:

"The single supply point at each floor level connection of the sprinkler system to the water supply (i.e., standpipe or riser) represented a single point failure location for the sprinkler systems on that floor. This resulted in an overall reduced operational reliability for the sprinkler systems under conditions where the standpipe was shut down for maintenance or the supply through one riser or standpipe was interrupted."

Comment:

The above sentence implies that the design of the sprinkler system protecting the towers is inherently unreliable, yet there are multiple single point failure locations throughout the design. A single connection to a sprinkler riser in a multi-story building is accepted engineering practice (employed in an excess of an estimated 99 percent of sprinklered buildings). The paragraph seems to imply that more than one set of supply pipes should be provided throughout sprinkler installations to improve the reliability of sprinkler systems.

The first sentence in improperly written. The words "(i.e. standpipe or riser)" refer to the same portion of the piping system-a standpipe is a riser.

Suggestion for Revision:

The paragraph should be revised to reflect the actual operational reliability of sprinkler systems with a single connection to the sprinkler riser.

It is suggested that the first sentence in this paragraph should be revised as follows:

The single supply point at each floor level connection to the sprinkler riser represented a single point failure location for the sprinkler systems on that floor.

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Paragraph/Sentence:

"An automatic supplemental supply has been required in NFPA 14 for some time and represents current best practice."

Comment:

The meaning of the phrase "for some time" is not clear. Does this mean days, weeks, months, years or decades? Given that the firm contracted by NIST to develop this section of the report is represented by NIST to be a "subject expert", it should be expected that the time frame referred to would have been researched and determined with more accuracy that "for some time".

Suggestion for Revision:

This phrase "for some time" should be deleted and replaced with a more accurate time frame reference.

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Page Number: xxxvii

Paragraph/Sentence:

"However, due to the extent of damage to the sprinkler and standpipe infrastructures on September 11, 2001, it is doubtful that an automatic water supply would have significantly improved the performance of the suppression systems in the upper floors of WTC 1 and WTC 2."

Comment:

Rather than refer to the risers as "infrastructure", it is recommended that the risers be referred to as risers. The use of the word "infrastructure", rather than the word "riser", sounds pompous.

Suggestion for Revision:

Substitute the word "risers" for the word "infrastructures" in the above sentence.

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Paragraph/Sentence:

"In some cases intermediate systems were also selected for evaluation because the arrangements of the systems varied as a result of using outside screw and yoke (OS&Y) or pressure reducing type control valves. A commercial computer program, Hydraulic Analyzer of Sprinkler Systems, Version 7.5 (HASS) was used to perform the calculations (HRS 2004). "

Comment:

The meaning of the first sentence is unclear. It is not clear whether the reference to OS&Y valves is intended to mean a valve without a pressure reducing devices or not. If that is what is intended, it is suggested that the reference to OS&Y valve be deleted and the use of the terms "standard control valve" or "control valve without a pressure reducing device" be substituted.

There is no reason to state the name of the computer software program used in the analysis (unless the contractor is receiving a fee for mentioning the name of the program). (Any fee received for mentioning the name of the sprinkler system hydraulics software should be remitted to the taxpayers.) It is assumed that the results of the analysis would be the same if other fire protection hydraulic calculation software was utilized.

Suggestion for Revision:

Clarify the meaning of the first sentence.

Delete the reference to HASS.

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Paragraph/Sentence:

"The primary source of water for the WTC complex was the NYC water distribution system. A complex grid of 20 in. and 12 in. mains surrounded the WTC complex, forming a robust water supply with an average static pressure of 50 psi. Each building was supplied with water from the NYC water distribution system from multiple access points."

Comment:

The term "robust" is an overused term (ever since it was introduced in FEMA WTC report) which has little meaning.

The above sentence indicates that the static pressure in the municipal distribution center is 50 psi, but does not state at what elevation this static pressure is measured. Since the island of Manhattan is not flat, it is assumed that the static pressure varies.

Suggestion for Revision:

It is suggested that the term "highly reliable" be substituted for the term "robust" in the sentence above (if that what the term "robust" is intended to mean).

An elevation at which the static pressure indicated was measured should be included. It is also suggested that the elevation of a reference point in the towers be included so that the indicated static pressure can be related to the elevations of WTC 1 and WTC 2.

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Paragraph/Sentence:

"Hydraulic calculations were performed based on the applicable occupancy hazard classification in NFPA 13 (NFPA 2002). The results of the hydraulic calculations for the Light Hazard Occupancy sprinkler systems in WTC 1 and 2 indicated that the expected supply densities ranged from 0.14 gpm/ft 2 to 0.27 gpm/ft 2 for four open sprinklers. The associated flow rate could be maintained from the primary water supply source for approximately 33 min to 89 min, depending on the location. A density of 0.13 gpm/ft 2 to 0.18 gpm/ft 2 could be maintained for eight open sprinklers for 18 min to 39 min. And a density of 0.10 gpm/ft 2 to 0.15 gpm/ft 2 could be provided for 16 open sprinklers for 10.5 min to 32.7 min."

Comment:

The words "the applicable occupancy hazard classification" have no meaning in the first sentence.

The term "NFPA 13 (NFPA 2002)" is confusing.

The paragraph above does not state whether WTC 1 and WTC 2 were protected by standard response or quick response sprinklers. The paragraph above also does not state whether the WTC 1 and WTC 2 were protected by standard sprinklers or extended coverage sprinklers. This information is required to determine the significance of the other information provided in the paragraph.

Suggestion for Revision:

The term "NFPA 13 (NFPA 2002)" should be replaced by "NFPA 13 (2002 edition)" or "the 2002 edition of NFPA 13".

It is suggested that the first sentence be revised to read as follows:

"Hydraulic calculations were performed based on the requirements contained in the 2002 edition of NFPA 13.

Additional information regarding the type of sprinklers used to protect the towers should be added.

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Paragraph/Sentence:

"The results of the hydraulic calculations for the Light Hazard Occupancy sprinkler systems in WTC 1 and 2 indicated that the expected supply densities ranged from 0.14 gpm/ft 2 to 0.27 gpm/ft 2 for four open sprinklers."

Comment:

The rationale for assuming that 4 sprinklers will operate may not be obvious to all readers of the report.

Suggestion for Revision:

It is recommended that a sentence or two be added to explain why a calculation based upon 4 sprinklers operating be added. This explanation could be added in a footnote.

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Page Number: xli

Paragraph/Sentence:

"Pressure reducing valves were used in all three buildings."

Comment:

The above sentence does not indicate where the pressure reducing valves were installed. The above sentence also does not indicate the pressures allowed by the pressure reducing valves.

Suggestion for Revision:

It is recommended that the location of the pressure reducing valves be indicated. It is also recommended that a statement regarding the pressures allowed by the pressure reducing valves be included.

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Paragraph/Sentence:

"The standpipe systems in WTC 1 and WTC 2 were separate from the automatic sprinkler systems within the protection zones."

Comment:

The above sentence infers that there were separate sprinkler and standpipe systems, when, in fact, both systems shared water storage tanks and pumps. It appears that the intent of this sentence is to indicate that there was a separate riser for the sprinkler system. In other words, the sprinkler supply piping on each floor was not supplied by the standpipe risers.

Suggestion for Revision:

The sentence should be revised to clearly indicate the actual design of the sprinkler and standpipe systems.

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Paragraph/Sentence:

"Hydraulic analyses relied on the minimum delivered density and pressure requirements in NFPA 13, Installation of Sprinkler Systems, as the basic criteria for evaluating the fire control capacity of the sprinkler systems."

Comment:

The above sentence does not indicate which edition of NFPA 13 is being referenced.

It should be noted that NFPA 13 permits a range of densities for each hazard depending upon the assumed area of operation. Hence, a density of less than 0.10 gpm/SF for a light hazard occupancy is not necessarily a deficient system.

Suggestion for Revision:

It is suggested that the statement made in the above sentence be expanded so that the meaning of this statement is clear.

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Paragraph/Sentence:

"It is important to recognize that in NFPA 13, the required densities and pressures are based on the assumption that an installed fire sprinkler system is designed to control a single fire. In addition, in the analyses performed here, small fires were assumed to be approximately the size of the area covered by a four-sprinkler array (i.e., ~ 750 ft 2). In fact, available performance history indicates that typical fires in high-rise office buildings are controlled or suppressed by less than four sprinklers, lending conservatism to the estimates of system capacity presented here."

Comment:

The second sentence in this paragraph makes reference to "small fires . . . approximately the size of the area covered by a four-sprinkler array. It should be noted that the size of the fire and the area protected by 4 sprinklers are two different concepts. A fire which is only 25 SF in area could activate 4 sprinklers, depending upon the location of the fire with respect to the sprinklers. Hence, the statement should differentiate between the size of the fire and the area protected by operating sprinklers.

Suggestion for Revision:

Revise the second sentence so that the difference between the size of the fire and the area protected by operating sprinklers is clearly differentiated.

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Paragraph/Sentence:

"The calculations identified limits of performance; however, these estimated limits were significantly greater than the limits associated with the requirements in NFPA 13. The available densities and pressures indicated that the installed systems generally exceeded the minimum requirements in NFPA 13 by significant margins."

Comment:

The first and second sentences above essentially mean the same thing. One of these two sentences can be eliminated.

Suggestion for Revision:

It is suggested that the above sentences be revised to read:

The calculations identified limits of performance; however, these estimated limits were significantly greater than the minimum design density requirements contained in NFPA 13 (2002 edition).

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Paragraph/Sentence:

"These systems would have been expected to control multiple small fires or single large fires up to two or three times the sprinkler system design area, and would have been considered robust installations with considerable excess capacity. At the same time, if large fires were to open all of the sprinklers in an area equivalent to . . . . .

Comment:

The term "robust" is an overused term (ever since it was introduced in FEMA WTC report) which has little meaning.

Suggestion for Revision:

The term "robust" should be replaced by another term. The terms "strong" or "overdesigned" might be used as a substitute for the term "robust".

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Page Number: xlii

Paragraph/Sentence:

"And, although these fire areas would be considered relatively large (i.e., 3,000 ft 2 to 4,500 ft 2), they only represented roughly 8 percent to 15 percent of the occupied floor areas in WTC 1, 2, and 7."

Comment:

The sentence above makes reference to "fire areas". The areas being discussed are not "fire areas", but rather "operating areas" for sprinklers. It is key to differentiate between the size of the fire and the size of the operating area.

The last phrase compares the size of the operating areas to the size of the floors. This information is of no interest since the design of a sprinkler system assumes that only a limited number of sprinklers will operate.

Suggestion for Revision:

The term "operating areas" should be substituted for the term "fire areas". The comparison between the operating areas and the size of the floors should be eliminated.

From: FPESCHULTE@aol.com
Subject: NIST Draft Final Report Comment
To: wtc@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1-4B

Page Number: xlii

Paragraph/Sentence:

"Flow restrictions existed in the mid-level water supply zones in WTC 1 and WTC 2, but the limits of available water flow were still considerably higher than those required in NFPA 13 for control of typical light hazard occupancy fires."

Comment:

This sentence makes the reader aware of a flow restriction, but does not elaborate or give any clues as to what the restriction is.

Suggestion for Revision:

This sentence should be revised to give the reader at least some information as to the reason for the flow restriction referenced.

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Report Number: NIST NCSTAR 1-4B

Page Number: xlii

Paragraph/Sentence:

"The booster pump on the 46th floor was undersized and could not provide the higher minimum flow and pressure required in NFPA 14, Standard for Installation of Standpipe, Private Hydrants and Hose Systems (NFPA 2000)."

Comment:

The sentence above does not state the reason why the booster pump is undersized. The reader is not sure whether the problem is a volume problem or a pressure problem, or both. Also the reader is left to wonder whether the determination that the pump is undersized is based upon a required pressure of 100 psi or 65 psi at the standpipe connections. A discussion of the pressure requirements for the nozzles used by the FDNY may be appropriate.

Suggestion for Revision:

Additional information has to why the booster pump is considered to be undersized should be provided.

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Report Number: NIST NCSTAR 1-4B

Page Number: xliii

Paragraph/Sentence:

"However, the focus of this analysis was limited to areas where the suppression system would have sustained damage to their infrastructures (i.e., risers and standpipes). This was primarily limited to the core areas of the buildings. "

Comment:

No explanation as to why the analysis was limited to the damage of the infrastructure is provided. It is likely that sprinklers, branch line piping and cross main piping was also damaged. This sentence also does not indicate why the effects of the "fireball" have not been addressed. It seems likely that the "fireball" would have operated sprinklers on the floors where the "fireball" originated (assuming that the sprinklers were not damaged by the impact).

Suggestion for Revision:

An explanation of why damage to the sprinklers, branch line piping and cross mains was not addressed should be included. An explanation of why the operation of sprinklers caused by the "fireball" also is not addressed should be included.

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Report Number: NIST NCSTAR 1-4B

Page Number: xliv

Paragraph/Sentence:

"The collapse of WTC 2 impacted the fire protection systems in WTC 1 as a result of the damage incurred to the sub-grade sprinkler and standpipe loops and damage caused by vibration and pressure waves. In addition, the collapse of WTC 2 damaged the NYC water distribution system near WTC 2 (Beyler 2002). The configuration of the water supply system minimized any initial impact to the fire protection systems in WTC 1 and WTC 7."

Comment:

It is recommended that the impact on the water system be addressed further. It would seem that broken 12 and 20 inch water mains would have a significant impact on the site water supply, regardless of the capacity of the municipal distribution system.

Suggestion for Revision:

Additional information on the impact on the integrity of the municipal distribution system should be provided.

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Report Number: NIST NCSTAR 1-4B

Page Number: xlvi

Paragraph/Sentence:

"The standpipe/pre-connected hose systems in WTC 1 and WTC 2 were supplied by storage tanks and the underground loop. The hose stations were Class III hose stations with 125 ft of hose and a nozzle for use by the fire brigade and/or the FDNY."

Comment:

No information on the nozzles is provided. Were the nozzles straight tip, fog nozzles or combination nozzles? What was the minimum operating pressure of the nozzles?

Suggestion for Revision:

Information on the nozzles should be included in this sentence.

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Report Number: NIST NCSTAR 1-4B

Page Number: xlvii

Paragraph/Sentence:

"The installation of the supply piping from the storage tanks on the 110th floor in WTC 1 and WTC 2 resulted in restricted flow capacity to several floors in the mid-level water supply zones in both buildings. While the flow capacity was sufficient to supply the sprinkler and standpipe systems, the installation was not consistent with engineering best practices at the time of the installation."

"No information was found to indicate that the standpipes were in excessive use on September 11, 2001."

Comment:

The statements above are contained in two separate paragraphs, however, these statements are related. The fact that the standpipe systems were not used extensively means that the any perceived flow restriction was immaterial.

Based upon my knowledge and understanding of the incident, it is my impression that the standpipe systems in WTC 1 and WTC 2 were not used at all. The statement above infers that the standpipe system were utilized. Documentation as to the use of the standpipe systems by the FDNY should be provided if it exists.

Suggestion for Revision:

It is suggested that the information on the use of the standpipe system be included in the paragraph on the flow restriction since this information is pertinent in determining whether the flow restriction is an important fact or simply irrelevent.

It is suggested that the words "excessive use" be replaced with the words "extensively used".

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Report Number: NIST NCSTAR 1-4B

Page Number: xlviii

Paragraph/Sentence:

"The systems were "control" type sprinkler systems and were phased in from 1983 to early 2001 (GC Engineering 1998). (Note that some systems were installed in the sub-grade levels when the buildings were built and others were installed around 1976 to protect core areas, maintenance areas, and select tenant spaces of the buildings.) The sprinkler systems in WTC 1 and WTC 2 were supplied by vertical risers located in the stairwells. In WTC 7, the risers were located in janitor's closets and wet columns supplied from gravity fed storage tanks above each of four supply zones (Syska & Hennessy 1984). The supply to all three buildings was supplemented by the underground water supply main that looped the WTC complex."

Comment:

Since WTC 1, WTC 2 and WTC 7 were office buildings, with sprinkler protection installed beginning in the 1980's, it would be assumed that the sprinkler protection installed would be the "fire control" systems. Hence, the reference to ""control" type sprinkler systems" sounds "high-brow".

The term "phased in" in the first sentence above doesn't sound good.

There is no need to refer to risers as "vertical risers" in the third sentence since risers are vertical.

The fourth sentence above uses the term "wet columns". The fire protection term for a "wet column" is a riser.

Suggestion for Revision:

The words ""control" type sprinkler systems and " in the first sentence above should be deleted.

It is suggested that the words "phased in" in the first sentence be replaced by "were installed over the course of years, from 1983 to 2001".

The words "vertical risers" in the third sentence above should be replaced with the word "riser".

The words "wet columns" in the fourth sentence above should be replaced by the word "risers".

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Page Number: xlviii

Paragraph/Sentence:

". . . . .Water flow density and pressure associated with the installed systems had the capacity to control a single fire on the order of two to three times the sprinkler system design area, depending on the location in the building, and the systems would be expected to concurrently control at least four to six fires similar in area to that protected by a four-sprinkler array (i.e., 750 ft 2). While these systems were considered very robust, a coverage area of two or three times the design area of the sprinkler system constituted less than 15 percent of the floor area of a typical single floor in these buildings."

Comment:

The term "robust" is a term which is overused and has very little meaning. The use of this term sounds "high-brow" and pompous.

The area of assumed sprinkler operation versus the total floor area is of no interest.

Suggestion for Revision:

The term "robust" should be replaced with a more descriptive term.

The last sentence in the paragraph above should be deleted.

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Report Number: NIST NCSTAR 1-4B

Page Number: xlix

Paragraph/Sentence:

"The intensity and extent of the initial fires in WTC 1 and WTC 2 on September 11, 2001 were considerably greater than two to three times the specified design areas and involved multiple floors. While there was no way to confirm the extent of the initial fires, it is likely that had the systems remained operable a large number of sprinklers would have been opened on multiple floors. Once the number of open sprinklers exceeded an area equivalent to two or three times the design areas, the system's ability to control the fire would have been reduced, and the duration of the primary water supply would have rapidly degraded. Furthermore, the likely damage to the suppression systems in WTC 1 and WTC 2 due to the aircraft impacts and the subsequent failures of structural components virtually ensured that significant parts of the systems were rendered inoperable, regardless of the extent of the initial fires."

Comment:

It is not clear whether the reference to "the initial fires" in the paragraph above is intended to reference the "fire balls" which erupted from the buildings. The report does not seem to discuss the impact of the "fire balls" on the operation of sprinklers.

Suggestion for Revision:

It is suggested that the issue of the impact of the "fire balls" which erupted from the building on the operation of sprinklers be discussed in the report.

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Report Number: NIST NCSTAR 1-4B

Page Number: xlix

Paragraph/Sentence:

"Although consistent with applicable codes, the typical floor level sprinkler system was installed with only one connection to the infrastructure riser. This arrangement provided a single point of failure of the water supply to the floor level sprinklers."

Comment:

The words "infrastructure riser" in the first sentence above is a "high-brow" way of referring to the sprinkler riser and sounds pompous.

The point that a single connection to the sprinkler riser is a potential " single point of failure" seems to infer a problem with the design of sprinkler systems. A single connection to the water supply is also a potential "single point of failure". A single point of failure will not necessary be eliminated by looping supply piping to two risers because, if one riser breaks, the break may have such a significant impact on the water supply that providing the second connection will not provide any additional reliability.

Suggestion for Revision:

It is suggested that the words "infrastructure riser" be replaced by the words "sprinkler riser".

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Report Number: NIST NCSTAR 1-4B

Page Number: xlix

Paragraph/Sentence:

"Even if the sprinkler systems had been designed to protect much higher hazard levels (i.e., Ordinary Group II or Extra Hazard), the magnitude of the fires experienced in these buildings, as well as accompanying impact damage, would have most likely resulted in the fires not being controlled."

Comment:

Since the sprinkler systems in WTC 1 and WTC 2 were damaged by the impact of the aircraft, speculation has to whether or not the sprinkler system would have controlled the fires if the system had been designed for an extra hazard occupancy is irrelevant. The sprinkler systems were damaged-end of story.

Suggestion for Revision:

Delete this paragraph.

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Report Number: NIST NCSTAR 1-4

Page Number: xlix

Paragraph/Sentence:

E.10 LIMITATIONS

"There was very little eyewitness or communications information regarding the performance of the fire suppression systems on September 11, 2001. The descriptions of the systems and their inherent operational capabilities described in this report are considered reasonably accurate. The performance of the individual suppression systems on September 11, 2001 was based on review of the incident information accumulated by NIST, analysis of the likely initial impact effects on the systems, and historical performance records for automatic sprinklers. Where possible, significant events and/or effects were determined based on information from more than one source. However, due to the fragmentation of available information regarding the events of September 11, this could not always be accomplished. Descriptions of suppression systems, likely events or actions, and subsequent effects were based on, and/or deduced from, available information. Events or effects that were considered "likely" or "probable," based on the accumulated information, were considered appropriate for inclusion."

Comment:

Section E.10 is the most important caveat of this section of the report and should be included in the executive summary. This section should be the first section in the report, not the last section.

It is noted that this section does not include a discussion of the settings of the pressure reducing valves. Most of the analysis in this section of the report is dependent upon the assumption that the pressure reducing valves setting is 160 psi. If the settings on the pressure reducing valves was less than 160 psi, then much of the analysis included in this section of the report is no longer valid. It appears that no attempt to verify that the settings on the pressure reducing valves was 160 psi. If a supplier of the valves was located, it may have been possible to verify whether the assumption made in this analysis was actually factual. It's possible that most of the analysis presented in this section of the report is erroneous. Suggestion for Revision:

Section E.10 should be included in the executive summary. This section should be the first section in this section of the report, not the last section.

A discussion of the process by which the settings of the pressure reducing valves was documented should be included in this section.

From: FPESCHULTE@aol.com
Subject: Fwd: NIST Draft Final Report Comment
To: wtc@nist.gov

Ladies and Gentlemen-

It appears that the pressure reducing valve referred to below are the PRV's in WTC 7, not WTC 1 and WTC 2.

Richard Schulte
Return-path: <FPESCHULTE@aol.com>
From: FPESCHULTE@aol.com
Full-name: FPESCHULTE
Message-ID: <d2.2d05b8ca.300d2c05@aol.com>
Date: Mon, 18 Jul 2005 12:00:05 EDT
Subject: NIST Draft Final Report Comment
To: wtc@nist.gov
MIME-Version: 1.0
Content-Type: text/plain; charset="US-ASCII"
Content-Transfer-Encoding: 7bit
X-Mailer: AOL 5.0 for Windows sub 124

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Report Number: NIST NCSTAR 1-4

Page Number: xlix

Paragraph/Sentence:

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A discussion of the process by which the settings of the pressure reducing valves was documented should be included in this section.

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Report Number: NIST NCSTAR 1-4B

Page Number: 9

Paragraph/Sentence:

"As an interstate compact under the U.S. Constitution, the Port Authority was not subjected to any state or local building codes."

Comment:

This sentence reads poorly.

Suggestion for Revision:

Revise the above sentence to read as follows:

"As an interstate compact permitted under the U.S. Construction, the Port Authority is not required to comply building codes adopted by either state of local governments."

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Report Number: NIST NCSTAR 1-4B

Page Number: 14

Paragraph/Sentence:

"Only those directly exposed to the fire actually operate and discharge water.
"

Comment:

The above sentence is factually inaccurate. Sprinklers are activated by heat (high temperatures), not fire.

Suggestion for Revision:

It is suggested that the sentence be revised to read as follows:

Only sprinklers exposed to the high temperatures generated by the fire actually operate and discharge water.

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Report Number: NIST NCSTAR 1-4B

Page Number: 15

Paragraph/Sentence:

"A dry-pipe sprinkler system contains pressurized air or nitrogen within the pipes."

"To limit the time delay between the operation of the first sprinkler and the application of water, building codes require that all dry-pipe sprinkler systems provide water to the inspector's test connection at the most remote area within a specified period of time, usually 60 s."

Comment:

In my 29 years in the fire protection field, I have yet to see a dry pipe system which contains pressurized nitrogen. Given this, the sentence above indicating that dry pipe systems are filled with nitrogen is misleading.

Building codes typically require that sprinkler systems comply with the requirements contained in NFPA 13. Given this, the second sentence above gives the false impression that building codes address the design of sprinkler systems, rather than NFPA 13.

Suggestion for Revision:

It is suggested that the first sentence above be revised to read as follows:

The overhead portion of a dry-pipe sprinkler system is typically filled with pressurized air.

It is suggested that the second sentence above be revised to read as follows:

NFPA 13 limits the size and configuration of the overhead portion of dry pipe systems to limit the time delay between the operation of a sprinkler and the discharge of water spray from the system.

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Report Number: NIST NCSTAR 1-4B

Page Number: 15

Paragraph/Sentence:

"With dry-pipe sprinkler systems, a larger number of sprinklers are expected to open as a result of the delay associated with the operation of the dry-pipe valve and the transport time for water to reach the location of the open sprinklers."

Comment:

The use of the words "transport time" is a "high-brow" way of making this statement.

Suggestion for Revision:

It is suggested that the sentence above be revised to read as follows:

". . . .with the operation of the dry-pipe valve and the time it takes for water to flow to the sprinklers which have operated."

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Report Number: NIST NCSTAR 1-4B

Page Number: 15 and 16

Paragraph/Sentence:

Non-interlocked Pre-action Systems

Non-interlocked pre-action systems require a sprinkler to open or a detection device to activate before water can be admitted to the piping system. This system is very similar to a dry-pipe sprinkler system in that a single sprinkler opening will admit water to the system, and water will flow from the sprinkler. However, there is an advantage with the incorporation of detectors for actuation. Smoke detectors are typically installed in pre-action system arrangements. Due to the more rapid response of smoke detectors than thermally actuated sprinklers, water will usually be admitted to a sprinkler system much sooner. Then, if the fire continues to grow in size to a point when sprinkler actuation occurs, water application is nearly immediate once the remaining air escapes from the system. However, if a fire grows rapidly, asingle sprinkler could actuate quickly, whereby water application commences similarly to a dry-pipe system. In this type of system, the air must be maintained and monitored at a minimum air pressure of 7 psi (NFPA 13 2002). The valve is set to open pneumatically if the air pressure drops below a certain threshold or electrically if the detection device activates.

Single Interlocked Pre-action Systems

Unlike a non-interlocked pre-action system, the single interlocked system will only admit water into the system upon activation of the detection device. The advantages of this type of system are similar to the non-interlocked system except the air in the sprinkler piping is at atmospheric pressure. When the appropriate detection device activates, the water immediately fills the entire system. The system then essentially becomes a wet-pipe system. When the fire grows to a point that results in sprinkler actuation, the sprinkler actuates, and the system provides immediate water application to the fire, similar to a wet-pipe system. Another advantage is that the activated smoke detector will bring attention to the fire for possible control and extinguishment prior to sprinkler actuation. A disadvantage is that the sprinkler system is subject to the reliability of the detection system to open the valve.
Double Interlocked Pre-action Systems

A double-interlocked pre-action system is a combination of both single and non-interlocked systems. The pre-action valve will only admit water to the sprinkler piping upon activation of the detection system and actuation of a sprinkler. In this type of system the detectors send a signal to a releasing panel, which transmits a signal, causing the pre-action valve to open. These systems are maintained at a minimum supervisory pressure of 7 psi. The panel is set such that the valve will not open until the air pressure drops below a certain threshold due to the opening of a sprinkler. This type of system has a major advantage in sensitive areas such as computer rooms or other areas with high value electronics or other electrical components. The only way for water to enter the pipe is if a fire is large enough to activate a smoke detector and actuate a sprinkler. A major concern in these types of applications is leaks and inadvertent discharges. Even if there is a leak in the piping or a sprinkler is damaged and opens for any reason, water will not enter the system until the detection device is activated.

Comment:

The paragraphs above are not necessary. This report is not intended for readers who are trying to learn about sprinkler installations. There are better sources of information on the basics of sprinkler systems that this report.

Suggestion for Revision:

Delete these paragraphs.

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Report Number: NIST NCSTAR 1-4B

Page Number: 17

Paragraph/Sentence:

"The general premise in the design of these types of sprinkler systems is to define a hazard imposed by the occupancy use of the area served and to design the sprinkler system to control the fire to the room or area of origin. Based on the specified occupancy hazard(s), a minimum water spray density and a minimum area of sprinkler operation must be determined."

Comment:

The sentences above are poorly written.

Suggestion for Revision:

It is suggested that the sentences above be revised to read:

The general approach used in the design of these types of sprinkler systems is to determine the hazard classification of the spaces protected by the system. The hazard classification determines the minimum water spray density and an assumed minimum area of sprinkler operation to be used as input for hydraulic calculations. Hydraulic calculations are used to determine the hydraulic demand (flow and pressure) for the system.

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Report Number: NIST NCSTAR 1-4B

Page Number: 17

Paragraph/Sentence:

"Based on the specified occupancy hazard(s), a minimum water spray density and a minimum area of sprinkler operation must be determined."

"Designs using this type of approach have existed for decades, originally in the form of pipe schedule systems and now also in the form of hydraulically calculated systems. This approach has been developed based on many years of fire testing and associated analyses."

Comment:

The two sentences above do not agree. The first sentence above indicates that the occupancy hazard classification is used to determine the water spray density and a minimum area of sprinkler operation. The second sentence above makes reference to a design method using the pipe schedules. The pipe schedule method of design does not directly utilize density or area of sprinkler operation.

Suggestion for Revision:

The sentences above should be revised so that they are in agreement with one another.

Consideration should be give to deleting this material. The material is too general to be of any use to anyone.

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Report Number: NIST NCSTAR 1-4B

Page Number: 18

Paragraph/Sentence:

3.2.5 Pipe Schedule Design Method

The term pipe schedule refers to a prescriptive design method utilizing predefined tables (schedules) of pipe sizes to be used to design sprinkler systems. The pipe schedule method requires the system designer to compare the actual building use to the examples for each of the occupancy hazards identified in NFPA 13. Three separate pipe schedules were formulated to encompass a variety of fire hazards and occupancy uses. These groupings are referred to as Light, Ordinary, and Extra Hazard Occupancies. The design of sprinkler systems in the late 1960s and early 1970s using the pipe schedule method was subjective and required approval from the authorities having jurisdiction. The pipe schedule method is often referred to as the "cookbook" design approach due to the simplicity of its use and the ability to pull required information from tabulated data for each of the Occupancies. Separate tables for each occupancy hazard group include the listing of the maximum number of sprinklers that can be supplied by each pipe size (diameter) for both steel and copper pipe.

3.2.6 Hydraulic Calculation Design Method

Modern designs using hydraulic calculations and the occupancy hazard fire control approach are based on the minimum performance criteria specified in NFPA 13 for the particular occupancy hazard groups contained within the building or area. Designs using hydraulic calculations and variations of this methodology have been commonly used since the early 1970s. This design method requires identifying the particular occupancy hazard as identified above and obtaining the minimum required application density and design area from the figure provided in NFPA 13. The application or discharge density refers to a water flow rate over a unit area. Densities are described in units of gallons per minute per square foot (gpm/ft 2). Design areas are described in units of square feet or square meters in metric units. The density is used to specify the minimum flow rate to be discharged from an individual sprinkler, the minimum "end sprinkler" conditions, and the minimum flow rate required for the system. By multiplying the distance between sprinklers along a branchline and the distance between branchlines, the sprinkler coverage area is obtained. Then by multiplying the density by the coverage area per sprinkler, the minimum required flow rate is determined. This is used to define an end sprinkler condition, which is then used as the starting point in the hydraulic calculations. Chapter 6 includes a more detailed discussion of the hydraulic calculation design method as it applied to WTC 1, 2, and 7. As an illustration, Fig. 32 depicts typpical area/density curves taken from the 1987 edition of NFPA 13. While the design curves have been modified in more recent editions of NFPA 13, the curves in Fig. 32 did not change over the period of time when the sprinkler systems in WTC 1, 2, and 7 were designed and installed.

Comment:

The paragraphs above are too general to be of any use to anyone. Readers without a background in fire protection will not read the above information and readers with a background in fire protection either already know the information or will know where to find more detailed and informative sources for this information.

It's hard to believe that we spent taxpayer funds on the above.

Suggestion for Revision:

The paragraphs above should be deleted.

From: FPESCHULTE@aol.com
Subject: NIST Draft Final Report Comment
To: wtc@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1-4B

Page Number: 20

Paragraph/Sentence:

"The primary causes for failure to achieve fire control in sprinklered buildings, which is infrequent, include partial, antiquated, poorly maintained, or inappropriate systems, and explosions or flash fires that overpower the system before the sprinklers can react (Rohr 2003)."

Comment:

The #1 cause of sprinkler system failure is a closed water supply valve. The list above does not include the #1 cause of sprinkler system failure.

The phrase "which is infrequent" appears to be "stuck into" this sentence.

Suggestion for Revision:

The list of reasons for sprinkler system failure should be revised to include the #1 cause for failure.

The phrase "which is infrequent" should be deleted since the topic is addressed in detail in paragraphs above.

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Report Number: NIST NCSTAR 1-4B

Page Number: 20

Paragraph/Sentence:

"Typically, standpipe systems for high-rise buildings consist of vertical pipe risers with hose connections at each floor. The systems are supported by control valves and pumps and have fire department connections at the street."

Comment:

Standpipe systems are typically supported by pipe hangers, not control valves and pumps. Control valves, pumps and fire department connections are integral parts of a standpipe system. The use of the term "supported by" in the second sentence above is an attempt to be "high-brow" and is pompous.

Suggestion for Revision:

It is suggested that the sentence above should be revised as follows:

Standpipe systems provided for high-rise buildings consist of risers with hose connections at each floor supplied by pumps and at least one fire departments connection.

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Report Number: NIST NCSTAR 1-4B

Page Number: 20

Paragraph/Sentence:

"While the Building Code of the City of New York (BCNYC) does not reference NFPA 14 specifically, the recognized types and classifications of standpipe systems, as well as associated requirements in the BCNYC have been cconsistent with those found in NFPA 14."

Comment:

The word "consistent" is properly spelled with only one "c". The spell checking program in a word processing program would have found this error. If the report was edited properly this spelling error would also have been found. (How much was this contractor paid to do this report?)

Suggestion for Revision:

The word "consistent" should be spelled properly.

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Report Number: NIST NCSTAR 1-4B

Page Number: 21

Paragraph/Sentence:

"Hose valves are required in all exit stair enclosures and throughout all portions of a story or building section, such that all portions of the building are within 30 ft of a nozzle at the end of a 100 ft hose."

Comment:

If I recall correctly, the requirement for the location of hose valves was changed about 10 years ago. Based upon the requirements contained in recent editions of NFPA 14, hose valves for Class I standpipe systems are now only required in exit stair enclosures and at horizontal exits. Additional hose valves are no longer required so that all portions of a building can be reached with a 100 feet of hose and a 30 foot stream. (The technical accuracy of this comment should be verified.)

Suggestion for Revision:

Delete the portion of the sentence which reads ". . . and throughout all portions of a story or building section, such that all portions of the building are within 30 ft of a nozzle at the end of a 100 ft hose."

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Report Number: NIST NCSTAR 1-4B

Page Number: 21

Paragraph/Sentence:

"The basis of design for Class I and Class III standpipe systems specify a performance requirement of 500 gpm at 100 psi to be supplied to the most hydraulically remote standpipe and 250 gpm at 100 psi to be supplied to each additional standpipe up to a maximum of 1,250 gpm. This performance requirement anticipates the use of two 2 ½ in. hose lines connected to the most remote standpipe and an additional hose line connected to each of the other standpipes. The term remote refers to hydraulic remoteness and not physical or spatial remoteness. The most hydraulically remote standpipe is the standpipe that requires the highest initial pressure to provide the specified flow and pressure to the end standpipe valve. The energy lost to friction as a result of water moving through the pipe increases the initial pressure. This could be the standpipe valve located on the top floor of a building or at the farthest end of a building from the water supply. The configuration of the system, including diameter of pipes, changes in elevation, and changes in direction, affects the amount of energy (pressure) required to meet the performance requirement of the system. For this reason, an analysis is typically performed to determine the hydraulically most remote standpipe (NFPA 14 2000; Cote 2003)."

Comment:

The term "hydraulically remote" is a slang term for the term "hydraulically most demanding".

If I recall, the maximum standpipe system demand of 1,250 gpm applies to standpipe systems in buildings protected throughout by a sprinkler system. The maximum standpipe system demand in unsprinklered buildings is higher. Given that WTC 1 and WTC 2 were originally designed without sprinkler protection, it would be a good idea to note that the maximum standpipe system demand of 1,250 gpm applies to sprinklered buildings.

Suggestion for Revision:

It is suggested that the term "hydraulically remote" be replaced with the term "hydraulically most demanding".

It is suggested that it be noted that the maximum standpipe system demand of 1,250 gpm only applies to sprinklered buildings.

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Report Number: NIST NCSTAR 1-4B

Page Number: 23

Paragraph/Sentence:

"Codes and standards are developed as a guide for the design and installation of building systems."

Comment:

The above sentence is factually inaccurate. When codes and referenced standards are adopted by a governmental jurisdiction, the codes and standards become mandatory. In other words, codes and standards adopted by governmental jurisdictions are not intended to be used as "guides", but rather represent minimum legal requirements for design and installation of systems intended to be regulated by the codes and/or standards.

Suggestion for Revision:

The above sentence should be revised to indicate that codes and standards which are adopted by governmental jurisdictions are considered to be legal minimums.

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Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1-4B

Page Number: 35

Paragraph/Sentence:

"A single fire (booster) pump was provided in each tower at the 108th floor level for the high zone sprinkler systems and the hose racks located on the 110th floor level."

Comment:

The term "hose racks" is a term used in the fire protection industry. The pump actually supplied the hose connections and hose.

Suggestion for Revision:

It is suggested that the term "hose connections" be substituted for the term " hose racks" in the above sentence.

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Report Number: NIST NCSTAR 1-4B

Page Number: 38

Paragraph/Sentence:

"A single standpipe riser was provided in each of the three exit stair enclosures of both towers."

Comment:

The above sentence does not indicate the size of the standpipe risers.

Suggestion for Revision:

It is suggested that the size of the standpipe risers be indicated.

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Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1-4B

Page Number: 25

Paragraph/Sentence:

Sprinkler System Code Provisions, WTC 1 and WTC 2

Sprinkler System Code Provisions, WTC 7

Comment:

The meaning of the title for these sections is not clear.

Suggestion for Revision:

It is suggested that the title of this section be revised to read as follows:

Code Provisions for Sprinkler System Installations, WTC 1 and WTC 2

Code Provisions for Sprinkler System Installations, WTC 7

or

Code Provisions for Sprinkler Protection, WTC 1 and WTC 2

Code Provisions for Sprinkler Protection, WTC 7

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Report Number: NIST NCSTAR 1-4B

Page Number: 26

Paragraph/Sentence:

Standpipe System Code Provisions, WTC 1, 2, and 7

Comment:

The meaning of this title is not clear.

Suggestion for Revision:

It is suggested that the title read as follows:

Code Provisions for Standpipe System Installations, WTC 1, 2, and 7

From: FPESCHULTE@aol.com
Subject: Fwd: NIST Draft Final Report Comment
To: wtc@nist.gov

Return-path: <FPESCHULTE@aol.com>
From: FPESCHULTE@aol.com
Full-name: FPESCHULTE
Message-ID: <78.7749f482.300e6e35@aol.com>
Date: Tue, 19 Jul 2005 10:54:45 EDT
Subject: NIST Draft Final Report Comment
To: wtc@nit.gov
MIME-Version: 1.0
Content-Type: text/plain; charset="ISO-8859-1"
X-Mailer: AOL 5.0 for Windows sub 124

Affiliation: Schulte & Associates

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Report Number: NIST NCSTAR 1-4B

Page Number: 22

Paragraph/Sentence:

"Damp standpipe systems are also filled with water, however, these systems are provided with small diameter, usually ¾ in. or 1 in., water supply connections to a building domestic plumbing system used only to maintain water within the system."

Comment:

Despite almost 29 years of experience in the field of fire protection, this is the first time I have ever heard of the term "damp standpipe system". A standpipe system filled with water supplied by a small connection to the domestic water supply system is still a wet system. Given this, it is recommended that it be verified that the term "damp standpipe system" is defined in NFPA 14.

Suggestion for Revision:

If the term "damp standpipe system" is not defined in NFPA 14, it is recommended that a term which is defined in NFPA 14, i.e. wet manual standpipe system, be used in the report.

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Subject: NIST Draft Final Report Comment
To: wtc@nist.gov

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Report Number: NIST NCSTAR 1-4

Page Number: 50 and 51

Paragraph/Sentence:

"Figure 511 is a photograph of an upright style standard spray spriinkler."

Comment:

Figure 5-11 is identified as a pendent sprinkler. Very sloppy editing job by the "subject" expert.

Suggestion for Revision:

The above sentence should be revised or Figure 5-11 should show an upright sprinkler as indicated.

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Report Number: NIST NCSTAR 1-4

Page Number: 50 and 51

Paragraph/Sentence:

"Concealed pendent sprinklers with chrome cover plates were installed in all finished areas. Figure 510 is a photograph of a typical concealed ssprinkler cover plate. Upright or pendent type sprinklers were installed in areas without finished ceilings (PANYNJ 1987a). Figure 511 is a photograph of an upright style standard spray sprinkler. Sprinklers with an operating temperature rating of 165 Â°F were installed throughout most areas (PANYNJ 1987a). Higher temperature rated sprinklers were installed in areas with ceiling temperatures above 100 Â°F (PANYNJ 1987a). Protective guards or shields were installed in areas where sprinklers were potentially subject to mechanical damage (PANYNJ 1987a). Documentation indicated that Â½ in. orifice sprinklers with a k-factor of 5.6 were installed throughout WTC 1 and WTC 2 (PANYNJ 1987a)."

Comment:

The photograph clearly shows a sprinkler manufactured by Reliable Automatic Sprinkler Company. Given this, the paragraph above should indicate that the sprinklers used in the installation were manufactured by Reliable (if this is indeed the case).

Suggestion for Revision:

The name of the manufacturer of the sprinklers installed in WTC 1 and WTC 2 should be indicated if a Port Authority building standard for WTC 1 and WTC 2 required the use of one manufacturer's sprinkler.

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Report Number: NIST NCSTAR 1-4

Page Number: 51

Paragraph/Sentence:

"Proper clearances were maintained between sprinkler pipes and all other piping, equipment, and structures."

Comment:

It is not clear as to the basis for this statement. What evidence leads the "subject" expert to this conclusion considering that all of the evidence to support this statement was destroyed in the collapse of the towers.

Suggestion for Revision:

The statement in the sentence above cannot be supported by any evidence. It is recommended that this statement be deleted.

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Report Number: NIST NCSTAR 1-4

Page Number: 52

Paragraph/Sentence:

"The sprinkler systems attached to riser A are referred to as the high zone and included the systems for floors 99 through 107."

Comment:

It is assumed that the sprinklers in the high zone were supplied by riser A, rather than "attached" to riser A.

Suggestion for Revision:

It is suggested that the words "supplied by" be substituted for the words "attached to" in the sentence above.

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Report Number: NIST NCSTAR 1-4

Page Number: 52

Paragraph/Sentence:

"The fire pumps were used to increase or "boost" the water pressure for the sprinkler systems on the upper levels since the pressure due to the elevation difference between the water level in the tanks and the sprinkler pipes was less than the required pressure for the proper operation of the sprinkler systems. "

Comment:

The purpose of providing a fire pump is to increase the available pressure. Hence, the sentence above states the obvious. There is no need to use both the words "increase" and "boost" at the same point in the above sentence.

Suggestion for Revision:

It is suggested that the sentence above be revised to read as follows:

A fire pump was provided on this level because the pressure available due to elevation difference was inadequate for the operation of the sprinkler system protecting level . . ..

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Report Number: NIST NCSTAR 1-4

Page Number: 53

Paragraph/Sentence:

"Pressure reducer type control valves were not required for the high zone sprinkler systems since the static pressures at the floor control valve elevations were less than the maximum working pressure of 175 psi for standard weight schedule 40 pipe, sprinklers, and fittings."

Comment:

The pressure rating of threaded schedule 40 steel pipe is 300 psi. Hence, the sentence above is factually in error. The pressure rating of standard weight cast iron fittings exceeding 2 inch in size is 175 psi.

Suggestion for Revision:

The sentence above should be revised to read as follows:

". . . .. were less than the maximum working pressure rating of 175 psi for standard weight fittings and sprinkler."

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Report Number: NIST NCSTAR 1-4

Page Number: 54

Paragraph/Sentence:

"The pressure in the system increased at the rate of 0.433 psi per foot of elevation drop and is referred to as elevation or gravity head pressure."

Comment:

The term "elevation drop" in the above sentence really means elevation change.

Suggestion for Revision:

It is suggested that the words "elevation drop" in the above sentence be replaced with the word "elevation change".

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Report Number: NIST NCSTAR 1-4

Page Number: 54

Paragraph/Sentence:

"The mid-level zone spanned the largest number of floors, which resulted in the greatest variation in pressure from the top to the bottom of the sprinkler riser (PANYNJ 1972, 1987a)."

Comment:

The word "spanned" in the sentence above is a structural engineering term.

Suggestion for Revision:

It is suggested that the word "spanned" in the sentence above be replaced by the word "served" or "included".

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Report Number: NIST NCSTAR 1-4

Page Number: 54

Paragraph/Sentence:

"Since schedule 40 pipe and standard weight fittings rated at 175 psi were used for all
individual floor level sprinkler systems, pressure-reducing valves were required to regulate the system pressures to within the working tolerances of the pipe and fittings (PANYNJ 1987a, 2000a)."

Comment:

According to NFPA 13, the maximum pressure rating of threaded schedule 40 pipe is 300 psi, not 175 psi. The maximum pressure rating of standard weight cast iron fittings greater than 2 inch in size is only 175 psi.

Suggestion for Revision:

The sentence should be revised so that it does not appear to indicate that the maximum pressure rating of threaded schedule 40 steel pipe is only 175 psi.

From: FPESCHULTE@aol.com
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Report Number: NIST NCSTAR 1-4

Page Number: 54

Paragraph/Sentence:

"Table 510 provides a summary of the static pressure observed at eaach floor control valve assembly attached to riser C in the low zone."

Comment:

Are floor control valve assemblies "attached" to risers or are they "connected" to risers? Connected is a better word.

The above sentence indicates that the static pressures at each floor control valve assembly were "observed". It is my understanding that all three buildings collapsed. If this is the case, how did the contractor observe the pressures? The pressures were "calculated", not "observed".

Suggestion for Revision:

Replace the word "attached" in the above sentence with the word "connected".

It is suggested that the sentence be revised to read:

"Table 5-10 provides a summary of the calculated static pressures at each floor control valve assembly connected to riser C in the low zone."

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Report Number: NIST NCSTAR 1-4

Page Number: 57

Paragraph/Sentence:

"Carbon dioxide (CO2) is a chemical compound that contains carbon and oxygen."

Comment:

Is it necessary to include a chemistry lesson in the report? Including the sentence above in the report is silly.

Suggestion for Revision:

Delete the above sentence.

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Report Number: NIST NCSTAR 1-4

Page Number: 58

Paragraph/Sentence:

"Halon relates to the halogen gases that are used in the extinguishing agent, including fluorine, chlorine, bromine and iodine. The halogen gases are combined with hydrocarbons to form the extinguishing agent. Halon extinguishes fires primarily by interrupting the combustion process."

Comment:

The above sentences are poorly written and factually inaccurate. The term "halon" refers to halogenated compounds. Halogenated compounds are hydrocarbons which contain one or more of the four chemical elements listed above.
Whoever wrote the sentence above doesn't know much about chemistry and is certainly not a "subject expert".

Suggestion for Revision:

It is suggested that the above sentence be revised to read:

The term "halon" refers to halogenated gases which are used as fire extinguishing agents. (Halogenated compounds are hydrocarbons which contain fluorine, chlorine, bromine or iodine.) Halon agents extinguish fires by interrupting the combustion process.

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Report Number: NIST NCSTAR 1-4

Page Number: 65

Paragraph/Sentence:

"The design criteria indicated that sprinkler systems were not to be extended into electric closets, communicating closets, telephone closets, emergency generator spaces, transformer and switchgear spaces, and telephone equipment rooms."

Comment:

The words "extended into" are a poor substitute for the words "installed in" in the above sentence.

The word "closets" in the sentence above should be changed to "rooms".

The words "communicating closets" in the sentence above should be changed to "communication rooms".

Suggestion for Revision:

It is suggested that the above sentence be revised to read:

The design criteria indicated that sprinkler piping was not to be installed in electrical equipment rooms, communication equipment rooms, telephone equipment rooms, emergency generator rooms, transformer and switchgear rooms, and telephone equipment rooms.

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Report Number: NIST NCSTAR 1-4

Page Number: 74

Paragraph/Sentence:

"Therefore, while a minor inconsistency existed, the overall robustness of the design of the sprinkler systems would be expected to meet or exceed the performance expectations of state-of-the-art best practices that existed at the time of construction of these three buildings for automatic fire sprinkler systems."

Comment:

The sentence above is poorly written and needs to be revised. The word "robust" is overused and appears to be an attempt to be "high-brow".

The sentence refers to the time of construction, however, sprinkler protection was not installed in WTC 1 and WTC 2 at the time of construction.

Who wrote this tortured language? Certainly not a "subject" expert.

Suggestion for Revision:

The above sentence should be revised.

From: FPESCHULTE@aol.com
Subject: Fwd: Sprinkler System Failure Statistics
To: sivaraj.shyam-sunder@nist.gov

Return-path: <FPESCHULTE@aol.com>
From: FPESCHULTE@aol.com
Full-name: FPESCHULTE
Message-ID: <ae.76e0c578.301790d7@aol.com>
Date: Tue, 26 Jul 2005 09:12:55 EDT
Subject: Fwd: Sprinkler System Failure Statistics
To: Info@afscc.org
MIME-Version: 1.0
Content-Type: multipart/mixed; boundary="part2_203.65d1dd8.301790d7_boundary"
X-Mailer: 9.0 Security Edition for Windows sub 5200

Ms. Lovell-

Yesterday, I reviewed e-mail correspondence between the NFPA and the NFSA regarding the sprinkler system failure rate data being cited in the ICC CTC meeting yesterday. The e-mail correspondence doesn't agree with your assertion that the NFPA has reviewed the data and agrees with the AFSCC's interpretation of the data. Obviously, the accuracy of the sprinkler failure rate statistics cited by the AFSCC will affect the credibility of the AFSCC.

Incidentally, I've worked in the fire protection field for 29-1/2 years. During this time, I only know of two failures of sprinkler systems in a fire- one in a locker room at a golf course in Glencoe, Illinois and the other in a 1 million square foot warehouse in New Orleans. Both buildings were completely destroyed.

If sprinkler systems failed in 1 out of 6 fires in sprinklered buildings, I would expect to hear of about a sprinkler system failure on a regular basis, perhaps once a week or even once a day. Sorry, but I have my doubts about the sprinkler system failure rate statistics being cited by the AFSCC.

This should be interesting.

Richard Schulte
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From: FPESCHULTE@aol.com
Full-name: FPESCHULTE
Message-ID: <cf.2d6f5fcc.30178e0e@aol.com>
Date: Tue, 26 Jul 2005 09:01:02 EDT
Subject: RE: Sprinkler System Failure Statistics
To: gkeith@NFPA.org
MIME-Version: 1.0
Content-Type: multipart/alternative; boundary="-----------------------------1122382862"
X-Mailer: 9.0 Security Edition for Windows sub 5200

Mr. Keith:

I attended a meeting of the ICC Code Technology Committee yesterday. One of the topics addressed was the issue of "balanced" fire protection (sprinkler trade-offs). During the meeting, several members of the Alliance for Fire an Smoke Control and Containment (AFSCC) quoted a report written by Koffel & Associates indicating that sprinkler protection fails in 1 in 6 fires. It was also stated by Vickie Lovell representing the AFSCC that the NFPA had reviewed these statistics and, in essence, agrees with Mr. Koffel's statistics.

My purpose in writing is two-fold. First, to verify the whether or not the NFPA has reviewed Koffel & Associates' report indicating that the failure rate of sprinkler systems is 1 out of every 6 fires occurring in sprinklered buildings. Second, assuming that the failure of sprinkler systems is indeed 1 out of every 6 fires occurring in sprinklered buildings, to ask why hasn't this statistics been publicized.

In my opinion a failure rate of 1 in 6 fires is an unacceptably high rate of failure. If this statistics is indeed accurate, it would seem to me that action must be taken to rectify the "problems" with sprinkler system installations. We know that, based upon data from Australia, sprinkler protection successfully operates 99 percent of the time in that country.

Although this is anecdotal, in my 29 years in the fire protection field, I only know of 2 sprinkler system failures-one in Glencoe, Illinois and the other at the McFrugal's Warehouse in New Orleans. That's it. Obviously, if the failure rate was as high as Koffel & Associates and the AFSCC maintain, I would expect to hear almost everyday of another sprinkler system failure.

I would appreciate your comments on the above.

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From: FPESCHULTE@aol.com
Subject: Re: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

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Report Number: NIST NCSTAR 1 (Chapter 9)

Page Number: 197

Paragraph/Sentence:

"*Codes and standards for the design, construction, operation, and maintenance of buildings are the documents by which a society states its intent to provide public safety and functionality. They incorporate the knowledge, experience, procedures, and practices of the applicable engineering disciplines, the values of the contemporary society, the experiences from prior successes and failures, and knowledge of the commercial products, services, and technologies available for the tasks at hand.*"

Comment:

The statements that codes and standards . . . are documents by which society states "*its intent to provide public safety and functionality*" and that codes and standards incorporate "*the values of the contemporary society*" are a stretch. The codes and standards development process adopted by both the International Code Council (ICC) and the National Fire Protection Association (NFPA) do not go through any process to determine what "*society's values*" actually are. This statement is an exaggeration at best. Most Americans do not have any awareness of safety codes and standards.

Suggestion for Revision:

The above paragraph should be rewritten to delete references to the fact that codes and standards reflect American "*society values*" and expectations.

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Report Number: NIST NCSTAR 1

Page Number: 197

Paragraph/Sentence:

"*The United States has a unique approach to such codes and standards. In virtually all other developed countries the national government has a primary role in the development of national model codes. In the United States, the private sector develops such codes and standards.*"

Comment:

The above sentences reflect a political viewpoint. The approach to the development of codes and standards is not unique for a capitalist country. Most developed countries referred to in the above sentences are socialist countries (i.e. Canada, Britain, France, Germany) where government is far more involved in the commerce of the country.

Most codes and standards in the United States are not developed in the private sector, but are developed by "quasi-public" non-profit entities. If the entities which developed codes and standards in the United States were for profit corporations, then it could be stated that codes and standards are developed in the private sector.

Suggestion for Revision:

It is suggested that the above sentences be deleted. The process by which codes and standards are developed in socialist countries are of no interest in a society which utilizes capitalism.

From: FPESCHULTE@aol.com
Subject: Re: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

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Report Number: NIST NCSTAR 1

Page Number: 197

Paragraph/Sentence:

"*Model codes are developed using committees of experts, generally adapted to reflect local climate and geological conditions by state and local governments, and updated every three years.*"

Comment:

The statement that "*model codes are developed using* committees of experts" is factually inaccurate. The ICC process does not utilize committees of experts, but rather committees composed of people which have some expertise in the subject, which is completely different from a committee of experts. Who ever wrote this sentence is apparently not familiar with the ICC code development process.

Suggestion for Revision:

It is suggested that the sentence making references to "*committees of experts*" be revised to be factually accurate.

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Report Number: NIST NCSTAR 1

Page Number: 197

Paragraph/Sentence:

"*Localities adopting model codes update their versions periodically as well, to follow roughly the same schedule as the model codes.*"

Comment:

The above sentence is not factually accurate. Some localities update their adoption of model building codes at regular intervals and some do not.

Suggestion for Revision:

It is suggested that the last phrase of the above sentence be deleted.

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Report Number: NIST NCSTAR 1

Page Number: 198

Paragraph/Sentence:

"*In addition to standards and codes organizations, there are other key stakeholder groups that either are responsible for or influence the practices used in the design, construction, operation, and maintenance of buildings in the United States.*"

Comment:

The word "*stakeholder*" is a "high-brow" word for "interest" groups.

Suggestion for Revision:

It is suggested that the word "*stakeholder*" in the above sentence be replaced with the term "interest" groups.

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Report Number: NIST NCSTAR 1

Page Number: 198

Paragraph/Sentence:

"***Rigorous enforcement of building codes and standards by state and local agencies, well trained and managed, is critical in order for standards and codes to ensure the expected level of safety. Unless they are complied with, the best codes and standards cannot protect occupants, emergency responders, or buildings.***"

Comment:

This statement is "**bolded**" in the report. It is assumed that the fact that the statement is "**bolded**" means that the statement is of some importance. **It is noted that this statement is not repeated in either the NIST's recommendations or in NIST's findings.** It would seem that if this statement is important that the concepts expressed in this statement would be included both in the findings and in the recommendations.

It particular, it should be noted that the fire service is typically responsible for the enforcement of the maintenance provisions contained in building and fire prevention codes. The fire service, in general, does a good job about complaining about the maintenance of building fire safety features, but does a poor job actually enforcing maintenance provisions which are under their jurisdiction. Given this, **it is Schulte & Associates' opinion that NIST's finding should include a finding of the poor job of code enforcement that the fire service does. It is also Schulte & Associates' opinion that one of NIST's recommendations should be that the fire service should devote more of its resources to code enforcement, rather than to fire suppression.**

Suggestion for Revision:

It is suggested that the concept expressed in this statement be included in both NIST's recommendations and in NIST's finding.

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Report Number: NIST NCSTAR 1

Page Number: 198 and 199

Paragraph/Sentence:

"As part of its WTC Investigation, NIST is issuing draft recommendations for public comment that identify specific improvements in the way buildings are designed, constructed, maintained, and used and in evacuation and emergency response procedures. NIST believes that these recommendations are both realistic and achievable within a reasonable period of time and that their implementation would make buildings safer for occupants and emergency responders in future emergencies."

Comment:

The above paragraph does not address the specific basis for making the recommendations contained in the report. Nor does the paragraph address the meaning of the phrase "make buildings safer for occupants and emergency responders in future emergencies". (Making buildings safer for occupants and emergency responders could mean anything, including recommending that buildings in excess of 1 story in height not be permitted to be constructed.) The public and the industries which would be affected by the recommendations are owed an explanation exactly what definition NIST is using for the term "safer".

The above paragraph also does not address the cost of implementing NIST's recommendations. Any proposal for changes to existing building codes should be accompanied by a cost estimate and also a cost/benefit analysis. A clear statement as to the actual reduction in injuries, deaths and property damage should be made by NIST so that the public can judge whether or not NIST's recommendations are cost effective. In order to do a cost/benefit analysis, **a clear definition of the actual problem which is being addressed is required. No where in the report does NIST provide a clear statement of the "problem" which exists.**

Schulte & Associates has gone on record numerous times stating that the fire safety record of commercial buildings, in particular high rise office buildings, in the the United States is excellent and has provided statistics to back up this opinion. NIST has yet to provide any statistics to back up its opinion that there is actually a fire safety problem which exists in the United States which needs to be addressed. The latest fire statistics published by the National Fire Protection Association (for 2004) indicate that more than 60 percent of fire fatalities which occurred in the U.S. occurred in 1- and 2-family dwellings and that in excess of 80 percent of the fire fatalities in the U.S. occurred in residential occupancies. The NFPA estimate of the number of fire fatalities which occurred in commercial (non-residential) buildings in the U.S. in 2004 is only 80 people. The number of fire fatalities in commercial buildings which occurred in the U.S. in 2004 is on the same order as the number of fatalities caused by lightning.

If there is a fire problem in the U.S., the problem is in 1- and 2-family dwellings. NIST's recommendations do <u>not</u> address the fire problem in 1- and 2-family dwellings. To recommend that additional capital be spent on making commercial buildings safer, without addressing the fire safety problem in 1- and 2-family dwellings is like "putting the cart in front of the mule". In my opinion, the Congressional Science Committee should severely chastise NIST for <u>not</u> clearly setting priorities and letting American know the actual safety record of commercial buildings in the United States.

In addition to the above, the paragraph above does <u>not</u> clearly address the issue of terrorism and how buildings should be designed to address this issue. It is my understanding from recent presentations made by NIST in Las Vegas (AIA and NFPA conventions) that NIST recommendations do <u>not</u> and will <u>not</u> address the issue of "terrorist-resistant" or "terrorist-proof" building construction. **Given that the statement made by the director of NIST, Dr. Arden Bement, at the Congressional Science Committee hearing on the collapse of the World Trade Center towers on March 6, 2002 specifically promised that this issue would be addressed, NIST should clearly make a statement as to why this issue is not being addressed in the investigation report. Clearly, NIST owes the Congressional Science Committee and the general public an explanation of why the issue of terrorism was not addressed.**

Suggestion for Revision:

The technical justifications for NIST's recommendations should be included in the report and sufficient time should be allowed for the public to review and comment on the technical justifications advanced by NIST.

An explanation as to why the issue of "terrorist-resistant" or "terrorist-proof" was <u>not</u> included in the report should be included in the NIST report and also be submitted to the Congressional Science Committee.

In addition to the above, it is my opinion that the director of NIST should be recalled to the Congressional Science Committee to explain Dr. Bement's testimony before the Congressional Science Committee on March 6, 2002.

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Report Number: NIST NCSTAR 1

Page Number: 198

Paragraph/Sentence:

"In addition to standards and codes organizations, there are other key stakeholder groups that either are responsible for or influence the practices used in the design, construction, operation, and maintenance of buildings in the United States. These typically include organizations representing building owners and managers (e.g., Building Owners and Managers Association, Construction Industry Institute), real estate developers (e.g., Real Estate Board of New York), contractors (e.g., Associated General Contractors, Associated Builders and Contractors), architects (e.g., American Institute of Architects), engineers (e.g., National Society of Professional Engineers, Society of Fire Protection Engineers, Structural Engineering Institute, National Council of Structural Engineering Associations), suppliers, and insurers. These groups also provide training, especially as it affects the ability to implement code provisions in practice. Lack of adequate training programs can limit the usefulness or widespread acceptance of improved code provisions. Very few members of the general public and building occupants participate in this process."

"The National Institute of Standards and Technology (NIST) is a non-regulatory agency of the U.S. Department of Commerce. NIST does not set building codes or standards, but provides technical support to the private sector and to other government agencies in the development of U.S. building and fire practice, standards and codes. NIST provides this support by: conducting research which helps to form the technical basis for such practice, standards, and codes; disseminating research results to practicing professionals; having its staff participate on technical and standards committees; and, providing technical assistance to the building and fire safety communities. Due to limited participation of the general public and building occupants, NIST has a responsibility to represent the public's interest. As an objective and impartial technical entity, NIST recommendations are given serious consideration by private sector organizations that develop national standards and model codes, which provide minimum requirements for public welfare and safety."

Comment:

See the attached article on these two paragraphs. This article will be published in the August issue of Plumbing Engineer magazine. The article is titled "The Public's Interest".

Suggestion for Revision:

It is suggested that the last two sentences of the second paragraph above be deleted. NIST does not necessarily "represent the public's interest", nor is NIST necessarily "an objective and impartial technical entity". NIST like every other government agency must secure funding. Hence, NIST is similar to the other interest groups listed in the first paragraph above.

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Report Number: NIST NCSTAR 1

Page Number: 199

Paragraph/Sentence:

"*While there were unique aspects to the design of the WTC towers and the terrorist attacks of September 11, 2001, the design, construction, operation, and maintenance of the WTC towers?and the eemergency response to the WTC towers?were based on procedures and practices thhat are commonly used for normal conditions. These include procedures and practices used for construction classification, establishing and determining fire resistance ratings, estimating wind loads, designing structural components and connections, designing egress systems, designing sprinkler systems, evacuation, and emergency response.*"

Comment:

Dr. Bement's statement before the Congressional Science Committee on March 6, 2002 included the following excerpt:

". . . .*The tragedy that the United States experienced on September 11, 2001, was unprecedented when compared with any prior accident, natural disaster, or terrorist/war attack. The collapse of the twin World Trade Center towers was the worst building disaster in human history. Engineers, emergency responders, and the nation did not anticipate, and were largely unprepared for, such a catastrophe. . . .*"

Dr. Bement's statement at the Congressional Science Committee hearing appears to be at odds with the above paragraph in the report. Either Dr. Bement or NIST is fibbing about whether or not September 11th was a unique event. It is my opinion that Dr. Bement is correct. September 11th was a unique event-the collapse of 2 of the tallest buildings in the United States within 30 minutes of one another, followed by the collapse of a 47 story building within hours of the collapse of the first two buildings. Only a few events in human history parallel this attack (i.e. the atomic bombing of Nagasaki and Hiroshima in August of 1945, fire bombing of Dresden, Germany on Valentine's Day in 1945, the hurricane which destroyed Galveston, Texas in 1900, the San Francisco earthquake and fire in 1906 and the Great Chicago fire in the 1870's).

Suggestion for Revision:

It is suggested that this first sentence in the paragraph above be revised to reflect the uniqueness of the events in Lower Manhattan on September 11th. To say that this event wasn't all that unique is an indication that the scientists at NIST do <u>not</u> understand or have an appreciation of the events in Lower Manhattan on September 11th.

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Report Number: NIST NCSTAR 1

Page Number: 199

Paragraph/Sentence:

"*NIST is also making recommendations for selected buildings that are at greater risk, e.g., due to their iconic status, critical function, or design.*"

Comment:

According to NIST, the NIST report will not address terrorism. Given this, it is not clear to what this sentence above actually refers.

Suggestion for Revision:

The above sentence should be reviewed to determine whether or not it is appropriate to include the sentence in this report.

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Report Number: NIST NCSTAR 1

Page Number: 200

Paragraph/Sentence:

"*Increased structural integrity, including methods for preventing conditions that could result in progressive collapse (when a building or a significant portion of a building collapses due to disproportionate spread of an initial local failure), standardizing the estimation of wind loads that frequently govern the design of tall buildings, and enhancing the stability of tall buildings.*"

Comment:

It appears that this series of recommendations is based upon the collapse of 3 buildings in Lower Manhattan on September 11th. If the NIST recommendations are not intended to address terrorist events as stated by NIST at both the AIA and NFPA conventions in Las Vegas in May and June of this year, it is not clear how these recommendations arise out of an investigation into a terrorist event. Information presented in the NIST study indicates that the collapse of tall buildings is a very rare event in the United States. Given this, it seems reasonable to ask what is the cost vs. benefit of making changes to the present procedures used to prevent progressive collapse.

Suggestion for Revision:

Since I am not a structural engineer, I am not qualified to make any proposals to change the above, however, the above comment is based upon "plain old common horse sense".

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Report Number: NIST NCSTAR 1

Page Number: 200

Paragraph/Sentence:

"*Improved active fire protection, including the design, erformance, reliability, and redundancy of sprinklers, standpipes/hoses, fire alarms, and smoke management systems.*"

Comment:

It was indicated by NIST at the AIA and NFPA conventions in Las Vegas in May and June of this year that NIST's recommendations will not address the issue of terrorism. Given that the fires in the WTC towers were initiated by a terrorist attacks and that the failure of sprinkler systems, standpipe systems, fire alarm systems and smoke management systems were caused by a missile impact, it is not clear how NIST determined that the fire protection systems installed in the towers were insufficiently reliable and that the standards governing the design and installation of these systems need to be improved.

The report does not provide any documentation as to the failure rate of sprinkler systems in high rise buildings (or the failure rate of sprinkler systems in general).

Given the lack of a technical documentation for this general recommendation, it seems reasonable that the construction industry should not act upon this recommendation until NIST provides technical substantiation for making this recommendation.

It should also be noted that the smoke management system in the WTC towers was only designed to be used after the fire was extinguished. Given this, it is puzzling why NIST recommended that the performance and reliability of smoke management system be improved when the fires in the WTC towers were never extinguished.

Suggestion for Revision:

The technical justification for this general recommendation should be included in the report.

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Report Number: NIST NCSTAR 1

Page Number: 200

Paragraph/Sentence:

"*Improved building evacuation, including system designs that facilitate safe and rapid egress, methods for ensuring clear and timely emergency communications to occupants, better occupant preparedness for evacuation during emergencies, and incorporation of appropriate egress technologies.*"

Comment:

The NIST study shows that the evacuation of the building below the floors of impact was acceptable. Given this, it is difficult to understand why NIST would recommend further improvements in a system which performed adequately. Again, no rationale for NIST's recommendation was included in the report. Given this, there is no reason why code provisions regarding egress provisions should be modified. Again, the September 11th events were terrorist events and since the NIST recommendations do not address terrorist events, it is difficult to understand how NIST determined that the egress provisions in codes are inadequate based upon this event.

Suggestion for Revision:

A technical justification for the general recommendation should be included in the report.

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Report Number: NIST NCSTAR 1

Page Number: 200

Paragraph/Sentence:

"Improved emergency response, including better access to the buildings and better operations, emergency communications, and command and control in large-scale emergencies."

Comment:

This general recommendation is too general to be of any use. Is NIST recommending that every jurisdiction in the United States be prepared to handle a terrorist event such as occurred in Lower Manhattan on September 11th? Implementation of such a recommendation would more than likely bankrupt the country. NIST needs to qualify and quantify exactly what is intended by this recommendation. At presently written, this recommendation is too general to be of any use.

Suggestion for Revision:

This recommendations should be clarified so that NIST's actual intent is reflected in the recommendation.

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Report Number: NIST NCSTAR 1

Page Number: 200

Paragraph/Sentence:

"*Improved procedures and practices, including encouraging code compliance by nongovernmental and quasi-governmental entities, adoption and application of egress requirements in available code provisions for existing buildings, and retention and availability of building documents over the life of a building.*"

Comment:
The report documents the excellent job the Port Authority did in designing, constructing and maintaining the WTC towers. Given this fact, it is difficult to understand why NIST would make the recommendation above (other than to satisfy the whining and complaining of the relatives of the victims of the terrorist attack). The Port Authority is exempt from compliance for a reason. The Port Authority should have used this exemption to comply with national standards for building fire safety and fire protection, rather than complying with New York City code requirements.

Suggestion for Revision:

Provide a justification for the recommendation. Without a justification, this general recommendation should be ignored.

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Report Number: NIST NCSTAR 1

Page Number: 204

Paragraph/Sentence:

"The procedures and practices used to ensure the fire resistance of structures should be enhanced by improving the technical basis for construction classifications and fire resistance ratings, improving the technical basis for standard fire resistance testing methods, use of the "structural frame" approach to fire resistance ratings, and developing in-service performance requirements and conformance criteria for spray-applied fire resistive materials."

Comment:

This recommendation completely ignores the fire safety record of modern high rise buildings. The recent fire safety record of high rise buildings includes both buildings which are protected throughout by sprinklers and buildings which are not protected by sprinklers. Despite the fact that many unsprinklered high rise office buildings still exist, a study conducted by the National Fire Protection Association found that a total of only 7 Americans died due to fires in high rise office buildings in the time period between 1985 and 1998. Lightning kills more Americans in one year than died as a result of fires in all of the high rise office buildings in the United States in a 14 year period.

Unfortunately, NIST apparently did not think that the NFPA statistics on high rise buildings worth including the report. It can only be assumed that this was an intentional oversight since Schulte & Associates has made NIST aware of these statistics on numerous occassions. Until NIST acknowledges the better than excellent safety record of high rise buildings and justifies the need to implement NIST's recommendations despite the fact that excellent safety record, NIST's recommendation above should be ignored. The high rise provisions presently included in the three regional model building codes (the BOCA National Building Code, the Standard Building Code and the Uniform Building Code) and the two newest model building codes, the International Building Code and NFPA 5000 Building Code, are more than adequate to provide protection for the building occupants and firefighters.

It should be noted that the structural frame approach to fire resistance ratings has been included in all building codes since I first became involved with building codes in the middle 1970's. The three regional model building codes required that floors in high rise buildings develop a 2 hour fire resistance rating and that vertical supports develop either a 2 or 3 hour fire resistance rating. In essence, these codes required a 2 hour structural frame and, in some cases, required the vertical supports to develop an additional hour of structural fire resistance rating. The statement recommending the "structural frame approach" simply demonstrates that NIST does not have a good grasp of the code requirements contained in the various model building codes utilized in the United States.

Suggestion for Revision:

NIST has not provided any technical basis for this recommendation. Without a technical substantiation for this recommendation, this recommendation simply represents an unsupported opinion.

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Paragraph/Sentence:

Footnote 22:

The construction classification and fire rating requirements should be risk-consistent with respect to the design-basis hazards and the consequences of those hazards. The fire rating requirements, which were originally developed based on experience with buildings less than 20 stories in height, have generally decreased over the past 80 years since historical fire data for buildings suggests considerable conservatism in those requirements. For tall buildings, the likely consequences of a given threat to an occupant on the upper floors are more severe than the consequences to an occupant on the first floor or the lower floors. For example, with non-functioning elevators, both the time requirements are much greater for full building evacuation from upper floors and emergency responder access to those floors. It is not clear how the current height and areas tables in building codes consider the technical basis for the progressively increasing risk to an occupant on the upper floors of tall buildings that are much greater than 20 stories in height.

Comment:

The footnote makes the assumption that the risk to building occupants and firefighters increases as the number of stories in a building increases. No technical basis has been provided for making this assumption and it is Schulte & Associates' opinion that the risk to building occupants and firefighters only increases minimally as the number of stories in a building increases (beyond a certain point). The NFPA statistics on high rise office buildings (both sprinkleres and unsprinklered) indicate that a total of only 7 Americans died as a result of fires in all of the high rise office buildings in the United States in a 14 year period between 1985 and 1998. Obviously, these statistics show that risk of dying in fire in a high rise office buildings over 20 stories in height is essentially the same as the risk of dying in a high rise office building under 20 stories in height. (The probability of dying in a fire in a high rise office building is essentially 0, regardless of the height of the building, and the probability of dying a fire in high rise building which is protected throughout by a standard NFPA 13 sprinkler system is even

less.)
The NFPA fire statistics clearly indicate that the most hazardous building occupancy is 1- and 2-family dwellings, not high rise buildings. The probability of dying in a fire in a 1 or 2 story single-family dwelling is far greater than the probability of dying in a fire in a high rise office building, regardless of the height of the office building. This statistic directly contradicts NIST's statement in the footnote above that indicates that occupants of higher floors in a high rise buildings are at greater risk (peril) than the occupants of lower floors or the first floor of a building.

Footnote 22 is a poor attempt by NIST to justify their recommendations for changes to the fire safety provisions which apply to high rise buildings. NIST has no way of quantifying the actual risk to occupants and firefighters. The only way to quantify the risk is to look at the NFPA statistics and the NFPA statistics do not support NIST's position.

It should noted that NIST makes reference to a total evacuation of a high rise building in Footnote 22. Given that NIST has stated that the report does not address terrorism, it is not clear why a total evacuation of a high rise building should ever be necessary. Again, the fire statistics for high rise buildings tell us that there has never been a major fire in a U.S. high rise building which is protected throughout by a sprinkler system. In other words, over the last 30 years, the fire record of sprinklered high rise buildings has been not been excellent, it has been perfect. Given this record, NIST needs to justify why a total evacuation is even mentioned in this footnote.

Suggestion for Revision:

NIST needs to provide a justification for the statements made in Footnote 22. Any reference to risk needs to be numerically quantified (i.e. probability as it relates to other events such as being struck by lightning or being involved in a fatal traffic accident). If NIST cannot quantify risk in a numerical way, then NIST's reference to risk in this footnote should be deleted.

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Paragraph/Sentence:

"*Recommendation 4. NIST recommends evaluating, and where needed improving, the technical basis for determining appropriate construction classification and fire rating requirements (especially for tall buildings greater than 20 stories in height)?and making rellated code changes now as much as possible?by explicitly considering factors inncluding* 21*:*

o *the need for redundancy in fire protection systems that are critical to structural integrity* 23;"

Comment:

This recommendation has already been implemented. The high rise provisions contained in the 3 regional model building codes, the International Building Code and NFPA 5000 all require that the structural elements of high rise office, hotel and apartment buildings develop a minimum fire resistance rating of 2 hours, in addition to being protected throughout with a sprinkler system. The fire which develops in typical office and residential occupancies has a severity equivalent to a 30 to 60 minute exposure to the ASTM E119 time-temperature curve (assuming sprinkler system failure) per NBS research conducted more than 40 years ago. In other words, office and residential buildings with 2 hour structural elements already are provided with redundant structural fire protection.

This point in Recommendation 4 is simply a recommendation for more research into a subject which we already have sufficient knowledge. There is really no critical need to conduct more research into this subject with public tax dollars. If the scientists at NIST want to fund the research out of their own pockets, then there should be no objections.

Suggestion for Revision:

This point in Recommendation 4 can be deleted.

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Paragraph/Sentence:

Recommendation 4. *NIST recommends evaluating, and where needed improving, the technical basis for determining appropriate construction classification and fire rating requirements (especially for tall buildings greater than 20 stories in height)?and making rellated code changes now as much as possible?by explicitly considering factors inncluding 21:*

? *the extent to which redundancy in active ffire protection (sprinkler and standpipe, fire alarm, and smoke management) systems should be credited for occupant life safety 22;*

Comment:

Since the middle 1970's, the high rise provisions contained in the BOCA Building Code, the Standard Building Code and the Uniform Building Code to varying degrees have permitted reductions ("trade-offs") in passive fire protection requirements when sprinkler protection is provided. These reductions is passive fire protection requirements reduced the net cost of installing sprinkler protection and were used as an incentive to install sprinkler protection. Since these reductions in the requirements for passive fire protection were introduced 30 years ago, no major fire in a U.S. high rise building protected throughout by a sprinkler system has occurred, while a number of major fire in partially sprinklered U.S. high rise buildings (i.e. MGM Grand Hotel-Las Vegas, Hilton Hotel-Las Vegas, First Interstate Bank Building-Los Angeles, One Meridian Plaza Building-Philadelphia) have occurred in this same time period.

Similarly, since the atrium provisions were introduced in these three codes in the late 1970's, there has not been a major fire in a building which has contained an atrium. (The atrium provisions substitute sprinkler protection for floor openings enclosures.)

Given this perfect record, it would be difficult to assert that sprinkler protection is not a highly reliable form of fire protection. Hence, it can be stated that increases in travel distances, exit stairs permitted to be closed to one another, reductions in egress component widths, etc., as well as reductions in passive fire protection which affect occupant fire safety, when sprinkler protection is provided have all been demonstrated to be "safe" in the real world, other than in terrorist incidents (which NIST states are not being addressed).

Suggestion for Revision:

This point in Recommendation 4 can be deleted.

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Paragraph/Sentence:

Recommendation 4. *NIST recommends evaluating, and where needed improving, the technical basis for determining appropriate construction classification and fire rating requirements (especially for tall buildings greater than 20 stories in height)?and making rellated code changes now as much as possible?by explicitly considering factors including21:*

o compartmentation requirements (e.g., 12,000 ft2 (24)) to protect the structure, including fire rated doors and automatic enclosures, and limiting air supply (e.g., thermally resistant window assemblies) to retard fire spread in buildings with large, open floor plans;

Comment:

This recommendation ignores the excellent history of sprinkler protection in preventing the spread of fire. In the last 30 years, there has been no record of a sprinkler system failure resulting in a major fire in a high rise building (regardless of whether the building is 7 stories or 100 stories in height). NIST has not included any justification for why we need compartmentation of floors in addition to providing sprinkler protection.

Given the excellent fire loss record of high rise buildings protected throughout by sprinklers in the last 30 years, it seems illogical (at best) that NIST would recommend compartmentation in addition (or more appropriately, on top of) providing sprinkler protection in high rise office buildings.

Based upon the fire record of high rise office buildings, it seems far more appropriate that NIST would recommend providing sprinkler protection in 1- and 2-family dwellings, rather that providing compartmentation in sprinklered high rise office buildings. The benefit of providing compartmentation in addition to sprinkler protection is simply not worth the cost. The probability of a major fire in a sprinklered high rise building is practically nil.

Suggestion for Revision:

The recommendation that compartmentation be provided in high rise buildings, in addition to sprinkler protection, should be deleted.

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Report Number: NIST NCSTAR 1

Page Number: 205

Paragraph/Sentence:

"Adoption of this recommendation will allow building codes to distinguish the risks associated with different building heights, fuel concentrations, and fire protection systems. Research is needed to develop the data and evaluate alternative proposals for construction classifications and fire ratings. National Model Building Codes: The national model building code committees should undertake a comprehensive review of current construction classification and fire rating requirements and establish a uniform set of revised thresholds with a firm technical basis that considers the factors identified above."

Comment:

The statement above makes the assumption that the fire safety risk of tall buildings is greater than buildings of lesser height. The NFPA fire fatality statistics indicate that this is not the case. The NFPA fire fatality statistics clearly indicate that the risk of residential occupancies of any height is far greater than the risk of commercial buildings again of any height. Hence, it is my opinion that the fire risk to occupants of a one story single family dwelling is significantly greater than the fire risk to occupants of the 100th floor of a high rise office building.

The risk to occupants of high rise buildings, of course, varies with the protection provided for the building. Providing 2 hour fire resistive construction Type II (222) construction (as defined by NFPA 220) substantially reduces the risk of building collapse in a fire in a high rise office and residential buildings. Providing sprinkler protection throughout a high rise office or residential building, in addition to Type II (222) construction, reduces the probability of building collapse in a fire to essentially to 0. Providing sprinkler protection in the building, along with egress routes, reduces the probability of a large fire with major life loss also essentially to zero. Given that the probability of a major fire and building collapse in a high rise office or residential building is essentially zero when Type II (222) construction and sprinkler protection is provided, the risk to building occupants of a high rise building simply cannot be significantly reduced by providing additional fire safety features in the building because the probability of a major fire in the building is already essentially zero. Increasing the structural fire resistance of columns to 3 hours will not significantly reduce the risk. Neither will providing additional compartmentation. Hence, NIST needs to justify its statements regarding risk in the above paragraph.

Suggestion for Revision:

It is recommended that a comprehensive discussion of risk be included in the report. This discussion should specifically address the fire risk to occupants of single family versus the fire risk to occupants of the upper stories of a high rise building.

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Report Number: NIST NCSTAR 1

Page Number: 205

Paragraph/Sentence:

"*NIST recommends that the technical basis for the century-old standard for fire resistance testing of components, assemblies, and systems should be improved through a national effort. Necessary guidance also should be developed for extrapolating the results of tested assemblies to* prototypical building systems."

Comment:

To quote an old saying: "If it ain't broke, don't fix it." The ASTM E119 fire resistance test has been in use for roughly 80 years, however, this does not necessarily mean that we need to find a new and more complex method of determining fire resistance if ASTM E119 still provides useful information. While I clearly agree with NIST's assessment that there are deficiencies with the ASTM E119 test, the use of the test has "stood the test of time". The reason for this is that the results of ASTM E119 are conservative (although it is difficult to quantify the conservatism built into the test). Any new method of determining fire resistance will likely reduce the conservatism inherent in ASTM E119. In other words, any new method of determining fire resistance would likely reduce the structural fire resistance built into our buildings. It is my opinion that reducing the conservatism built in to the structural fire resistance of buildings would be a positive step, however, it is my opinion that developing a replacement for ASTM E119 is not absolutely essential to providing structural fire safety. In other words, ASTM E119 is working just fine. We have more important safety issues to address than finding a replacement for ASTM E119 such as 1- and 2-family dwelling fire safety and highway safety. To my knowledge, no one has died as a result of the unquantifiable conservatism built into ASTM E119.

Suggestion for Revision:

It is suggested that Recommendation 5 be deleted in its entirety or be revised to indicate that this is a relatively unimportant research project.

In

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Report Number: NIST NCSTAR 1

Page Number: 205

Paragraph/Sentence:

Footnote 26:

"The technical issues were identified from the series of four fire resistance tests of the WTC floor system and the review and analysis of relevant documents that were conducted as part of this Investigation."

Comment:

NIST being a science-based organization should be aware that a series of 4 fire resistance tests is too small of a sample to make the sweeping generalizations made in this recommendation. This statement in Footnote 26 reflects poorly on NIST.

The draft report actually contradicts this statement. The performance of the floor construction of the WTC towers in the 9/11 incident far exceeded expectations. NIST has concluded that the impact of the aircraft damaged the fireproofing on the structural members supporting the floor construction. No fire testing was conducted on trusses with damaged fireproofing because the results of such tests are already known, however, the actual fire resistance of the WTC towers floor construction far exceeded that which would be predicted testing per ASTM E119. Hence, the series of four fire tests actually proved nothing more than the structural response to fire exposure is extremely complex. We already know that to be the case.

Suggestion for Revision:

Revise or delete Footnote 26.

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Report Number: NIST NCSTAR 1

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Paragraph/Sentence:

Footnote 27:

"*There is a lack of test data on the fire resistance ratings of loaded connections. The fire resistance of structural connections is not rated in current practice. Also, standards and codes do not provide guidance on fireproofing requirements for structural connections when the connected members have different fire resistance ratings.*"

Comment:

NIST's statement in Footnote 27 is correct. There is a lack of data on the fire resistance of connections between structural members. It should be noted, however, that NIST has determined that the failure of connections apparently did not play a part in the collapse of the WTC 1 and WTC 2 towers. Given this fact determined by NIST, it would seem that the fire resistance of connections is not really that important of an issue. It appears based on NIST's investigation that NIST's concern about the fire resistance of connections is overblown.

Suggestion for Revision:

It is suggested that the above footnote be revised to note that the NIST investigation did not find that structural connections played a part in the collapse of the WTC towers.

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Paragraph/Sentence:

Footnote 25:

"The National Fire Protection Association (NFPA) 5000 model code and the International Building Code (IBC) both recognize the risks associated with different building heights and accepted changes in 2001 and 2004, respectively. Both model codes now require that buildings 420 feet and higher have a minimum 4 hour structural fire-resistance rating. The previous requirement was 2 hours. The change provides increased fire resistance for the structural system leading to enhanced tenability of the structure and gives firefighters additional protection while fighting a fire. While NIST supports these changes as an interim step, NIST believes that it is essential to complete a comprehensive review that will establish a firm technical basis for construction classification and fire rating requirements."

Comment:

The statement that both the IBC and NFPA 5000 require a minimum 4 hour structural fire resistance rating is incorrect. It is recommended that NIST review the changes to the model codes for buildings in excess of 420 feet recently adopted.

The IBC requires that the structural frame in Type 1A construction develop a minimum 3 hour fire resistance rating and that the floor construction develop a 2 hour fire resistance rating. Type IA construction is the construction type with the maximum fire resistance rating requirements.

Suggestion for Revision:

Revise Footnote 25 so that it is technically accurate.

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Report Number: NIST NCSTAR 1

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Paragraph/Sentence:

Recommendation 7. *NIST recommends the nationwide adoption and use of the "structural frame" approach to fire resistance ratings.*

Comment:

Every model building code has already incorporated this recommendation at least 30 years ago. For instance, both the BOCA Code and the Standard Building Code in one type of construction require 3 hour vertical members and 2 hour horizontal members. In other words, both of these codes require a 2 hour structural frame and require that the vertical members have an additional 1 hour fire resistance rating. This recommendation is simply one of semantics.

Suggestion for Revision:

This recommendation can and should be deleted.

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Report Number: NIST NCSTAR 1

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Paragraph/Sentence:

Footnote 29

"NIST tests showed that the adhesive strength of SFRM on steel coated with primer paint was a third to half of the adhesive strength on steel that had not been coated with primer paint. The SFRM products used in the WTC towers were applied to steel components coated with primer paint."

Comment:

The above footnote implies that the fireproofing on the WTC towers was defective because the fireproofing was applied to steel surfaces which were covered with primer paint. Rather than make this implication, the NIST report should explicitly address this issue. The question which this footnote raises and which needs to be answered is whether applying fireproofing to surfaces covered with primer paint was the proximate cause of the collapse of the WTC towers.

Suggestion for Revision:

The issue which Footnote 29 raises needs to be addressed in detail in the report. In my reading of the report, this is the only place where this issue is mentioned.

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Report Number: NIST NCSTAR 1

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Paragraph/Sentence:

"***Recommendation 8.*** *NIST recommends that the fire resistance of structures should be enhanced by requiring a performance objective that uncontrolled building fires result in burnout without local or global collapse.*"

Comment:

It is not clear why the collapse (or failure) of a portion of the building structure is unacceptable. Minor structural failures will not affect the overall structural stability of the building. The 9/11 incident clearly demonstrated the resiliency of the WTC towers to withstand simultaneous partial collapses without affecting the overall stability of the WTC tower under the most adverse conditions.

It is also not clear under what conditions the building is to be subjected too as a design basis. Since the NIST report does not clearly state that NIST's recommendations are not intended to address terrorism, NIST recommendations could be interpreted to mean that no local or global collapse should occur under 9/11 conditions. Recommendation 8 should clearly state what are the design assumptions, i.e. single typical fire, multiple typical fires, multiple atypical fires, multiple atypical fires with prior structural damage, multiple atypical fires with simultaneous wind event, multiple atypical fires with simultaneous wind and seismic events, etc., etc.

Suggestion for Revision:

Recommendation 8 should be revised to include the design assumptions under which no local or global collapse is to occur. Recommendation 8 should also be revised to define the term "local collapse".

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Paragraph/Sentence:

"*The issue of non-operational sprinklers could be addressed using the existing concept of Design Scenario 8 of NFPA 5000, where such compromise is assumed and the result is required to be acceptable to the Authority Having Jurisdiction.*"

Comment:

The technical justification for the assumption that the sprinkler system fails is not clear. NIST has provided no statistics on the failure rate of sprinkler systems in high rise buildings. The fire record in the United States over the last 30 years is devoid of any major fire occurring in a high rise building protected throughout by a sprinkler system. (The fires in the WTC towers have been excluded because these fires were caused by missile attacks. NIST has indicated that terrorist activity is not being addressed in this report, hence, terrorist activity should also not be addressed in NIST's recommendations.)

Suggestion for Revision:

Given the fire record cited above, a technical justification for the above sentence should be included in the report.

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Report Number: NIST NCSTAR 1

Page Number: 207

Paragraph/Sentence:

Footnote 30

"Had this requirement been adopted by the 1968 New York City building code, the WTC floor system, including its connections, would have had the 3 hour rating required for the columns since the floors braced the columns."

Comment:

This statement as written makes it appear that the 1968 NYC Building Code was defective, however, a number of model building codes used in the United States over the last 30 years have permitted 2 hour horizontal structural members for high rise buildings. In fact, the BOCA Code permitted a 2 hour structural frame and floor construction for high rise office and residential buildings of any height for years.

The information provided in Footnote 30 is an observation which is essentially irrelevant.

Suggestion for Revision:

Footnote 30 should be deleted.

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Paragraph/Sentence:

Recommendation 9. *NIST recommends the development of: (1) performance-based standards and code provisions, as an alternative to current prescriptive design methods, to enable the design and retrofit of structures to resist real building fire conditions, including their ability to achieve the performance objective of burnout without structural or local floor collapse: and (2) the tools, guidelines, and test methods necessary to evaluate the fire performance of the structure as a whole system.*

Comment:

The development of performed-based code provisions has been underway since at least the middle 1970's. At present, insufficient data exists to support much of the performance approach to building fire safety. Given this, the use of the prescriptive design approach will be used in most building designs.

It should also be noted that the performance approach to building fire safety design really only has application to major buildings, however, most buildings constructed in the United States are relatively small. NFPA fire statistics clearly indicate that the buildings with the worst fire record are 1- and 2-family dwellings. Given this, NIST should address the application of the performance approach to the fire safety design of 1- and 2-family dwellings. It is doubtful that there is any application of the performance approach to 1- and 2-family dwellings. Given this, it is questionable why we should spend additional research dollars to the development of the performance approach for buildings with the best fire record. Again, NFPA statistics indicate that the number of fire fatalities which occur in commercial (non-residential) buildings is 200 or less each year and, in recent years, this number has dwindled to less than 100 fire deaths. Given this, the need to develop the performance approach to fire safety is questionable given that the existing prescriptive approach is working rather well.
The question which should be asked and answered by NIST is are there any more important research projects which should be funded instead of research into developing the performance approach to fire safety. Government statistics consistently indicate that more than 40,000 Americans die each year as a result of

traffic accidents. 40,000+ fatalities vs. 200 fatalities (at most). That means that there are at least 39,800 more highway fatalities each year in the U.S. than there are fire fatalities in commercial buildings. Is it unethical to be using research dollars into fire safety for commercial buildings when 200 times the number of Americans who die in fires in commercial buildings die in traffic accidents?

Suggestion for Revision:

It is suggested that NIST provide a technical justification for the need to develop the performance approach to building fire safety.

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Paragraph/Sentence:

"*This performance-based capability should include, but not be limited to:*

a. *Standard methodology, supported by performance criteria, analytical design tools, and practical design guidance; related building standards and codes for fire resistance design and retrofit of structures, working through the consensus process for nationwide adoption; comprehensive design rules and guidelines; methodology for evaluating thermostructural performance of structures; and computational models and analysis procedures for use in routine design practice.*
b. *Standard methodology for specifying multicompartment, multifloor fire scenarios for use in the design and analysis of structures to resist fires, accounting for building-specific conditions such as geometry, compartmentation, fuel load (e.g., building contents and any flammable fuels such as oil and gas), fire spread, and ventilation; and methodology for rating the fire resistance of structural systems and barriers under realistic design-basis fire scenarios.*

c. *Publicly available computational software to predict the effects of fires in tall buildings? developed, validated, and maaintained through a national effort?for use in the design of fire protection ssystems and the analysis of building response to fires. Improvements should include the fire behavior and contribution of real combustibles; the performance of openings, including door openings and window breakage, that controls the amount of oxygen available to support the growth and spread of fires and whether the fire is fuel-controlled or ventilation-controlled; the floor-to-floor flame spread; the temperature rise in both insulated and uninsulated structural members and fire barriers; and the structural response of components, subsystems, and the total building system due to the fire.*

d. *New test methods, together with associated conformance assessment criteria, to support the performance-based methods for fire resistance design and retrofit of structures. The performance objective of burnout without collapse will require the development of standard fire exposures that differ from those currently used.*"

Comment:

It appears that NIST is proposing a massive research effort which could take years to implement. It is assumed that the funding for the research would either go to NIST or be controlled by NIST, yet NIST hasn't attempted to make a case why the method in use today is "broken". With the exception of residential occupancies, the fire record of buildings in the United States is excellent. Given this, one would certainly have to question NIST's motives in making this proposal. Again, given the number of traffic fatalities which occur in the United States each year vs. the minuscule number of fire fatalities which occur in commercial buildings each year, is it even ethical that we spend the sort of capital required to implement NIST's recommendations?

Suggestion for Revision:

Recommendation 9 should be deleted.

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Report Number: NIST NCSTAR 1

Page Number: 208

Paragraph/Sentence:

"***Recommendation 10.*** *NIST recommends the development and evaluation of new fire resistive coating materials, systems, and technologies with significantly enhanced performance and durability to provide protection following major events. This could include, for example, technologies with improved adhesion, double-layered materials, intumescent coatings, and more energy absorbing SFRMs.31 Consideration should be given to pre-treatment of structural steel members with some type of mill-applied fire protection to minimize the uncertainties associated with field application and in-use damage. If such an approach was feasible, only connections and any fire protection damaged during construction and fit-out would need to be field-treated.*"

Comment:

This recommendation does not address the cost vs. benefit. NIST has yet to define the problem (in terms of loss history) that the nation faces. Will the cost of implementing this recommendation exceed the benefits produced? On the surface, this recommendation appears to be logical, however, without additional information on the cost of such products, no conclusion can be made as to whether or not this is a good idea.

Suggestion for Revision:

Provide a technical justification and the cost vs. benefit analysis so that it can be determined whether or not this recommendation makes economic sense.

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Report Number: NIST NCSTAR 1

Page Number: 208

Paragraph/Sentence:

Footnote 31:

"*Other possibilities include encapsulation of SFRM by highly elastic energy absorbing membranes or commodity grade carbon fiber or other wraps. The membrane would remain intact under shock, vibration, and impact but may be compromised in a fire, yet allowing the SFRM to perform its thermal insulation function. The carbon wrap would remain intact under shock, vibration, and impact and, possibly, under fire conditions as well.*"

Comment:

Interesting concepts, but it is not clear what the intent of the proposed concepts is. Is this an attempt to address a September11th style missile attack or a typical building fire? If the answer is a typical building fire, then a loss history should be presented indicating that there is a problem with the present system of fireproofing.

Suggestion for Revision:

The specific purpose of the concepts discussed should be indicated and a loss history should be provided.

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Report Number: NIST NCSTAR 1

Page Number: 209

Paragraph/Sentence:

"**Recommendation 12.** *NIST recommends that the performance and redundancy of active fire protection systems (sprinklers, standpipes/hoses, fire alarms, and smoke management systems) in buildings should be enhanced to accommodate the greater risks associated with increasing building height and population, increased use of open spaces, available compartmentation, high-risk building activities, fire department response limits, transient fuel loads, and higher threat profile. The performance attributes should deal realistically with the system design basis, reliability of automatic/manual operations, redundancy, and reduction of vulnerabilities due to single point failures.*"

Comment:

There are numerous points in sprinkler and standpipe systems were failure could cause the failure of the entire system. (For example, the breaking a riser could imperil the water supply for the sprinkler system even in systems designed with a two riser supply.) Even though this is the case, both sprinkler and standpipe systems are highly reliable systems. In the last 30 years, Schulte & Associates is unaware of a major fire occurring in a high rise building protected throughout by a sprinkler system, although several major fires have occurred in buildings partially protected by a sprinkler system (i.e. MGM Grand Hotel-Las Vegas and the One Meridian Plaza Building-Philadelphia). That's quite a record.

Given the excellent fire safety record of U.S. high rise buildings, it is difficult to understand the basis for the NIST's recommendation. NFPA's statistics on high rise buildings show that the taller the building, the safer the building is from a fire safety standpoint. This statistic is logical simply because larger buildings have more professional and larger maintenance staffs.

One project which should have been included in the WTC towers collapse investigation was a project to determine the failure rate of sprinkler systems, particularly in high rise buildings.

Suggestion for Revision:

NIST should provide a technical basis for this recommendation or delete Recommendation 12 in its entirety.

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Report Number: NIST NCSTAR 1

Page Number: 209 and 210.

Paragraph/Sentence:

"**Recommendation 14.** *NIST recommends that control panels at fire/emergency command stations in buildings should be adapted to accept and interpret a larger quantity of more reliable information from the active fire protection systems that provide tactical decision aids to fireground commanders, including water flow rates from pressure and flow measurement devices, and that standards for their performance be developed."*

Comment:

The above is a curious recommendation. The background on the formulation of this recommendation would be of interest. Also of interest would a cost/benefit analysis. Given that the performance of high rise buildings protected throughout by a sprinkler system has been perfect over the last 30 years, the need to implement this recommendation appears to be questionable.

Given my experience working with the San Jose Fire Department, I can state that most fire officers have absolutely no interest in the control panels required to be provided in high rise buildings. Given this, providing this additional information may simply be one more "gadget" that is not utilized by fire departments.

Suggestion for Revision:

Information should be provided on the background used to develop this recommendation. A cost/benefit analysis for this recommendation should be included in the report. It is also suggested that information from fire ground commanders as to whether or not the information which would be provided would be of useful to them should be included in the report.

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Report Number: NIST NCSTAR 1

Page Number: 210

Paragraph/Sentence:

"**Recommendation 15.** *NIST recommends that systems should be developed and implemented for: (1) real-time off-site secure transmission of valuable information from fire alarm and other monitored building systems for use by emergency responders, at any location, to enhance situational awareness and response decisions and maintain safe and efficient operations32; and (2) preservation of that information either off-site or in a black box that will survive a fire or other building failure for purposes of subsequent investigations and analysis. Standards for the performance of such systems should be developed, and their use should be required.* "

Comment:

NIST does not provide any technical justification for this recommendation. How often would this information be of use? What is the cost? It seems like this recommendation is just another "gadget". Simply because we can do it, do we really want to implement this recommendation?

Suggestion for Revision:

NIST should provide a technical justification for this recommendation, including a cost/benefit analysis.

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Report Number: NIST NCSTAR 1

Page Number: 210

Paragraph/Sentence:

"**Recommendation 16.** *NIST recommends that public agencies, non-profit organizations concerned with building and fire safety, and building owners and managers should develop and carry out public education campaigns, jointly and on a nationwide scale, to improve building occupants' preparedness for evacuation in case of building emergencies.* "

Comment:

This recommendation sounds a lot like the safety demonstration that they give on aircraft which nobody pays any attention. With all of the warnings we are given today, this will simply be one more warning which the public ignores. This sounds like a big waste of money to me. The benefit of such a public education campaign is simply not worth the cost.

This recommendation appears to assume that there is an unlimited supply of taxpayer money to support such a public education program. We can't even teach our children to read and do math. What makes NIST think that we can educate the public on evacuation procedures if we can't educate our own children?

Suggestion for Revision:

Delete Recommendation 16.

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Report Number: NIST NCSTAR 1

Page Number: 211

Paragraph/Sentence:

"**Recommendation 17.** *NIST recommends that tall buildings should be designed to accommodate timely full building evacuation of occupants due to building-specific or large-scale emergencies such as widespread power outages, major earthquakes, tornadoes, hurricanes without sufficient advanced warning, fires, accidental explosions, and terrorist attack. Building size, population, function, and iconic status should be taken into account in designing the egress system. Stairwell and exit capacity35 should be adequate to accommodate counterflow due to emergency access by responders.*"

Comment:

Based upon statements made by Dr. Sunder, NIST recommendations do not address terrorist attacks, yet Recommendation 17 specifically mentions terrorist attacks. NIST needs to definitively state whether or not its recommendations are intended to address terrorist attacks. If indeed the recommendations are intended to address terrorist attacks, then NIST needs to define the type of terrorist attack which these recommendations are supposed to address. Stating that this recommendation is intended to address terrorist attack without defining the type of terrorist attack is meaningless.

This recommendation specifically states that the egress system should be designed for total evacuation in the event of a hurricane which arises without warning. Schulte & Associates is aware that such events used to occur a century ago, but it is Schulte & Associates understanding that the NOAA is now able to track hurricanes as they form. Given this, NIST should provide an explanation as to what a hurricane which arises without warning actually is.

The high rise provisions included in the model building codes specifically require that standby electrical power systems be provided in high rise buildings. Given this, it is not clear why the egress system serving a building needs to be designed for rapid evacuation in the event of a power outage.

In general, it is not apparent what the basis is for this recommendation. It is also noted that NIST did not mention meteor strikes or attack by alien spacecraft in Recommendation 17. In many cases, the probability of sudden hurricanes and earthquakes is as about as probable as meteor strikes and attacks by alien spacecraft.

Suggestion for Revision:

NIST should include a technical justification for this recommendation which among other things addresses probability of the occurrences listed above and includes a loss history.

Suggestion for Revision:

NIST should include a technical justification for this recommendation which among other things addresses probability of the occurrences listed above and includes a loss history.

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Report Number: NIST NCSTAR 1

Page Number: 211

Paragraph/Sentence:

"Mobility challenged occupants should be provided a means for self-evacuation in the event of a building emergency. Current strategies (and law) generally require the mobility challenged to shelter-in-place and await assistance. New procedures, which provide redundancy in the event that the floor warden system or co-worker assistance fails, should consider full building evacuation, and may include use of fire-protected and structurally hardened elevators37, motorized evacuation technology, and/or dedicated communication technologies for the mobility challenged."

Comment:

Again, NIST has not provided a technical justification for this statement. A cost/benefit analysis should be provided, as well as a loss history. Sufficient data should be available from the collapse of the WTC towers to determine the need for special egress facilities for "mobility challenged occupants".

The probability of events which would require a full building evacuation should be provided. At this point in time, we know that more than 40,000 Americans die each year in traffic accidents. From a cost/benefit standpoint, it seems reasonable that we would get a greater return on our investment investing in traffic safety than we would get implementing the recommendation above. It should be noted that far more "mobility impaired occupants" die in traffic accidents each year than die in building incidents which require full building evacuation.

Suggestion for Revision:

This paragraph should be revised and expanded to include a cost/benefit analysis and a loss history.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comments
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 211

Paragraph/Sentence:

Footnote 35

"*Egress capacity should be based on an all-hazards approach that considers the number and width of stairs (and doors) as well as the possible use of scissor stairs credited as a single stair.* "

Comment:

It is not clear as to exactly what an "all-hazards approach" means in the above footnote. In addition to hurricanes and earthquakes in areas where hurricanes and earthquakes have never historically occurred, this statement could refer to meteor strikes and attacks by space aliens. It is recommended that NIST specifically enumerate the hazards which NIST anticipates in the "all-hazards approach" and also provide probabilities for each event occurring and for multiple hazard events, i.e. simultaneous seismic events and hurricanes. It is my opinion that the probability of some of these events occurring is so close to zero that designing for these events is simply illogical.

Suggestion for Revision:

The statement above should be expanded to list the specific hazards NIST intends to be addressed, as well as provide estimates of the probability that these hazards would actually occur.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 211

Paragraph/Sentence:

Footnote 36

"*Use of egress models is required to estimate the egress capacity for a range of different evacuation strategies, including full building evacuation. NIST found that the average surviving occupant in the WTC towers descended stairwells at about half the slowest speed previously measured for non-emergency evacuations.*"

Comment:

The above footnote implies that the egress facilities provided for the towers were deficient. The statement in the footnote appears to be at odds with NIST's finding that more that 99 percent of the occupants of the WTC towers below the floors of impact in each tower were able to evacuate safely.

Suggestion for Revision:

Footnote 35 should be deleted.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 212

Paragraph/Sentence:

"**Recommendation 18.** *NIST recommends that egress systems should be designed: (1) to maximize remoteness of egress components (i.e., stairs, elevators, exits) without negatively impacting the average travel distance; (2) to maintain their functional integrity and survivability under foreseeable building-specific or large-scale emergencies; and (3) with consistent layouts, standard signage, and guidance so that systems become intuitive and obvious to building occupants during evacuations.* "

Comment:

NIST has provided no basis for Recommendation 18. The 9/11 incident at the WTC towers only proved that the towers were not designed for a missile attack and, even though this was the case, the performance of the WTC towers under such adverse conditions was excellent.

The location of exit stairs has to be balanced by the functionality of the building. Present code provisions for the locations of exit stairs with respect to one another address both occupant safety and building functionality. The historical record demonstrates that this is the case. Based upon this, it is my conclusion that item (1) in Recommendation 18 is in error.

Item (2) addresses the structural integrity of exit stair enclosures. Again, the historical record indicates that the performance of gypsum wallboard enclosures is more than adequate. Providing masonry enclosures of the exit stairs at the WTC towers would not necessarily have affected the outcome of the 9/11 incident. Masonry or concrete enclosures are no match for missiles impacting a building at speeds of 400 mph. Item (2) appears to suggest that exit stair and elevator enclosures should be designed to withstand the impact of missiles. It should also be noted that item (2) does not address the issue of the protection of door openings into exit stair and elevator hoistway enclosures.

There have been numerous failures of concrete enclosures of exit stairs. One recent failure involving concrete stair enclosures is the fire at the Cook County

Administration Building on October 17, 2003. Another failure of a concrete exit stair enclosure is the fire at the One Meridian Plaza Building in Philadelphia.

Item (3) above appears to be common sense, however, the historical record indicates that problems with the layout of exit stairs is rarely, if ever, a problem. The problems which occurred in the WTC towers on 9/11 appear to be a problem unique to the City of New York. It appears that NIST is blaming the stair layout design instead of an ordinance passed by the City of New York

Suggestion for Revision:

Recommendation 18 should be revised and expanded to provide a technical justification for this recommendation.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 212

Paragraph/Sentence:

"While NIST does not believe that buildings should be designed for aircraft impact, as the last line of defense for life safety, the stairwells and elevator shafts individually, or the core if these egress components are contained within the core, should have adequate structural integrity to withstand accidental structural loads and anticipated risks."

Comment:

The above does not provide any technical documentation for the statement. The historical record has demonstrated that gypsum wallboard enclosures provide more than adequate protection for exit stairs and elevator hoistways.

In the statement above, NIST specifically states that it is NIST's opinion that stair and elevator hoistway enclosures should not be designed for aircraft impact. Given this, there seems to little basis for this statement.

Suggestion for Revision:

The statement above should be deleted.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 212

Paragraph/Sentence:

"*Stairwell remoteness requirements should be met by a physical separation of the stairwells that provide a barrier to both fire and accidental structural loads. Maximizing stairwell remoteness, without negatively impacting the average travel distance, would allow a stairwell to maintain its structural integrity independent of any other stairwell that is subject to accidental loads, even if the stairwells are located within the same structural barrier such as the core. The current "walking path" measurement allows stairwells to be physically next to each other, separated only by a fire barrier. Reducing the clustering of stairways that also contain standpipe water systems provide the fire service with increased options for formulating firefighting strategies.*"

Comment:

Again, NIST has not provided any technical documentation to support this recommendation. The historical record indicates that the code provisions included in recent editions of the either the International Building Code or NFPA 5000 are more than adequate.

Suggestion for Revision:

Provide a technical justification for this recommendation or delete the above paragraph.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 213

Paragraph/Sentence:

"*Egress systems should have consistent layouts with standard signage and guidance so that the systems become intuitive and obvious to all building occupants, including visitors, during evacuations. Particular consideration should be given to unexpected deviations in the stairwells (e.g., floors with transfer hallways).*"

Comment:

Again, NIST has not provided any technical justification or information on the historical record to support this recommendation.

This statement also do not recognize the benefit of compartmenting the stair enclosures. Transfer corridors within stairs are likely to be necessary if the exit stairs are to be compartmented. Compartmenting the stair enclosures prevents entire stairs from being contaminated with combustion products in the event of a failure of the enclosure.

Suggestion for Revision:

Revise the report to include a technical documentation for this statement or delete the sentence above.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 213

Paragraph/Sentence:

"*Recommendation 19. NIST recommends that building owners, managers, and emergency responders develop a joint plan and take steps to ensure that accurate emergency information is communicated in a timely manner to enhance the situational awareness of building occupants and emergency responders affected by an event.*"

Comment:

Recommendation 19 is obviously a response to 9/11. Given that no one ever anticipated an event of this magnitude occurring in Lower Manhattan, it isn't surprising that there problems with coordination of emergency responders. The question is do we really want our first responders to be capable of responding to an event of this magnitude? At first blush, this sounds like a silly question, however, the cost of training for such an event and maintaining readiness for a similar event will be astronomical. Given this, NIST needs to clarify exactly the magnitude and type of events that NIST is recommending readiness. In my mind, it is doubtful that the City of New York could afford the cost of maintaining sufficient readiness for another 9/11 event say 15 years in the future.

It should be noted that the terrorist organizations are engaging in economic warfare against the United States and other countries. It is possible to spend ourselves into defeat without the enemy expending a great deal of capital if we overact to the 9/11 event. It is sad to say, but we may need to absorb and accept civilian casualties in this war in order to actually win. Casualties are fact of life in war. Given the number of terrorist targets in the United States, it is simply not possible to protect them all.

Suggestion for Revision:

Recommendation 19 should be revised to specifically state what the magnitude of incidence NIST has in mind to address with this recommendation. A cost/benefit analysis should accompany this recommendation so that readers have a idea of the magnitude of the expenditures anticipated by NIST and the benefits that will be provided if this recommendation is implemented. (It should be noted that the benefits would be zero if another event of this magnitude never occurs again.)

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

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Report Number: NIST NCSTAR 1

Page Number: 213

Paragraph/Sentence:

"Situational awareness of building occupants and emergency responders in the form of information and event knowledge should be improved through better coordination of such information among emergency responder groups (9-1-1 dispatch, fire department or police department dispatch, emergency management dispatch, site security, and appropriate federal agencies), efficient sharing and communication of information between building occupants and emergency responders, and improved emergency responder communication systems (i.e., including effective communication within steel and reinforced concrete buildings, capacity commensurate with the scale of operations, and interoperability among different communication systems)."

Comment:

The above statement appears to be in response to the 9/11 incident, however, given the magnitude of the event, communication problems should be expected. The size of the incident will have an impact on the ability of emergency responders to communicate. The problems with communications would likely not have arisen in a smaller event. To conclude that there are major problems with communications based upon this one freak (and totally unanticipated) incident doesn't make sense. The above statement appears to have been specifically included in the report to satisfy complaints by relatives of the victims, rather through thoughtful consideration of the incident.

Suggestion for Revision:

A technical justification for this statement should be provided or this statement should be deleted from the report.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 213

Paragraph/Sentence:

"*The emergency communications systems in buildings should be designed with sufficient robustness and redundancy to continue providing public address announcements or instructions in foreseeable building-specific or large-scale emergencies, including widespread power outage, major earthquakes, tornadoes, hurricanes, fires, and accidental explosions. Consideration should be given to placement of building announcement speakers in stairways in addition to other standard locations.*"

Comment:

The cost of the emergency communications system installation in a building will be dependent upon the damage which we expect the communications system to survive and still be capable of functioning. Given the low probability of the events listed above, the question is whether the cost of increasing the survivability of the communications system is worth the benefit. We don't expect aircraft passenger to survive a crash, why should be expect a communications system to survive a strike by a tornado?

One other question we need to ask is, if the communications system is designed to survive an event listed above, such as a tornado, but the building is destroyed because the building has not been designed to withstand a tornado, what is the point of having the communications systems still be operative? The statement above is simply not logical.

Suggestion for Revision:

The statement above should be reconsidered and revised so that the statement is logical.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@NIST.GOV

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 214

Paragraph/Sentence:

"**Recommendation 20.** *NIST recommends that the full range of current and next generation evacuation technologies should be evaluated for future use, including protected/hardened elevators, exterior escape devices, and stairwell navigation devices, which may allow all occupants an equal opportunity for evacuation and facilitate emergency response access.*"

Comment:

The above recommendation does not specifically indicate what hazard is being addressed by this recommendation. Based upon the historical record, it would seem that the performance of the forms of egress presently considered to acceptable by building codes is acceptable. It seems that Recommendation 20 has been specifically included to address missile attacks by terrorists. NIST needs to decide whether or not this report is intended to address terrorist missile attacks. If NIST believes that buildings should be designed for terrorist missile attacks, it should state that this is the case.

Suggestion for Revision:

A further explanation of this recommendation is required.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

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Report Number: NIST NCSTAR 1

Page Number: 216 and 217

Paragraph/Sentence:

"**Recommendation 25.** *Nongovernmental and quasi-governmental entities that own or lease buildings and are not subject to building and fire safety code requirements of any governmental jurisdiction are nevertheless concerned about the safety of the building occupants and the responding emergency personnel. NIST recommends that such entities should be encouraged to provide a level of safety that equals or exceeds the level of safety that would be provided by strict compliance with the code requirements of an appropriate governmental jurisdiction. To gain broad public confidence in the safety of such buildings, NIST further recommends that it is important that as-designed and as-built safety be certified by a qualified third party, independent of the building owner(s). The process should not use self-approval for code enforcement in areas including interpretation of code provisions, design approval, product acceptance, certification of the final construction, and post-occupancy inspections over the life of the buildings.* "

Comment:

This comments appears to have been included in the report to satisfy relatives of the families of the victims and lends credence to their charges that the buildings were somehow defective (even though NIST has been unable to document that this is the case).

Based upon the NIST report, it is my conclusion that the Port Authority, the design professionals and the construction team did an excellent job of designing and construction WTC 1 and WTC 2. Given this, there appears to be no basis for Recommendation 25. The recommendation presupposes that a governmental body cannot design and construct a building which complies with code requirements without some outside entity verifying that this is the case. This comment also presupposes that governmental bodies are capable of reviewing building designs and inspecting building construction to verify compliance. It has been my experience that most enforcing authorities do a poor job of verifying compliance with code requirements. Hence, it appears that NIST is suggesting a higher degree of standard for governmental bodies, such as the Port Authority, than the local governments utilize for their review of private sector construction.

Suggestion for Revision:

Recommendation 25 should be deleted.

From: FPESCHULTE@aol.com
Subject: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 217

Paragraph/Sentence:

"**Recommendation 26.** *NIST recommends that state and local jurisdictions should adopt and aggressively enforce available provisions in building codes to ensure that egress and sprinkler requirements are met by existing buildings44. Further, occupancy requirements should be modified where needed (such as when there are assembly use spaces within an office building) to meet the requirements in model building codes.*"

Comment:

It should be noted that our present fire record in the United States has been established with relatively lax enforcement of codes for both new and existing buildings. The NFPA has recently released its estimates for fire fatalities in 2004. The NFPA estimates that only 80 fire fatalities occurred in all of the commercial buildings in the United States in 2004. In other words, the fire record of commercial buildings in the United States is excellent, despite the relatively lax enforcement. Given this, it seems that a rigorous cost/benefit analysis should be applied to determine whether it makes sense to implement Recommendation 26.

Statistics published by the National Fire Protection Association indicate that a total of only 7 fire deaths occurred in all of the high rise office buildings in the United States in the 14 year period between 1985 and 1998. This statistic includes both sprinklered and unsprinklered high rise buildings. Given this, it can be concluded that the risk of fire fatalities in both sprinklered and unsprinklered high rise buildings is practically zero. Based upon this, the need to implement Recommendation 26 is questionable.

These statistics also seem the challenge the need for more restrictive code requirements recommended by NIST.

Suggestion for Revision:

A rigorous cost/benefit analysis should be included in the report to establish whether or not the upgrading of existing buildings to comply with requirements for existing buildings contained in various codes is actually cost effective.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 217

Paragraph/Sentence:

"**Recommendation 27.** *NIST recommends that building codes should incorporate a provision that requires building owners to retain documents, including supporting calculations and test data, related to building design, construction, maintenance and modifications over the entire life of the building45. Means should be developed for offsite storage and maintenance of the documents. In addition, NIST recommends that relevant building information should be made available in suitably designed hard copy or electronic format for use by emergency responders. Such information should be easily accessible by responders during emergencies.*"

Comment:

Simply because a provision is included in building codes which requires that building owners retain construction documents does not mean that building owners will comply with the requirement. Given this, who will be checking to see if building owners do indeed retain the construction documents over the life of a building when it is conceivable that the life of building could extend a century or more? What will be the penalty if a building owner does not retain the documents?

The last sentence of Recommendation 27 is an interesting statement. Imagine if the construction documents had been available to the FDNY on 9/11. Could you imagine fire ground commanders thumbing through 30 year old construction documents during the incident? It took NIST almost 2 years of investigation to determine the cause of the collapse without a raging fire overhead. Imagine looking through construction documents for these two buildings during the actual incident.

On the surface, this recommendation appears to be logical, however, in the context of the 9/11 incident in Lower Manhattan, this recommendation is essentially useless. The real purpose of this recommendation is to assist in an investigation after an incident.

Suggestion for Revision:

Recommendation 27 should be revised so that it addresses the practicality of the real world.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 218

Paragraph/Sentence:

"**Recommendation 28.** *NIST recommend that the role of the "Design Professional in Responsible Charge"46 should be clarified to ensure that: (1) all appropriate design professionals (including, e.g., the fire protection engineer) are part of the design team providing the standard of care when designing buildings employing innovative or unusual fire safety systems47, and (2) all appropriate design professionals (including, e.g., the structural engineer and the fire protection engineer) are part of the design team providing the standard of care when designing the structure to resist fires, in buildings that employ innovative or unusual structural and fire safety systems.*"

Comment:

Recommendation 28 appears to assume that the design of the World Trade Center towers was somehow "innovative or unusual". As an engineer, I am not sure that I would agree that the design of the WTC towers was either "innovative or unusual".

Recommendation 28 also appears to assume that the design of the World Trade Center towers would have been done differently if a fire protection engineer had been part of the design team. Based upon information that I am aware of, the Port Authority did employ fire protection engineers.

Testing of the floor construction conducted by NIST in August 2004 demonstrated that the floor construction in the WTC towers did indeed develop a 2 hour fire resistance rating. The actual incident on 9/11 clearly demonstrated that the actual fire resistance of the structural system supporting the floor far exceeded 2 hours (with the fireproofing intact). The performance of the WTC towers far exceeded that which would have been predicted by either fire testing or a fire protection engineer.

Suggestion for Revision:

Recommendation 28 should include a clarification as to the meaning of "innovative or unusual" or, preferrably, be deleted in its entirety.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 218

Paragraph/Sentence:

"**Recommendation 29.** *NIST recommends that continuing education curricula should be developed and programs should be implemented for training fire protection engineers and architects in structural engineering principles and design, and training structural engineers, architects, and fire protection engineers in modern fire protection principles and technologies, including fire-resistance design of structures. The outcome would further the integration of the disciplines in effective fire-safe design of buildings.*"

Comment:

Recommendation 29 does not address the cost effectiveness of such a recommendation. This recommendation assumes that there is a problem which needs to be addressed, but provides no justification for making this assumption.

The fire record of the United States indicates that, if there is a fire problem in the U.S., it is in 1- and 2-family dwellings, not high rise buildings. NIST does not provide an explanation as to why design professionals designing 1- and 2-family dwellings need the level of expertise which NIST recommends in this recommendation.

Suggestion for Revision:

Delete this recommendation in its entirety.

From: FPESCHULTE@aol.com
Subject: (no subject)
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 218

Paragraph/Sentence:

"**Recommendation 30.** *NIST recommends that academic, professional short-course, and webbased training materials in the use of computational fire dynamics and thermostructural analysis tools should be developed and delivered to strengthen the base of available technical capabilities and human resources.*"

Comment:

Given the fire record in the United States, it is difficult to see why the proposed training is necessary. More than 60 percent of the fire fatalities which occur in the United States occur in 1- and 2-family dwellings and more than 80 percent of the fire fatalities occur in residential occupancies. These percentages have been consistent for years. Given these, it seems that we should be concentrating on the fire problem in residential occupancies. It is highly unlikely that course on computational fire dynamics and thermostructural analysis will have any application in the fire protection of 1- and 2-family dwellings.

Suggestion for Revision:

Recommendation 30 should be deleted.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

Return-path: <FPESCHULTE@aol.com>
From: FPESCHULTE@aol.com
Full-name: FPESCHULTE
Message-ID: <1ff.6b74406.301d5ba0@aol.com>
Date: Sat, 30 Jul 2005 18:39:28 EDT
Subject: (no subject)
To: WTC@nist.gov
MIME-Version: 1.0
Content-Type: multipart/alternative; boundary="-----------------------------1122763168"
X-Mailer: 9.0 Security Edition for Windows sub 5200

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 218

Paragraph/Sentence:

b□**Recommendation 30.** *NIST recommends that academic, professional short-course, and webbased training materials in the use of computational fire dynamics and thermostructural analysis tools should be developed and delivered to strengthen the base of available technical capabilities and human resources.*b□

Comment:

Given the fire record in the United States, it is difficult to see why the proposed training is necessary. More than 60 percent of the fire fatalities which occur in the United States occur in 1- and 2-family dwellings and more than 80 percent of the fire fatalities occur in residential occupancies. These percentages have been consistent for years. Given these, it seems that we should be concentrating on the fire problem in residential occupancies. It is highly unlikely that course on computational fire dynamics and thermostructural analysis will have any application in the fire protection of 1- and 2-family dwellings.

Suggestion for Revision:

Recommendation 30 should be deleted.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 219

Paragraph/Sentence:

"*In its final report, which is expected to be released by September 2005, NIST will finalize these draft recommendations for specific and appropriate improvements to the way buildings are designed, constructed, maintained, and used. It will be important for these recommendations to be thoroughly and promptly considered by the many organizations responsible for building and fire safety.*"

Comment:

NIST has not provided any technical justification for its recommendations. In the absence of a technical justification, which should include a loss history and cost/benefit analysis, NIST should not expect that its recommendations will be taken seriously. It is my opinion that portions of the investigation report which I have reviewed are poorly written and demonstrate a lack of understanding of fire protection concepts. Given this, it is my opinion that NIST needs to do more work on the report prior to finalizing the report.

At this point in time, there is no need for either the ICC or the NFPA to promptly consider NIST's recommendations. It took NIST 3 years to complete its investigation of the WTC towers collapse and submit its recommendations. Given this fact, both the ICC and the NFPA should spend at least another 3 years reviewing NIST's recommendations prior to making a decision as to whether or not the recommendations merit inclusion in the building codes developed by both of these organizations.

It should be noted that the 6 week public comment period on this report is far too short. NIST has spent roughly 1,000 days on its investigation. Allowing only 42 days for public comment on a 10,000 page report is a clear indication that NIST is attempting to limit public comment.

Suggestion for Revision:

It is suggested that the date September 2005 be revised to September 2006.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comment
To: WTC@nist.gov

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Report Number: NIST NCSTAR 1

Page Number: 218

Paragraph/Sentence:

Footnote 47:

"If the fire safety concepts in tall buildings had been sufficiently mature in the 1960s, it is possible that the risks associated with jet-fuel ignited multifloor fires might have been recognized and taken into account when the impact of a Boeing 707 aircraft was considered by the structural engineer during the design of the WTC towers. "

Comment:

The following excerpt is from page 212 of the draft final report:

"*While NIST does not believe that buildings should be designed for aircraft impact, ...*"

This excerpt from page 212 of the report directly contradicts the statement made in Footnote 47.

On September 10, 2001, anyone who would have suggested that buildings should be designed to withstand the events of September 11 would have been considered to be a kook. In fact, it is my opinion that anyone who would suggest that buildings be designed to withstand the events of September 11 after September 11 is a kook.

Suggestion for Revision:

This footnote should be deleted.

From: FPESCHULTE@aol.com
Subject: RE: NIST Draft Final Report Comments
To: WTC@nist.gov

Ladies and Gentlemen-

Attached is a pdf file of the comments submitted by Schulte & Associates between July 26 and July 31.

Richard Schulte
Schulte & Associates
Building Code Consultants
Evanston, Illinois
504/220-7475
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Comments.01.pdf

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NIST DRAFT FINAL REPORT COMMENTS

Comment #1

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1 (Chapter 9)

Page Number: 197

Paragraph/Sentence:

"Codes and standards for the design, construction, operation, and maintenance of buildings are the documents by which a society states its intent to provide public safety and functionality. They incorporate the knowledge, experience, procedures, and practices of the applicable engineering disciplines, the values of the contemporary society, the experiences from prior successes and failures, and knowledge of the commercial products, services, and technologies available for the tasks at hand."

Comment:

The statements that codes and standards . . . are documents by which society states "its intent to provide public safety and functionality" and that codes and standards incorporate "the values of the contemporary society" are a stretch. The codes and standards development process adopted by both the International Code Council (ICC) and the National Fire Protection Association (NFPA) do not go through any process to determine what "society's values" actually are. This statement is an exaggeration at best. Most Americans do not have any awareness of safety codes and standards.

Suggestion for Revision:

The above paragraph should be rewritten to delete references to the fact that codes and standards reflect American "society values" and expectations.

Comment #2

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 197

Paragraph/Sentence:

"The United States has a unique approach to such codes and standards. In virtually all other developed countries the national government has a primary role in the development of national model codes. In the United States, the private sector develops such codes and standards."

Comment:

The above sentences reflect a political viewpoint. The approach to the development of codes and standards is not unique for a capitalist country. Most developed countries referred to in the above sentences are socialist countries (i.e. Canada, Britain, France, Germany) where government is far more involved in the commerce of the country.

Most codes and standards in the United States are not developed in the private sector, but are developed by "quasi-public" non-profit entities. If the entities which developed codes and standards in the United States were for profit corporations, then it could be stated that codes and standards are developed in the private sector.

Suggestion for Revision:

It is suggested that the above sentences be deleted. The process by which codes and standards are developed in socialist countries are of no interest in a society which utilizes capitalism.

Comment #3

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 197

Paragraph/Sentence:

"*Model codes are developed using committees of experts, generally adapted to reflect local climate and geological conditions by state and local governments, and updated every three years.*"

Comment:

The statement that "*model codes are developed using committees of experts*" is factually inaccurate. The ICC process does not utilize committees of experts, but rather committees composed of people which have some expertise in the subject, which is completely different from a committee of experts. Who ever wrote this sentence is apparently not familiar with the ICC code development process.

Suggestion for Revision:

It is suggested that the sentence making references to "*committees of experts*" be revised to be factually accurate.

Comment #4

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 197

Paragraph/Sentence:

"Localities adopting model codes update their versions periodically as well, to follow roughly the same schedule as the model codes."

Comment:

The above sentence is <u>not</u> factually accurate. Some localities update their adoption of model building codes at regular intervals and some do not.

Suggestion for Revision:

It is suggested that the last phrase of the above sentence be deleted.

Comment #5

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 198

Paragraph/Sentence:

"*In addition to standards and codes organizations, there are other key stakeholder groups that either are responsible for or influence the practices used in the design, construction, operation, and maintenance of buildings in the United States.*"

Comment:

The word "*stakeholder*" is a "high-brow" word for "interest" groups.

Suggestion for Revision:

It is suggested that the word "*stakeholder*" in the above sentence be replaced with the term "interest" groups.

Comment #6

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number:

Paragraph/Sentence:

"*Rigorous enforcement of building codes and standards by state and local agencies, well trained and managed, is critical in order for standards and codes to ensure the expected level of safety. Unless they are complied with, the best codes and standards cannot protect occupants, emergency responders, or buildings.*"

Comment:

This statement is "bolded" in the report. It is assumed that the fact that the statement is "bolded" means that the statement is of some importance. **It is noted that this statement is <u>not</u> repeated in either the NIST's recommendations or in NIST's findings.** It would seem that if this statement is important that the concepts expressed in this statement would be included both in the findings and in the recommendations.

It particular, it should be noted that the fire service is typically responsible for the enforcement of the maintenance provisions contained in building and fire prevention codes. The fire service, in general, does a good job about complaining about the maintenance of building fire safety features, but does a poor job actually enforcing maintenance provisions which are under their jurisdiction. Given this, **it is Schulte & Associates' opinion that NIST's finding should include a finding of the poor job of code enforcement that the fire service does. It is also Schulte & Associates' opinion that one of NIST's recommendations should be that the fire service should devote more of its resources to code enforcement, rather than to fire suppression.**

Suggestion for Revision:

It is suggested that the concept expressed in this statement be included in both NIST's recommendations and in NIST's finding.

Comment #7

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 198 and 199

Paragraph/Sentence:

"As part of its WTC Investigation, NIST is issuing draft recommendations for public comment that identify specific improvements in the way buildings are designed, constructed, maintained, and used and in evacuation and emergency response procedures. NIST believes that these recommendations are both realistic and achievable within a reasonable period of time and that their implementation would make buildings safer for occupants and emergency responders in future emergencies."

Comment:

The above paragraph does <u>not</u> address the specific basis for making the recommendations contained in the report. Nor does the paragraph address the meaning of the phrase *"make buildings safer for occupants and emergency responders in future emergencies"*. (Making buildings safer for occupants and emergency responders could mean anything, including recommending that buildings in excess of 1 story in height <u>not</u> be permitted to be constructed.) The public and the industries which would be affected by the recommendations are owed an explanation exactly what definition NIST is using for the term "*safer*".

The above paragraph also does <u>not</u> address the cost of implementing NIST's recommendations. Any proposal for changes to existing building codes should be accompanied by a cost estimate and also a cost/benefit analysis. A clear statement as to the actual reduction in injuries, deaths and property damage should be made by NIST so that the public can judge whether or not NIST's recommendations are cost effective. In order to do a cost/benefit analysis, a clear definition of the actual problem which is being addressed is required. No where in the report does NIST provide a clear statement of the "problem" which exists.

Schulte & Associates has gone on record numerous times stating that the fire safety record of commercial buildings, in particular high rise office buildings, in the United States is excellent and has provided statistics to back up this opinion. NIST has yet to provide any statistics to back up its opinion that there is actually a fire safety problem which exists in the United States which needs to be addressed. The latest fire statistics published by the National Fire Protection Association (for 2004) indicate that more than 60 percent of fire fatalities which occurred in the U.S. occurred in 1- and 2-family dwellings and that in excess of 80 percent of the fire fatalities in the U.S. occurred in residential occupancies. The NFPA estimate of the number of fire fatalities which occurred in commercial (non-residential) buildings in the U.S. in 2004 is only 80 people. The number of fire fatalities in commercial buildings which occurred in the U.S. in 2004 is on the same order as the number of fatalities caused by lightning.

If there is a fire problem in the U.S., the problem is in 1- and 2-family dwellings. NIST's recommendations do not address the fire problem in 1- and 2-family dwellings. To recommend that additional capital be spent on making commercial buildings safer, without addressing the fire safety problem in 1- and 2-family dwellings is like "putting the cart in front of the mule". In my opinion, the Congressional Science Committee should severely chastise NIST for not clearly setting priorities and letting American know the actual safety record of commercial buildings in the United States.

In addition to the above, the paragraph above does not clearly address the issue of terrorism and how buildings should be designed to address this issue. It is my understanding from recent presentations made by NIST in Las Vegas (AIA and NFPA conventions) that NIST recommendations do not and will not address the issue of "terrorist-resistant" or "terrorist-proof" building construction. Given that the statement made by the director of NIST, Dr. Arden Bement, at the Congressional Science Committee hearing on the collapse of the World Trade Center towers on March 6, 2002 specifically promised that this issue would be addressed, NIST should clearly make a statement as to why this issue is not being addressed in the investigation report. Clearly, NIST owes the Congressional Science Committee and the general public an explanation of why the issue of terrorism was not addressed.

Suggestion for Revision:

The technical justifications for NIST's recommendations should be included in the report and sufficient time should be allowed for the public to review and comment on the technical justifications advanced by NIST.

An explanation as to why the issue of "terrorist-resistant" or "terrorist-proof" was not included in the report should be included in the NIST report and also be submitted to the Congressional Science Committee.

In addition to the above, it is my opinion that the director of NIST should be recalled to the Congressional Science Committee to explain Dr. Bement's testimony before the Congressional Science Committee on March 6, 2002.

Comment #8

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 198

Paragraph/Sentence:

"*In addition to standards and codes organizations, there are other key stakeholder groups that either are responsible for or influence the practices used in the design, construction, operation, and maintenance of buildings in the United States. These typically include organizations representing building owners and managers (e.g., Building Owners and Managers Association, Construction Industry Institute), real estate developers (e.g., Real Estate Board of New York), contractors (e.g., Associated General Contractors, Associated Builders and Contractors), architects (e.g., American Institute of Architects), engineers (e.g., National Society of Professional Engineers, Society of Fire Protection Engineers, Structural Engineering Institute, National Council of Structural Engineering Associations), suppliers, and insurers. These groups also provide training, especially as it affects the ability to implement code provisions in practice. Lack of adequate training programs can limit the usefulness or widespread acceptance of improved code provisions. Very few members of the general public and building occupants participate in this process.*"

"*The National Institute of Standards and Technology (NIST) is a non-regulatory agency of the U.S. Department of Commerce. NIST does not set building codes or standards, but provides technical support to the private sector and to other government agencies in the development of U.S. building and fire practice, standards and codes. NIST provides this support by: conducting research which helps to form the technical basis for such practice, standards, and codes; disseminating research results to practicing professionals; having its staff participate on technical and standards committees; and, providing technical assistance to the building and fire safety communities. Due to limited participation of the general public and building occupants, NIST has a responsibility to represent the public's interest. As an objective and impartial technical entity, NIST recommendations are given serious consideration by private sector organizations that develop national standards and model codes, which provide minimum requirements for public welfare and safety.*"

Comment:

See the attached article on these two paragraphs. This article will be published in the August issue of Plumbing Engineer magazine. The article is titled "The Public's Interest".

Suggestion for Revision:

It is suggested that the last two sentences of the second paragraph above be deleted. NIST does not necessarily "represent the public's interest", nor is NIST necessarily "an objective and impartial technical entity". NIST like every other government agency must secure funding. Hence, NIST is similar to the other interest groups listed in the first paragraph above.

Comment #9

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 199

Paragraph/Sentence:

"*While there were unique aspects to the design of the WTC towers and the terrorist attacks of September 11, 2001, the design, construction, operation, and maintenance of the WTC towers—and the emergency response to the WTC towers—were based on procedures and practices that are commonly used for normal conditions. These include procedures and practices used for construction classification, establishing and determining fire resistance ratings, estimating wind loads, designing structural components and connections, designing egress systems, designing sprinkler systems, evacuation, and emergency response.*"

Comment:

Dr. Bement's statement before the Congressional Science Committee on March 6, 2002 included the following excerpt:

> ". . . *The tragedy that the United States experienced on September 11, 2001, was unprecedented when compared with any prior accident, natural disaster, or terrorist/war attack. The collapse of the twin World Trade Center towers was the worst building disaster in human history. Engineers, emergency responders, and the nation did not anticipate, and were largely unprepared for, such a catastrophe. . . .* "

Dr. Bement's statement at the Congressional Science Committee hearing appears to be at odds with the above paragraph. Either Dr. Bement or NIST is fibbing about whether or not September 11th was a unique event. It is my opinion that Dr. Bement is correct. September 11th was a unique event-the collapse of 2 of the tallest buildings in the United States within 30 minutes of one another, followed by the collapse of a 47 story building within hours of the collapse of the first two buildings. Only a few events in human history parallel this attack (i.e. the atomic bombing of Nagasaki and Hiroshima in August of 1945, fire bombing of Dresden, Germany on Valentine's Day in 1945, the hurricane which destroyed Galveston, Texas in 1900, the San Francisco earthquake and fire in 1906 and the Great Chicago fire in the 1870's).

Suggestion for Revision:

It is suggested that this first sentence in the paragraph above be revised to reflect the uniqueness of the events in Lower Manhattan on September 11th. To say that this event wasn't all that unique is an indication that the scientists at NIST do not understand or have an appreciation of the events in Lower Manhattan on September 11th.

Comment #10

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 199

Paragraph/Sentence:

"*NIST is also making recommendations for selected buildings that are at greater risk, e.g., due to their iconic status, critical function, or design.*"

Comment:

According to NIST, the NIST report will not address terrorism. Given this, it is not clear to what this sentence above actually refers.

Suggestion for Revision:

The above sentence should be reviewed to determine whether or not it is appropriate to include the sentence in this report.

Comment #11

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 200

Paragraph/Sentence:

"*Increased structural integrity, including methods for preventing conditions that could result in progressive collapse (when a building or a significant portion of a building collapses due to disproportionate spread of an initial local failure), standardizing the estimation of wind loads that frequently govern the design of tall buildings, and enhancing the stability of tall buildings.*"

Comment:

It appears that this series of recommendations is based upon the collapse of 3 buildings in Lower Manhattan on September 11th. If the NIST recommendations are not intended to address terrorist events as stated by NIST at both the AIA and NFPA conventions in Las Vegas in May and June of this year, it is not clear how these recommendations arise out of an investigation into a terrorist event. Information presented in the NIST study indicates that the collapse of tall buildings is a very rare event in the United States. Given this, it seems reasonable to ask what is the cost vs. benefit of making changes to the present procedures used to prevent progressive collapse.

Suggestion for Revision:

Since I am not a structural engineer, I am not qualified to make any proposals to change the above, however, the above comment is based upon "plain old common sense".

Comment #12

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 200

Paragraph/Sentence:

"*Improved active fire protection, including the design, performance, reliability, and redundancy of sprinklers, standpipes/hoses, fire alarms, and smoke management systems.*"

Comment:

It was indicated by NIST at the AIA and NFPA conventions in Las Vegas in May and June of this year that NIST's recommendations will not address the issue of terrorism. Given that the fires in the WTC towers were initiated by a terrorist attacks and that the failure of sprinkler systems, standpipe systems, fire alarm systems and smoke management systems were caused by a missile impact, it is not clear how NIST determined that the fire protection systems installed in the towers were insufficiently reliable and that the standards governing the design and installation of these systems need to be improved.

The report does not provide any documentation as to the failure rate of sprinkler systems in high rise buildings (or the failure rate of sprinkler systems in general).

Given the lack of a technical documentation for this general recommendation, it seems reasonable that the construction industry should not act upon this recommendation until NIST provides technical substantiation for making this recommendation.

It should also be noted that the smoke management system in the WTC towers was only designed to be used after the fire was extinguished. Given this, it is puzzling why NIST recommended that the performance and reliability of smoke management system be improved when the fires in the WTC towers were never extinguished.

Suggestion for Revision:

The technical justification for this general recommendation should be included in the report.

Comment #13

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 200

Paragraph/Sentence:

"*Improved building evacuation, including system designs that facilitate safe and rapid egress, methods for ensuring clear and timely emergency communications to occupants, better occupant preparedness for evacuation during emergencies, and incorporation of appropriate egress technologies.*"

Comment:

The NIST study shows that the evacuation of the building below the floors of impact was acceptable. Given this, it is difficult to understand why NIST would recommend further improvements in a system which performed adequately. Again, no rationale for NIST's recommendation was included in the report. Given this, there is no reason why code provisions regarding egress provisions should be modified. Again, the September 11th events were terrorist events and since the NIST recommendations do not address terrorist events, it is difficult to understand how NIST determined that the egress provisions in codes are inadequate based upon this event.

Suggestion for Revision:

A technical justification for the general recommendation should be included in the report.

Comment #14

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 200

Paragraph/Sentence:

"*Improved emergency response, including better access to the buildings and better operations, emergency communications, and command and control in large-scale emergencies.*"

Comment:

This general recommendation is too general to be of any use. Is NIST recommending that every jurisdiction in the United States be prepared to handle a terrorist event such as occurred in Lower Manhattan on September 11^{th}? Implementation of such a recommendation would more than likely bankrupt the country. NIST needs to qualify and quantify exactly what is intended by this recommendation. At presently written, this recommendation is too general to be of any use.

Suggestion for Revision:

This recommendations should be clarified so that NIST's actual intent is reflected in the recommendation.

Comment #15

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 200

Paragraph/Sentence:

"*Improved procedures and practices, including encouraging code compliance by nongovernmental and quasi-governmental entities, adoption and application of egress requirements in available code provisions for existing buildings, and retention and availability of building documents over the life of a building.*"

Comment:

The report documents the excellent job the Port Authority did in designing, constructing and maintaining the WTC towers. Given this fact, it is difficult to understand why NIST would make the recommendation above (other than to satisfy the whining and complaining of the relatives of the victims of the terrorist attack). The Port Authority is exempt from compliance for a reason. The Port Authority should have used this exemption to comply with national standards for building fire safety and fire protection, rather than complying with New York City code requirements.

Suggestion for Revision:

Provide a justification for the recommendation. Without a justification, this general recommendation should be ignored.

Comment #16

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 204

Paragraph/Sentence:

"*The procedures and practices used to ensure the fire resistance of structures should be enhanced by improving the technical basis for construction classifications and fire resistance ratings, improving the technical basis for standard fire resistance testing methods, use of the "structural frame" approach to fire resistance ratings, and developing in-service performance requirements and conformance criteria for spray-applied fire resistive materials.*"

Comment:

This recommendation completely ignores the fire safety record of modern high rise buildings. The recent fire safety record of high rise buildings includes both buildings which are protected throughout by sprinklers and buildings which are not protected by sprinklers. Despite the fact that many unsprinklered high rise office buildings still exist, a study conducted by the National Fire Protection Association found that a total of only 7 Americans died due to fires in high rise office buildings in the time period between 1985 and 1998. Lightning kills more Americans in one year than died as a result of fires in all of the high rise office buildings in the United States in a 14 year period.

Unfortunately, NIST apparently did not think that the NFPA statistics on high rise buildings worth including the report. It can only be assumed that this was an intentional oversight since Schulte & Associates has made NIST aware of these statistics on numerous occasions. Until NIST acknowledges the better than excellent safety record of high rise buildings and justifies the need to implement NIST's recommendations despite the fact that excellent safety record, NIST's recommendation above should be ignored. The high rise provisions presently included in the three regional model building codes (the BOCA National Building Code, the Standard Building Code and the Uniform Building Code) and the two newest model building codes, the International Building Code and NFPA 5000 Building Code, are more than adequate to provide protection for the building occupants and firefighters.

It should be noted that the structural frame approach to fire resistance ratings has been included in all building codes since I first became involved with building codes in the middle 1970's. The three regional model building codes required that floors in high rise buildings develop a 2 hour fire resistance rating and that vertical supports develop either a 2 or 3 hour fire resistance rating. In essence, these codes required a 2 hour structural frame and, in some cases, required the vertical supports to develop an additional hour of structural fire resistance rating. The statement recommending the "structural frame approach" simply demonstrates that NIST does <u>not</u> have a good grasp of the code requirements contained in the various model building codes utilized in the United States.

Suggestion for Revision:

NIST has not provided any technical basis for this recommendation. Without a technical substantiation for this recommendation, this recommendation simply represents an unsupported opinion.

Comment #17

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 204

Paragraph/Sentence:

Footnote 22:

The construction classification and fire rating requirements should be risk-consistent with respect to the design-basis hazards and the consequences of those hazards. The fire rating requirements, which were originally developed based on experience with buildings less than 20 stories in height, have generally decreased over the past 80 years since historical fire data for buildings suggests considerable conservatism in those requirements. For tall buildings, the likely consequences of a given threat to an occupant on the upper floors are more severe than the consequences to an occupant on the first floor or the lower floors. For example, with non-functioning elevators, both the time requirements are much greater for full building evacuation from upper floors and emergency responder access to those floors. It is not clear how the current height and areas tables in building codes consider the technical basis for the progressively increasing risk to an occupant on the upper floors of tall buildings that are much greater than 20 stories in height.

Comment:

The footnote makes the assumption that the risk to building occupants and firefighters increases as the number of stories in a building increases. No technical basis has been provided for making this assumption and it is Schulte & Associates' opinion that the risk to building occupants and firefighters only increases minimally as the number of stories in a building increases (beyond a certain point). The NFPA statistics on high rise office buildings (both sprinklered and unsprinklered) indicate that a total of only 7 Americans died as a result of fires in all of the high rise office buildings in the United States in a 14 year period between 1985 and 1998. Obviously, these statistics show that risk of dying in fire in a high rise office buildings over 20 stories in height is essentially the same as the risk of dying in a high rise office building under 20 stories in height. (The probability of dying in a fire in a high rise office building is essentially 0, regardless of the height of the building, and the probability of dying a fire in high rise building which is protected throughout by a standard NFPA 13 sprinkler system is even less.)

The NFPA fire statistics clearly indicate that the most hazardous building occupancy is 1- and 2-family dwellings, not high rise buildings. The probability of dying in a fire in a 1 or 2 story single-family dwelling is far greater than the probability of dying in a fire in a high rise office building regardless of the height of the building. This statistic directly contradicts NIST's statement in the footnote above that indicates that occupants of higher floors in a high rise buildings are at greater risk (peril) than the occupants of lower floors or the first floor of a building.

Footnote 22 is a poor attempt by NIST to justify their recommendations for changes to the fire safety provisions which apply to high rise buildings. NIST has no way of quantifying the actual risk to occupants and firefighters. The only way to quantify the risk is to look at the NFPA statistics and the NFPA statistics do not support NIST's position.

It should noted that NIST makes reference to a total evacuation of a high rise building in Footnote 22. Given that NIST has stated that the report does not address terrorism, it is not clear why a total evacuation of a high rise building should ever be necessary. Again, the fire statistics for high rise buildings tell us that there has never been a major fire in a U.S. high rise building which is protected throughout by a sprinkler system. In other words, over the last 30 years, the fire record of sprinklered high rise buildings has been not been excellent, it has been perfect. Given this record, NIST needs to justify why a total evacuation is even mentioned in this footnote.

Suggestion for Revision:

NIST needs to provide a justification for the statements made in Footnote 22. Any reference to risk needs to be numerically quantified (i.e. probability as it relates to other events such as being struck by lightning or being involved in a fatal traffic accident). If NIST cannot quantify risk in a numerical way, then NIST's reference to risk in this footnote should be deleted.

Comment #18

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 204

Paragraph/Sentence:

Recommendation 4. NIST recommends evaluating, and where needed improving, the technical basis for determining appropriate construction classification and fire rating requirements (especially for tall buildings greater than 20 stories in height)—and making related code changes now as much as possible—by explicitly considering factors including[21]:

- o the need for redundancy in fire protection systems that are critical to structural integrity[23];

Comment:

This recommendation has already been implemented. The high rise provisions contained in the 3 regional model building codes, the International Building Code and NFPA 5000 all require that the structural elements of high rise office, hotel and apartment buildings develop a minimum fire resistance rating of 2 hours, in addition to being protected throughout with a sprinkler system. The fire which develops in typical office and residential occupancies has a severity equivalent to a 30 to 60 minute exposure to the ASTM E119 time-temperature curve (assuming sprinkler system failure). In other words, a buildings with 2 hour structural elements already are provided with redundant structural fire protection.

This point in Recommendation 4 is simply a recommendation for more research into a subject which we already have sufficient knowledge. There is really no critical need to conduct more research into this subject with public tax dollars. If the scientists at NIST want to fund the research out of their own pockets, then there should be no objections.

Suggestion for Revision:

This point in Recommendation 4 can be deleted.

Comment #19

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 204

Paragraph/Sentence:

Recommendation 4. NIST recommends evaluating, and where needed improving, the technical basis for determining appropriate construction classification and fire rating requirements (especially for tall buildings greater than 20 stories in height)—and making related code changes now as much as possible—by explicitly considering factors including[21]:

- the extent to which redundancy in active fire protection (sprinkler and standpipe, fire alarm, and smoke management) systems should be credited for occupant life safety[22];

Comment:

Since the middle 1970's, the high rise provisions contained in the BOCA Building Code, the Standard Building Code and the Uniform Building Code to varying degrees have permitted reductions ("trade-offs") in passive fire protection requirements when sprinkler protection is provided. These reductions is passive fire protection requirements reduced the net cost of installing sprinkler protection and were used as an incentive to install sprinkler protection. Since these reductions in the requirements for passive fire protection were introduced 30 years ago, no major fire in a U.S. high rise building protected throughout by a sprinkler system has occurred, while a number of major fire in partially sprinklered U.S. high rise buildings (i.e. MGM Grand Hotel-Las Vegas, Hilton Hotel-Las Vegas, First Interstate Bank Building-Los Angeles, One Meridian Plaza Building-Philadelphia) have occurred in this same time period.

Similarly, since the atrium provisions were introduced in these three codes in the late 1970's, there has not been a major fire in a building which has contained an atrium. (The atrium provisions substitute sprinkler protection for floor openings enclosures.)

Given this perfect record, it would be difficult to assert that sprinkler protection is not a highly reliable form of fire protection. Hence, it can be stated that increases in travel distances, exit stairs permitted to be closed to one another, reductions in egress component widths, etc., as well as reductions in passive fire protection which affect occupant fire safety, when sprinkler protection is provided have all been demonstrated to be "safe" in the real world, other than in terrorist incidents (which NIST states are not being addressed).

Suggestion for Revision:

This point in Recommendation 4 can be deleted.

Comment #20

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 204

Paragraph/Sentence:

Recommendation 4. *NIST recommends evaluating, and where needed improving, the technical basis for determining appropriate construction classification and fire rating requirements (especially for tall buildings greater than 20 stories in height)—and making related code changes now as much as possible—by explicitly considering factors including*[21]:

- o *compartmentation requirements (e.g., 12,000 ft^2 (24)) to protect the structure, including fire rated doors and automatic enclosures, and limiting air supply (e.g., thermally resistant window assemblies) to retard fire spread in buildings with large, open floor plans;*

Comment:

This recommendation ignores the excellent history of sprinkler protection in preventing the spread of fire. In the last 30 years, there has been no record of a sprinkler system failure resulting in a major fire in a high rise building (regardless of whether the building is 7 stories or 100 stories in height). NIST has not included any justification for why we need compartmentation of floors in addition to providing sprinkler protection.

Given the excellent fire loss record of high rise buildings protected throughout by sprinklers in the last 30 years, it seems illogical (at best) that NIST would recommend compartmentation in addition (or more appropriately, on top of) providing sprinkler protection in high rise office buildings.

Based upon the fire record of high rise office buildings, it seems far more appropriate that NIST would recommend providing sprinkler protection in 1- and 2-family dwellings, rather that providing compartmentation in sprinklered high rise office buildings. The benefit of providing compartmentation in addition to sprinkler protection is simply <u>not</u> worth the cost. The probability of a major fire in a sprinklered high rise building is practically nil.

Suggestion for Revision:

The recommendation that compartmentation be provided in high rise buildings, in addition to sprinkler protection, should be deleted.

Comment #21

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 205

Paragraph/Sentence:

"*Adoption of this recommendation will allow building codes to distinguish the risks associated with different building heights, fuel concentrations, and fire protection systems. Research is needed to develop the data and evaluate alternative proposals for construction classifications and fire ratings. National Model Building Codes: The national model building code committees should undertake a comprehensive review of current construction classification and fire rating requirements and establish a uniform set of revised thresholds with a firm technical basis that considers the factors identified above.*"

Comment:

The statement above makes the assumption that the fire safety risk of tall buildings is greater than buildings of lesser height. The NFPA fire fatality statistics indicate that this is <u>not</u> the case. The NFPA fire fatality statistics clearly indicate that the risk of residential occupancies of any height is far greater than the risk of commercial buildings again of any height. Hence, it is my opinion that the fire risk to occupants of a one story single family dwelling is significantly greater than the fire risk to occupants of the 100th floor of a high rise office building.

The risk to occupants of high rise buildings, of course, varies with the protection provided for the building. Providing 2 hour fire resistive construction Type II (222) construction (as defined by NFPA 220) substantially reduces the risk of building collapse in a fire in a high rise office and residential buildings. Providing sprinkler protection throughout a high rise office or residential building, in addition to Type II (222) construction, reduces the probability of building collapse in a fire to essentially to 0. Providing sprinkler protection in the building, along with egress routes, reduces the probability of a large fire with major life loss also essentially to zero. Given that the probability of a major fire and building collapse in a high rise office or residential building is essentially zero when Type II (222) construction and sprinkler protection is provided, the risk to building occupants of a high rise building simply cannot be significantly reduced by providing additional fire safety features in the building because the probability of a major fire in the building is already essentially zero. Increasing the structural fire resistance of columns to 3 hours will not significantly reduce the risk. Neither will providing additional compartmentation. Hence, NIST needs to justify its statements regarding risk in the above paragraph.

Suggestion for Revision:

It is recommended that a comprehensive discussion of risk be included in the report. This discussion should specifically address the fire risk to occupants of single family versus the fire risk to occupants of the upper stories of a high rise building.

Comment #22

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 205

Paragraph/Sentence:

"*NIST recommends that the technical basis for the century-old standard for fire resistance testing of components, assemblies, and systems should be improved through a national effort. Necessary guidance also should be developed for extrapolating the results of tested assemblies to prototypical building systems.*"

Comment:

To quote an old saying: "If it ain't broke, don't fix it." The ASTM E119 fire resistance test has been in use for roughly 80 years, however, this does not necessarily mean that we need to find a new and more complex method of determining fire resistance if ASTM E119 still provides useful information. While I clearly agree with NIST's assessment that there are deficiencies with the ASTM E119 test, the use of the test has "stood the test of time". The reason for this is that the results of ASTM E119 are conservative (although it is difficult to quantify the conservatism built into the test). Any new method of determining fire resistance will likely reduce the conservatism inherent in ASTM E119. In other words, any new method of determining fire resistance would likely reduce the structural fire resistance built into our buildings. It is my opinion that reducing the conservatism built in to the structural fire resistance of buildings would be a positive step, however, it is my opinion that developing a replacement for ASTM E119 is not absolutely essential to providing structural fire safety. In other words, ASTM E119 is working just fine. We have more important safety issues to address than finding a replacement for ASTM E119 such as 1- and 2-family dwelling fire safety and highway safety. To my knowledge, no one has died as a result of the unquantifiable conservatism built into ASTM E119.

Suggestion for Revision:

It is suggested that Recommendation 5 be deleted in its entirety or be revised to indicate that this is a relatively unimportant research project.

Comment #23

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 205

Paragraph/Sentence:

Footnote 26:

"*The technical issues were identified from the series of four fire resistance tests of the WTC floor system and the review and analysis of relevant documents that were conducted as part of this Investigation.*"

Comment:

NIST being a science-based organization should be aware that a series of 4 fire resistance tests is too small of a sample to make the sweeping generalizations made in this recommendation. This statement in Footnote 26 reflects poorly on NIST.

The draft report actually contradicts this statement. The performance of the floor construction of the WTC towers in the 9/11 incident far exceeded expectations. NIST has concluded that the impact of the aircraft damaged the fireproofing on the structural members supporting the floor construction. No fire testing was conducted on trusses with damaged fireproofing because the results of such tests are already known, however, the actual fire resistance of the WTC towers floor construction far exceeded that which would be predicted testing per ASTM E119. Hence, the series of four fire tests actually proved nothing more than the structural response to fire exposure is extremely complex. We already know that to be the case.

Suggestion for Revision:

Revise or delete Footnote 26.

Comment #24

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 205

Paragraph/Sentence:

Footnote 27:

"*There is a lack of test data on the fire resistance ratings of loaded connections. The fire resistance of structural connections is not rated in current practice. Also, standards and codes do not provide guidance on fireproofing requirements for structural connections when the connected members have different fire resistance ratings.*"

Comment:

NIST's statement in Footnote 27 is correct. There is a lack of data on the fire resistance of connections between structural members. It should be noted, however, that NIST has determined that the failure of connections apparently did not play a part in the collapse of the WTC 1 and WTC 2 towers. Given this fact determined by NIST, it would seem that the fire resistance of connections is not really that important of an issue. It appears based on NIST's investigation that NIST's concern about the fire resistance of connections is over-blown.

Suggestion for Revision:

It is suggested that the above footnote be revised to note that the NIST investigation did not find that structural connections played a part in the collapse of the WTC towers.

Comment #25

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 205

Paragraph/Sentence:

Footnote 25:

The National Fire Protection Association (NFPA) 5000 model code and the International Building Code (IBC) both recognize the risks associated with different building heights and accepted changes in 2001 and 2004, respectively. Both model codes now require that buildings 420 feet and higher have a minimum 4 hour structural fire-resistance rating. The previous requirement was 2 hours. The change provides increased fire resistance for the structural system leading to enhanced tenability of the structure and gives firefighters additional protection while fighting a fire. While NIST supports these changes as an interim step, NIST believes that it is essential to complete a comprehensive review that will establish a firm technical basis for construction classification and fire rating requirements.

Comment:

The statement that both the IBC and NFPA 5000 require a minimum 4 hour structural fire resistance rating is incorrect. It is recommended that NIST review the changes to the model codes for buildings in excess of 420 feet recently adopted.

The IBC requires that the structural frame in Type 1A construction develop a minimum 3 hour fire resistance rating and that the floor construction develop a 2 hour fire resistance rating. Type IA construction is the construction type with the maximum fire resistance rating requirements.

Suggestion for Revision:

Revise Footnote 25 so that it is technically accurate.

Comment #26

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 206

Paragraph/Sentence:

Footnote 29

"*NIST tests showed that the adhesive strength of SFRM on steel coated with primer paint was a third to half of the adhesive strength on steel that had not been coated with primer paint. The SFRM products used in the WTC towers were applied to steel components coated with primer paint.* "

Comment:

The above footnote implies that the fireproofing on the WTC towers was defective because the fireproofing was applied to steel surfaces which were covered with primer paint. Rather than make this implication, the NIST report should explicitly address this issue. The question which this footnote raises and which needs to be answered is whether applying fireproofing to surfaces covered with primer paint was the proximate cause of the collapse of the WTC towers.

Suggestion for Revision:

The issue which Footnote 29 raises needs to be addressed in detail in the report. In my reading of the report, this is the only place where this issue is mentioned.

Comment #27

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 207

Paragraph/Sentence:

Recommendation 7. NIST recommends the nationwide adoption and use of the "structural frame" approach to fire resistance ratings.

Comment:

Every model building code has already incorporated this recommendation at least 30 years ago. For instance, both the BOCA Code and the Standard Building Code in one type of construction require 3 hour vertical members and 2 hour horizontal members. In other words, both of these codes require a 2 hour structural frame and require that the vertical members have an additional 1 hour fire resistance rating. This recommendation is simply one of semantics.

Suggestion for Revision:

This recommendation can and should be deleted.

Comment #28

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 207

Paragraph/Sentence:

"***Recommendation 8.*** *NIST recommends that the fire resistance of structures should be enhanced by requiring a performance objective that uncontrolled building fires result in burnout without local or global collapse.*"

Comment:

It is not clear why the collapse (or failure) of a portion of the building structure is unacceptable. Minor structural failures will not affect the overall structural stability of the building. The 9/11 incident clearly demonstrated the resiliency of the WTC towers to withstand simultaneous partial collapses without affecting the overall stability of the WTC tower under the most adverse conditions.

It is also not clear under what conditions the building is to be subjected too as a design basis. Since the NIST report does <u>not</u> clearly state that NIST's recommendations are <u>not</u> intended to address terrorism, NIST recommendations could be interpreted to mean that no local or global collapse should occur under 9/11 conditions. Recommendation 8 should clearly state what are the design assumptions, i.e. single typical fire, multiple typical fires, multiple atypical fires, multiple atypical fires with prior structural damage, multiple atypical fires with simultaneous wind event, multiple atypical fires with simultaneous wind and seismic events, etc., etc.

Suggestion for Revision:

Recommendation 8 should be revised to include the design assumptions under which no local or global collapse is to occur. Recommendation 8 should also be revised to define the term "local collapse".

Comment #29

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 207

Paragraph/Sentence:

"*The issue of non-operational sprinklers could be addressed using the existing concept of Design Scenario 8 of NFPA 5000, where such compromise is assumed and the result is required to be acceptable to the Authority Having Jurisdiction.*"

Comment:

The technical justification for the assumption that the sprinkler system fails is not clear. NIST has provided no statistics on the failure rate of sprinkler systems in high rise buildings. The fire record in the United States over the last 30 years is devoid of any major fire occurring in a high rise building protected throughout by a sprinkler system. (The fires in the WTC towers have been excluded because these fires were caused by missile attacks. NIST has indicated that terrorist activity is not being addressed in this report, hence, terrorist activity should also not be addressed in NIST's recommendations.)

Suggestion for Revision:

Given the fire record cited above, a technical justification for the above sentence should be included in the report.

Comment #30

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 207

Paragraph/Sentence:

Footnote 30

"Had this requirement been adopted by the 1968 New York City building code, the WTC floor system, including its connections, would have had the 3 hour rating required for the columns since the floors braced the columns."

Comment:

This statement as written makes it appear that the 1968 NYC Building Code was defective, however, a number of model building codes used in the United States over the last 30 years have permitted 2 hour horizontal structural members for high rise buildings. In fact, the BOCA Code permitted a 2 hour structural frame and floor construction for high rise office and residential buildings of any height for years.

The information provided in Footnote 30 is an observation which is essentially irrelevant.

Suggestion for Revision:

Footnote 30 should be deleted.

Comment #31

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 207

Paragraph/Sentence:

Recommendation 9. NIST recommends the development of: (1) performance-based standards and code provisions, as an alternative to current prescriptive design methods, to enable the design and retrofit of structures to resist real building fire conditions, including their ability to achieve the performance objective of burnout without structural or local floor collapse: and (2) the tools, guidelines, and test methods necessary to evaluate the fire performance of the structure as a whole system.

Comment:

The development of performed-based code provisions has been underway since at least the middle 1970's. At present, insufficient data exists to support much of the performance approach to building fire safety. Given this, the use of the prescriptive design approach will be used in most building designs.

It should also be noted that the performance approach to building fire safety design really only has application to major buildings, however, most buildings constructed in the United States are relatively small. NFPA fire statistics clearly indicate that the buildings with the worst fire records are 1- and 2-family dwellings. Given this, NIST should address the application of the performance approach to the fire safety design of 1- and 2-family dwellings. It is doubtful that there is any application of the performance approach to 1- and 2-family dwellings. Given this, it is questionable why we should spend additional research dollars to the development of the performance approach for buildings with the best fire record. Again, NFPA statistics indicate that the number of fire fatalities which occur in commercial (non-residential) buildings is 200 or less each year and, in recent years, this number has dwindled to less than 100 fire deaths. Given this, the need to develop the performance approach to fire safety is questionable given that the existing prescriptive approach is working rather well.

The question which should be asked and answered by NIST is are there any more important research projects which should be funded instead of research into developing the performance approach to fire safety. Government statistics consistently indicate that more than 40,000 Americans die each year as a result of traffic accidents. 40,000+ fatalities vs. 200 fatalities (at most) each year. That means that there are at least 39,800 more highway fatalities each year in the U.S. than there are fire fatalities in commercial buildings. Is it unethical to be using research dollars into fire safety for commercial buildings when 200 times the number of Americans who die in fires in commercial buildings die in traffic accidents?

Suggestion for Revision:

It is suggested that NIST provide a technical justification for the need to develop the performance approach to building fire safety.

Comment #32

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 208

Paragraph/Sentence:

"*This performance-based capability should include, but not be limited to:*

a. *Standard methodology, supported by performance criteria, analytical design tools, and practical design guidance; related building standards and codes for fire resistance design and retrofit of structures, working through the consensus process for nationwide adoption; comprehensive design rules and guidelines; methodology for evaluating thermostructural performance of structures; and computational models and analysis procedures for use in routine design practice.*

b. *Standard methodology for specifying multicompartment, multifloor fire scenarios for use in the design and analysis of structures to resist fires, accounting for building-specific conditions such as geometry, compartmentation, fuel load (e.g., building contents and any flammable fuels such as oil and gas), fire spread, and ventilation; and methodology for rating the fire resistance of structural systems and barriers under realistic design-basis fire scenarios.*

c. *Publicly available computational software to predict the effects of fires in tall buildings— developed, validated, and maintained through a national effort—for use in the design of fire protection systems and the analysis of building response to fires. Improvements should include the fire behavior and contribution of real combustibles; the performance of openings, including door openings and window breakage, that controls the amount of oxygen available to support the growth and spread of fires and whether the fire is fuel-controlled or ventilation-controlled; the floor-to-floor flame spread; the temperature rise in both insulated and uninsulated structural members and fire barriers; and the structural response of components, subsystems, and the total building system due to the fire.*

d. *New test methods, together with associated conformance assessment criteria, to support the performance-based methods for fire resistance design and retrofit of structures. The performance objective of burnout without collapse will require the development of standard fire exposures that differ from those currently used.* "

Comment:

It appears that NIST is proposing a massive research effort which could take years to implement. It is assumed that the funding for the research would either go to NIST or be controlled by NIST, yet NIST hasn't attempted to make a case why the method in use today is "broken". With the exception of residential occupancies, the fire record of buildings in the United States is excellent. Given this, one would certainly have to question NIST's motives in making this proposal. Again, given the number of traffic fatalities which occur in the United States each year vs. the minuscule number of fire fatalities which occur in commercial buildings each year, is it even ethical that we spend the sort of capital required to implement NIST's recommendations?

Suggestion for Revision:

Recommendation 9 should be deleted.

Comment #33

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 208

Paragraph/Sentence:

"**Recommendation 10.** *NIST recommends the development and evaluation of new fire resistive coating materials, systems, and technologies with significantly enhanced performance and durability to provide protection following major events. This could include, for example, technologies with improved adhesion, double-layered materials, intumescent coatings, and more energy absorbing SFRMs.31 Consideration should be given to pre-treatment of structural steel members with some type of mill-applied fire protection to minimize the uncertainties associated with field application and in-use damage. If such an approach was feasible, only connections and any fire protection damaged during construction and fit-out would need to be field-treated.*"

Comment:

This recommendation does not address the cost vs. benefit. NIST has yet to define the problem (in terms of loss history) that the nation faces. Will the cost of implementing this recommendation exceed the benefits produced? On the surface, this recommendation appears to be logical, however, without additional information on the cost of such products, no conclusion can be made as to whether or not this is a good idea.

Suggestion for Revision:

Provide a technical justification and the cost vs. benefit analysis so that it can be determined whether or not this recommendation makes economic sense.

Comment #34

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 208

Paragraph/Sentence:

Footnote 31:

"Other possibilities include encapsulation of SFRM by highly elastic energy absorbing membranes or commodity grade carbon fiber or other wraps. The membrane would remain intact under shock, vibration, and impact but may be compromised in a fire, yet allowing the SFRM to perform its thermal insulation function. The carbon wrap would remain intact under shock, vibration, and impact and, possibly, under fire conditions as well."

Comment:

Interesting concepts, but it is not clear what the intent of the proposed concepts is. Is this an attempt to address a September11th style missile attack or a typical building fire? If the answer is a typical building fire, then a loss history should be presented indicating that there is a problem with the present system of fireproofing.

Suggestion for Revision:

The specific purpose of the concepts discussed should be indicated and a loss history should be provided.

Comment #35

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 209

Paragraph/Sentence:

"**Recommendation 12**. *NIST recommends that the performance and redundancy of active fire protection systems (sprinklers, standpipes/hoses, fire alarms, and smoke management systems) in buildings should be enhanced to accommodate the greater risks associated with increasing building height and population, increased use of open spaces, available compartmentation, high-risk building activities, fire department response limits, transient fuel loads, and higher threat profile. The performance attributes should deal realistically with the system design basis, reliability of automatic/manual operations, redundancy, and reduction of vulnerabilities due to single point failures.* "

Comment:

There are numerous points in sprinkler and standpipe systems were failure could cause the failure of the entire system. (For example, the breaking a riser could imperil the water supply for the sprinkler system even in systems designed with a two riser supply.) Even though this is the case, both sprinkler and standpipe systems are highly reliable systems. In the last 30 years, Schulte & Associates is unaware of a major fire occurring in a high rise building protected throughout by a sprinkler system, although several major fires have occurred in buildings partially protected by a sprinkler system (i.e. MGM Grand Hotel-Las Vegas and the One Meridian Plaza Building-Philadelphia). That's quite a record.

Given the excellent fire safety record of U.S. high rise buildings, it is difficult to understand the basis for the NIST's recommendation. NFPA's statistics on high rise buildings show that the taller the building, the safer the building is from a fire safety standpoint. This statistic is logical simply because larger buildings have more professional and larger maintenance staffs.

One project which should have been included in the WTC towers collapse investigation was a project to determine the failure rate of sprinkler systems, particularly in high rise buildings.

Suggestion for Revision:

NIST should provide a technical basis for this recommendation or delete Recommendation 12 in its entirety.

Comment #36

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 209 and 210.

Paragraph/Sentence:

Recommendation 14. NIST recommends that control panels at fire/emergency command stations in buildings should be adapted to accept and interpret a larger quantity of more reliable information from the active fire protection systems that provide tactical decision aids to fireground commanders, including water flow rates from pressure and flow measurement devices, and that standards for their performance be developed.

Comment:

The above is a curious recommendation. The background on the formulation of this recommendation would be of interest. Also of interest would a cost/benefit analysis. Given that the performance of high rise buildings protected throughout by a sprinkler system has been perfect over the last 30 years, the need to implement this recommendation appears to be questionable.

Given my experience working with the San Jose Fire Department, I can state that most fire officers have absolutely no interest in the control panels required to be provided in high rise buildings. Given this, providing this additional information may simply be one more "gadget" that is not utilized by fire departments.

Suggestion for Revision:

Information should be provided on the background used to develop this recommendation. A cost/benefit analysis for this recommendation should be included in the report. It is also suggested that information from fire ground commanders as to whether or not the information which would be provided would be of useful to them should be included in the report.

Comment #37

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 210

Paragraph/Sentence:

Recommendation 15. NIST recommends that systems should be developed and implemented for: (1) real-time off-site secure transmission of valuable information from fire alarm and other monitored building systems for use by emergency responders, at any location, to enhance situational awareness and response decisions and maintain safe and efficient operations32; and (2) preservation of that information either off-site or in a black box that will survive a fire or other building failure for purposes of subsequent investigations and analysis. Standards for the performance of such systems should be developed, and their use should be required.

Comment:

NIST does not provide any technical justification for this recommendation. How often would this information be of use? What is the cost? It seems like this recommendation is just another "gadget". Simply because we can do it, do we really want to implement this recommendation?

Suggestion for Revision:

NIST should provide a technical justification for this recommendation, including a cost/ benefit analysis.

Comment #38

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 210

Paragraph/Sentence:

"**Recommendation 16.** *NIST recommends that public agencies, non-profit organizations concerned with building and fire safety, and building owners and managers should develop and carry out public education campaigns, jointly and on a nationwide scale, to improve building occupants' preparedness for evacuation in case of building emergencies.* "

Comment:

This recommendation sounds a lot like the safety demonstration that they give on aircraft which nobody pays any attention. With all of the warnings we are given today, this will simply be one more warning which the public ignores. This sounds like a big waste of money to me. The benefit of such a public education campaign is simply not worth the cost.

This recommendation appears to assume that there is an unlimited supply of taxpayer money to support such a public education program. We can't even teach our children to read and do math. What makes NIST think that we can educate the public on evacuation procedures if we can't educate our own children?

Suggestion for Revision:

Delete Recommendation 16

Comment #39

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 211

Paragraph/Sentence:

"**Recommendation 17.** *NIST recommends that tall buildings should be designed to accommodate timely full building evacuation of occupants due to building-specific or large-scale emergencies such as widespread power outages, major earthquakes, tornadoes, hurricanes without sufficient advanced warning, fires, accidental explosions, and terrorist attack. Building size, population, function, and iconic status should be taken into account in designing the egress system. Stairwell and exit capacity[35] should be adequate to accommodate counterflow due to emergency access by responders.* "

Comment:

Based upon statements made by Dr. Sunder, NIST recommendations do not address terrorist attacks, yet Recommendation 17 specifically mentions terrorist attacks. NIST needs to definitively state whether or not its recommendations are intended to address terrorist attacks. If indeed the recommendations are intended to address terrorist attacks, then NIST needs to define the type of terrorist attack which these recommendations are supposed to address. Stating that this recommendation is intended to address terrorist attack without defining the type of terrorist attack is meaningless.

This recommendation specifically states that the egress system should be designed for total evacuation in the event of a hurricane which arises without warning. Schulte & Associates is aware that such events used to occur a century ago, but it is Schulte & Associates understanding that the NOAA is now able to track hurricanes as they form. Given this, NIST should provide an explanation as to what a hurricane which arises without warning actually is.

The high rise provisions included in the model building codes specifically require that standby electrical power systems be provided in high rise buildings. Given this, it is not clear why the egress system serving a building needs to be designed for rapid evacuation in the event of a power outage.

In general, it is not apparent what the basis is for this recommendation. It is also noted that NIST did not mention meteor strikes or attack by alien spacecraft in Recommendation 17. In many cases, the probability of sudden hurricanes and earthquakes is as about as probable as meteor strikes and attacks by alien spacecraft.

Suggestion for Revision:

NIST should include a technical justification for this recommendation which among other things addresses probability of the occurrences listed above and includes a loss history.

Comment #40

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 211

Paragraph/Sentence:

"*Mobility challenged occupants should be provided a means for self-evacuation in the event of a building emergency. Current strategies (and law) generally require the mobility challenged to shelter-in-place and await assistance. New procedures, which provide redundancy in the event that the floor warden system or co-worker assistance fails, should consider full building evacuation, and may include use of fire-protected and structurally hardened elevators37, motorized evacuation technology, and/or dedicated communication technologies for the mobility challenged.*"

Comment:

Again, NIST has not provided a technical justification for this statement. A cost/benefit analysis should be provided, as well as a loss history. Sufficient data should be available from the collapse of the WTC towers to determine the need for special egress facilities for "mobility challenged occupants".

The probability of events which would require a full building evacuation should be provided. At this point in time, we know that more than 40,000 Americans die each year in traffic accidents. From a cost/benefit standpoint, it seems reasonable that we would get a greater return on our investment investing in traffic safety than we would get implementing the recommendation above. It should be noted that far more "mobility impaired occupants" die in traffic accidents each year than die in building incidents which require full building evacuation.

Suggestion for Revision:

This paragraph should be revised and expanded to include a cost/benefit analysis and a loss history.

Comment #41

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 211

Paragraph/Sentence:

Footnote 35

"*Egress capacity should be based on an all-hazards approach that considers the number and width of stairs (and doors) as well as the possible use of scissor stairs credited as a single stair.* "

Comment:

It is not clear as to exactly what an "all-hazards approach" means in the above footnote. In addition to hurricanes and earthquakes in areas where hurricanes and earthquakes have never historically occurred, this statement could refer to meteor strikes and attacks by space aliens. It is recommended that NIST specifically enumerate the hazards which NIST anticipates in the "all-hazards approach" and also provide probabilities for each event occurring and for multiple hazard events, i.e. simultaneous seismic events and hurricanes. It is my opinion that the probability of some of these events occurring is so close to zero that designing for these events is simply illogical.

Suggestion for Revision:

The statement above should be expanded to list the specific hazards NIST intends to be addressed, as well as provide estimates of the probability that these hazards would actually occur.

Comment #42

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 211

Paragraph/Sentence:

Footnote 36

"Use of egress models is required to estimate the egress capacity for a range of different evacuation strategies, including full building evacuation. NIST found that the average surviving occupant in the WTC towers descended stairwells at about half the slowest speed previously measured for non-emergency evacuations. "

Comment:

The above footnote implies that the egress facilities provided for the towers were deficient. The statement in the footnote appears to be at odds with NIST's finding that more that 99 percent of the occupants of the WTC towers below the floors of impact in each tower were able to evacuate safely.

Suggestion for Revision:

Footnote 35 should be deleted.

Comment #43

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 212

Paragraph/Sentence:

"**Recommendation 18.** *NIST recommends that egress systems should be designed: (1) to maximize remoteness of egress components (i.e., stairs, elevators, exits) without negatively impacting the average travel distance; (2) to maintain their functional integrity and survivability under foreseeable building-specific or large-scale emergencies; and (3) with consistent layouts, standard signage, and guidance so that systems become intuitive and obvious to building occupants during evacuations.* "

Comment:

NIST has provided no basis for Recommendation 18. The 9/11 incident at the WTC towers only proved that the towers were not designed for a missile attack and, even though this was the case, the performance of the WTC towers under such adverse conditions was excellent.

The location of exit stairs has to be balanced by the functionality of the building. Present code provisions for the locations of exit stairs with respect to one another address both occupant safety and building functionality. The historical record demonstrates that this is the case. Based upon this, it is my conclusion that item (1) in Recommendation 18 is in error.

Item (2) addresses the structural integrity of exit stair enclosures. Again, the historical record indicates that the performance of gypsum wallboard enclosures is more than adequate. Providing masonry enclosures of the exit stairs at the WTC towers would not necessarily have affected the outcome of the 9/11 incident. Masonry or concrete enclosures are no match for missiles impacting a building at speeds of 400 mph. Item (2) appears to suggest that exit stair and elevator enclosures should be designed to withstand the impact of missiles. It should also be noted that item (2) does <u>not</u> address the issue of the protection of door openings into exit stair and elevator hoistway enclosures.

There have been numerous failures of concrete enclosures of exit stairs. One recent failure involving concrete stair enclosures is the fire at the Cook County Administration Building on October 17, 2003. Another failure of a concrete exit stair enclosure is the fire at the One Meridian Plaza Building in Philadelphia.

Item (3) above appears to be common sense, however, the historical record indicates that problems with the layout of exit stairs is rarely, if ever, a problem. The problems which occurred in the WTC towers on 9/11 appear to be a problem unique to the City of New York. It appears that NIST is blaming the stair layout design instead of an ordinance passed by the City of New York

Suggestion for Revision:

Recommendation 18 should be revised and expanded to provide a technical justification for this recommendation.

Comment #44

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 212

Paragraph/Sentence:

"*While NIST does not believe that buildings should be designed for aircraft impact, as the last line of defense for life safety, the stairwells and elevator shafts individually, or the core if these egress components are contained within the core, should have adequate structural integrity to withstand accidental structural loads and anticipated risks.* "

Comment:

The above does not provide any technical documentation for the statement. The historical record has demonstrated that gypsum wallboard enclosures provide more than adequate protection for exit stairs and elevator hoistways.

In the statement above, NIST specifically states that it is NIST's opinion that stair and elevator hoistway enclosures should not be designed for aircraft impact. Given this, there seems to little basis for this statement.

Suggestion for Revision:

The statement above should be deleted.

Comment #45

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 212

Paragraph/Sentence:

"*Stairwell remoteness requirements should be met by a physical separation of the stairwells that provide a barrier to both fire and accidental structural loads. Maximizing stairwell remoteness, without negatively impacting the average travel distance, would allow a stairwell to maintain its structural integrity independent of any other stairwell that is subject to accidental loads, even if the stairwells are located within the same structural barrier such as the core. The current "walking path" measurement allows stairwells to be physically next to each other, separated only by a fire barrier. Reducing the clustering of stairways that also contain standpipe water systems provide the fire service with increased options for formulating firefighting strategies.*"

Comment:

Again, NIST has not provided any technical documentation to support this recommendation. The historical record indicates that the code provisions included in recent editions of the either the International Building Code or NFPA 5000 are more than adequate.

Suggestion for Revision:

Provide a technical justification for this recommendation or delete the above paragraph.

Comment #46

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 213

Paragraph/Sentence:

"*Egress systems should have consistent layouts with standard signage and guidance so that the systems become intuitive and obvious to all building occupants, including visitors, during evacuations. Particular consideration should be given to unexpected deviations in the stairwells (e.g., floors with transfer hallways).* "

Comment:

Again, NIST has not provided any technical justification or information on the historical record to support this recommendation.

This statement also do not recognize the benefit of compartmenting the stair enclosures. Transfer corridors within stairs are likely to be necessary if the exit stairs are to be compartmented. Compartmenting the stair enclosures prevents entire stairs from being contaminated with combustion products in the event of a failure of the enclosure.

Suggestion for Revision:

Revise the report to include a technical documentation for this statement or delete the sentence above.

Comment #47

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 213

Paragraph/Sentence:

"**Recommendation 19.** *NIST recommends that building owners, managers, and emergency responders develop a joint plan and take steps to ensure that accurate emergency information is communicated in a timely manner to enhance the situational awareness of building occupants and emergency responders affected by an event.* "

Comment:

Recommendation 19 is obviously a response to 9/11. Given that no one ever anticipated an event of this magnitude occurring in Lower Manhattan, it isn't surprising that there problems with coordination of emergency responders. The question is do we really want our first responders to be capable of responding to an event of this magnitude? At first blush, this sounds like a silly question, however, the cost of training for such an event and maintaining readiness for a similar event will be astronomical. Given this, NIST needs to clarify exactly the magnitude and type of events that NIST is recommending readiness. In my mind, it is doubtful that the City of New York could afford the cost of maintaining sufficient readiness for another 9/11 event say 15 years in the future.

It should be noted that the terrorist organizations are engaging in economic warfare against the United States and other countries. It is possible to spend ourselves into defeat without the enemy expending a great deal of capital if we overact to the 9/11 event. It is sad to say, but we may need to absorb and accept civilian casualties in this war in order to actually win. Casualties are fact of life in war. Given the number of terrorist targets in the United States, it is simply not possible to protect them all.

Suggestion for Revision:

Recommendation 19 should be revised to specifically state what the magnitude of incidence NIST has in mind to address with this recommendation. A cost/benefit analysis should accompany this recommendation so that readers have a idea of the magnitude of the expenditures anticipated by NIST and the benefits that will be provided if this recommendation is implemented. (It should be noted that the benefits would be zero if another event of this magnitude never occurs again.)

Comment #48

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 213

Paragraph/Sentence:

"*Situational awareness of building occupants and emergency responders in the form of information and event knowledge should be improved through better coordination of such information among emergency responder groups (9-1-1 dispatch, fire department or police department dispatch, emergency management dispatch, site security, and appropriate federal agencies), efficient sharing and communication of information between building occupants and emergency responders, and improved emergency responder communication systems (i.e., including effective communication within steel and reinforced concrete buildings, capacity commensurate with the scale of operations, and interoperability among different communication systems).*"

Comment:

The above statement appears to be in response to the 9/11 incident, however, given the magnitude of the event, communication problems should be expected. The size of the incident will have an impact on the ability of emergency responders to communicate. The problems with communications would likely not have arisen in a smaller event. To conclude that there are major problems with communications based upon this one freak (and totally unanticipated) incident doesn't make sense. The above statement appears to have been specifically included in the report to satisfy complaints by relatives of the victims, rather through thoughtful consideration of the incident.

Suggestion for Revision:

A technical justification for this statement should be provided or this statement should be deleted from the report.

Comment #49

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 213

Paragraph/Sentence:

"The emergency communications systems in buildings should be designed with sufficient robustness and redundancy to continue providing public address announcements or instructions in foreseeable building-specific or large-scale emergencies, including widespread power outage, major earthquakes, tornadoes, hurricanes, fires, and accidental explosions. Consideration should be given to placement of building announcement speakers in stairways in addition to other standard locations."

Comment:

The cost of the emergency communications system installation in a building will be dependent upon the damage which we expect the communications system to survive and still be capable of functioning. Given the low probability of the events listed above, the question is whether the cost of increasing the survivability of the communications system is worth the benefit. We don't expect aircraft passenger to survive a crash, why should be expect a communications system to survive a strike by a tornado?

One other question we need to ask is, if the communications system is designed to survive an event listed above, such as a tornado, but the building is destroyed because the building has not been designed to withstand a tornado, what is the point of having the communications systems still be operative? The statement above is simply not logical.

Suggestion for Revision:

The statement above should be reconsidered and revised so that the statement is logical.

Comment #50

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 214

Paragraph/Sentence:

"**Recommendation 20.** *NIST recommends that the full range of current and next generation evacuation technologies should be evaluated for future use, including protected/ hardened elevators, exterior escape devices, and stairwell navigation devices, which may allow all occupants an equal opportunity for evacuation and facilitate emergency response access.* "

Comment:

The above recommendation does not specifically indicate what hazard is being addressed by this recommendation. Based upon the historical record, it would seem that the performance of the forms of egress presently considered to acceptable by building codes is acceptable. It seems that Recommendation 20 has been specifically included to address missile attacks by terrorists. NIST needs to decide whether or not this report is intended to address terrorist missile attacks. If NIST believes that buildings should be designed for terrorist missile attacks, it should state that this is the case.

Suggestion for Revision:

A further explanation of this recommendation is required.

Comment #51

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 216 and 217

Paragraph/Sentence:

Recommendation 25. Nongovernmental and quasi-governmental entities that own or lease buildings and are not subject to building and fire safety code requirements of any governmental jurisdiction are nevertheless concerned about the safety of the building occupants and the responding emergency personnel. NIST recommends that such entities should be encouraged to provide a level of safety that equals or exceeds the level of safety that would be provided by strict compliance with the code requirements of an appropriate governmental jurisdiction. To gain broad public confidence in the safety of such buildings, NIST further recommends that it is important that as-designed and as-built safety be certified by a qualified third party, independent of the building owner(s). The process should not use self-approval for code enforcement in areas including interpretation of code provisions, design approval, product acceptance, certification of the final construction, and post-occupancy inspections over the life of the buildings.

Comment:

This comments appears to have been included in the report to satisfy relatives of the families of the victims and lends credence to their charges that the buildings were somehow defective (even though NIST has been unable to document that this is the case).

Based upon the NIST report, it is my conclusion that the Port Authority, the design professionals and the construction team did an excellent job of designing and construction WTC 1 and WTC 2. Given this, there appears to be no basis for Recommendation 25.

The recommendation presupposes that a governmental body cannot design and construct a building which complies with code requirements without some outside entity verifying that this is the case. This comment presupposes that governmental bodies are capable of reviewing building designs and inspecting building construction to verify compliance. It has been my experience that most enforcing authorities do a poor job of verifying compliance with code requirements. Hence, it appears that NIST is suggesting a higher degree of standard for governmental bodies, such as the Port Authority, than the local governments utilize for their review of private sector construction.

Suggestion for Revision:

Recommendation 25 should be deleted.

Comment #52

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 217

Paragraph/Sentence:

"**Recommendation 26.** *NIST recommends that state and local jurisdictions should adopt and aggressively enforce available provisions in building codes to ensure that egress and sprinkler requirements are met by existing buildings44. Further, occupancy requirements should be modified where needed (such as when there are assembly use spaces within an office building) to meet the requirements in model building codes.*"

Comment:

It should be noted that our present fire record in the United States has been established with relatively lax enforcement of codes for both new and existing buildings. The NFPA has recently released its estimates for fire fatalities in 2004. The NFPA estimates that only 80 fire fatalities occurred in all of the commercial buildings in the United States in 2004. In other words, the fire records of commercial buildings in the United States is excellent, despite the relatively lax enforcement. Given this, it seems that a rigorous cost/benefit analysis should be applied to determine whether it makes sense to implement Recommendation 26.

Statistics published by the National Fire Protection Association indicate that a total of only 7 fire deaths occurred in all of the high rise office buildings in the United States in the 14 year period between 1985 and 1998. This statistic includes both sprinklered and unsprinklered high rise buildings. Given this, it can be concluded that the risk of fire fatalities in both sprinklered and unsprinklered high rise buildings is practically zero. Based upon this, the need to implement Recommendation 26 is questionable.

These statistics also seem the challenge the need for more restrictive code requirements recommended by NIST.

Suggestion for Revision:

A rigorous cost/benefit analysis should be included in the report to establish whether or not the upgrading of existing buildings to comply with requirements for existing buildings contained in various codes is actually cost effective.

Comment #53

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 217

Paragraph/Sentence:

"**Recommendation 27.** *NIST recommends that building codes should incorporate a provision that requires building owners to retain documents, including supporting calculations and test data, related to building design, construction, maintenance and modifications over the entire life of the building[45]. Means should be developed for offsite storage and maintenance of the documents. In addition, NIST recommends that relevant building information should be made available in suitably designed hard copy or electronic format for use by emergency responders. Such information should be easily accessible by responders during emergencies.* "

Comment:

Simply because a provision is included in building codes which requires that building owners retain construction documents does not mean that building owners will comply with the requirement. Given this, who will be checking to see if building owners do indeed retain the construction documents over the life of a building when it is conceivable that the life of building could extend a century or more? What will be the penalty if a building owner does not retain the documents?

The last sentence of Recommendation 27 is an interesting statement. Imagine if the construction documents had been available to the FDNY on 9/11. Could you imagine fire ground commanders thumbing through 30 year old construction documents during the incident? It took NIST almost 2 years of investigation to determine the cause of the collapse without a raging fire overhead. Imagine looking through construction documents for these two buildings during the actual incident.

On the surface, this recommendation appears to be logical, however, in the context of the 9/11 incident in Lower Manhattan, this recommendation is essentially useless. The real purpose of this recommendation is to assist in an investigation after an incident.

Suggestion for Revision:

Recommendation 27 should be revised so that it addresses the practicality of the real world.

Comment #54

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 218

Paragraph/Sentence:

"**Recommendation 28.** *NIST recommend that the role of the "Design Professional in Responsible Charge"46 should be clarified to ensure that: (1) all appropriate design professionals (including, e.g., the fire protection engineer) are part of the design team providing the standard of care when designing buildings employing innovative or unusual fire safety systems[47], and (2) all appropriate design professionals (including, e.g., the structural engineer and the fire protection engineer) are part of the design team providing the standard of care when designing the structure to resist fires, in buildings that employ innovative or unusual structural and fire safety systems.*"

Comment:

Recommendation 28 appears to assume that the design of the World Trade Center towers was somehow "innovative or unusual". As an engineer, I am not sure that I would agree that the design of the WTC towers was either "innovative or unusual".

Recommendation 28 also appears to assume that the design of the World Trade Center towers would have been done differently if a fire protection engineer had been part of the design team. Based upon information I am aware, the Port Authority did employ fire protection engineers.

Testing of the floor construction conducted by NIST in August 2004 demonstrated that the floor construction in the WTC towers did indeed develop a 2 hour fire resistance rating. The actual incident on 9/11 clearly demonstrated that the actual fire resistance of the structural system supporting the floor far exceeded 2 hours (with the fireproofing intact). The performance of the WTC towers far exceeded that which would have been predicted by either fire testing or a fire protection engineer.

Suggestion for Revision:

Recommendation 28 should include a clarification as to the meaning of "innovative or unusual" or, preferrably, be deleted in its entirety.

Comment #55

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 218

Paragraph/Sentence:

"**Recommendation 29.** *NIST recommends that continuing education curricula should be developed and programs should be implemented for training fire protection engineers and architects in structural engineering principles and design, and training structural engineers, architects, and fire protection engineers in modern fire protection principles and technologies, including fire-resistance design of structures. The outcome would further the integration of the disciplines in effective fire-safe design of buildings.*"

Comment:

Recommendation 29 does not address the cost effectiveness of such a recommendation. This recommendation assumes that there is a problem which needs to be addressed, but provides no justification for making this assumption.

The fire record of the United States indicates that, if there is a fire problem in the U.S., it is in 1- and 2-family dwellings, not high rise buildings. NIST does not provide an explanation as to why design professionals designing 1- and 2-family dwellings need the level of expertise which NIST recommends in this recommendation.

Suggestion for Revision:

Delete this recommendation in its entirety.

Comment #56

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 218

Paragraph/Sentence:

"**Recommendation 30.** *NIST recommends that academic, professional short-course, and webbased training materials in the use of computational fire dynamics and thermostructural analysis tools should be developed and delivered to strengthen the base of available technical capabilities and human resources.*"

Comment:

Given the fire record in the United States, it is difficult to see why the proposed training is necessary. More than 60 percent of the fire fatalities which occur in the United States occur in 1- and 2-family dwellings and more than 80 percent of the fire fatalities occur in residential occupancies. These percentages have been consistent for years. Given these, it seems that we should be concentrating on the fire problem in residential occupancies. It is highly unlikely that course on computational fire dynamics and thermostructural analysis will have any application in the fire protection of 1- and 2-family dwellings.

Suggestion for Revision:

Recommendation 30 should be deleted.

Comment #57

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 219

Paragraph/Sentence:

"*In its final report, which is expected to be released by September 2005, NIST will finalize these draft recommendations for specific and appropriate improvements to the way buildings are designed, constructed, maintained, and used. It will be important for these recommendations to be thoroughly and promptly considered by the many organizations responsible for building and fire safety.*"

Comment:

NIST has not provided any technical justification for its recommendations. In the absence of a technical justification, which should include a loss history and cost/benefit analysis, NIST should not expect that its recommendations will be taken seriously. It is my opinion that portions of the investigation report which I have reviewed are poorly written and demonstrate a lack of understanding of fire protection concepts. Given this, it is my opinion that NIST needs to do more work on the report prior to finalizing the report.

At this point in time, there is no need for either the ICC or the NFPA to promptly consider NIST's recommendations. It took NIST 3 years to complete its investigation of the WTC towers collapse and submit its recommendations. Given this fact, both the ICC and the NFPA should spend at least another 3 years reviewing NIST's recommendations prior to making a decision as to whether or not the recommendations merit inclusion in the building codes developed by both of these organizations.

It should be noted that the 6 week public comment period on this report is far too short. NIST has spent roughly 1,000 days on its investigation. Allowing only 42 days for public comment on a 10,000 page report is a clear indication that NIST is attempting to limit public comment.

Suggestion for Revision:

It is suggested that the date September 2005 be revised to September 2006.

Affiliation: Schulte & Associates

Contact: fpeschulte@aol.com; 504/220-7475

Report Number: NIST NCSTAR 1

Page Number: 218

Paragraph/Sentence:

Footnote 47:

"*If the fire safety concepts in tall buildings had been sufficiently mature in the 1960s, it is possible that the risks associated with jet-fuel ignited multifloor fires might have been recognized and taken into account when the impact of a Boeing 707 aircraft was considered by the structural engineer during the design of the WTC towers.* "

Comment:

The following excerpt is from page 212 of the draft final report:

> "*While NIST does not believe that buildings should be designed for aircraft impact, ...*"

This excerpt from page 212 of the report directly contradicts the statement made in Footnote 47.

On September 10, 2001, anyone who would have suggested that buildings should be designed to withstand the events of September 11 would have been considered to be a kook. In fact, it is my opinion that anyone who would suggest that buildings be designed to withstand the events of September 11 after September 11 is a kook.

Suggestion for Revision:

This footnote should be deleted.

* * * * *

From: FPESCHULTE@aol.com
Subject: Fwd: Koffel Sprinkler Failure Rate Analysis
To: WTC@nist.gov

Ladies and Gentlemen-

Below is an abbreviated analysis of the failure rate of sprinkler systems reported in a paper by William E. Koffel, P.E. commissioned by the *Alliance for Fire Safety*. Based upon this simple analysis, it appears that the sprinkler system failure rate reported by Koffel should be questioned. Of course, this has an impact on the recommendations made by NIST in its WTC towers collapse study.

Richard Schulte
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Return-path: <FPESCHULTE@aol.com>
From: FPESCHULTE@aol.com
Full-name: FPESCHULTE
Message-ID: <1e9.4114e733.301f7420@aol.com>
Date: Mon, 1 Aug 2005 08:48:32 EDT
Subject: RE: Koffel Sprinkler Failure Rate Analysis
To: kelly@nfsa.org
CC: Info@afscc.org, KAIHQ@aol.com
MIME-Version: 1.0
Content-Type: multipart/mixed; boundary="part2_211.5e627dc.301f7420_boundary"
X-Mailer: 9.0 Security Edition for Windows sub 5200

Kevin-

Attached is a simple analysis of the sprinkler system failure rate reported by Bill Koffel in his paper commissioned for the *Alliance for Fire Safety*.

The analysis shows that with a sprinkler system failure rate of 1 in 6 fires, there should be on average 380 failures each month in the United States. In contrast, if the failure rate is 1 in 400, there should be on average 6 failures each month in the United States.

The attached analysis is predicated upon the fact that the number of fires in sprinklered buildings over the 10 year period between 1989 and 1998 indicated in Koffel's paper is correct. Assuming the number of fires in sprinklered buildings used as a basis for Koffel' analysis is correct, I don't believe that Koffel's conclusion that the failure rate of sprinkler systems is 1 in 6 fires passes the "smell test".

Rich Schulte

PDF Sprinkler Reliabilty Analysis.00.pdf

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SPRINKLER SYSTEM FAILURE ANALYSIS
UNITES STATES EXPERIENCE
1989-1998

Number of Fires in Sprinklered Buildings: 273,400 Fires
(1989-1998)

(Source: William E. Koffel, P.E.)

Average Number of Fires In Sprinklered Buildings: 27,340 Fires/Year
(1989-1998)

Number of Fires in Sprinklered Bldgs.	Failure Rate	Number of Failures Per Year	Number of Failures Per Month
27,340 fires/year	1 in 6 fires	4,557	380
27,340 fires/year	1 in 10 fires	2,734	228
27,340 fires/year	1 in 20 fires	1,367	114
27,340 fires/year	1 in 50 fires	547	46
27,340 fires/year	1 in 100 fires	274	23
27,340 fires/year	1 in 200 fires	137	12
27,340 fires/year	1 in 400 fires	69	6

* * * * *

August 1, 2005

From: FPESCHULTE@aol.com
Subject: RE: Aircraft Safety vs. High Rise Bldg. Safety
To: WTC@nist.gov

Ladies and Gentlemen-

The following is a quote from a column which will appear in the September issue of Plumbing Engineer:

"Just *an observation, but the federal government presently permits aircraft carrying passengers (an assembly occupancy located 35,000 feet in the air) to fly over oceans without sprinkler protection, compartmentation or exits. Certainly, if providing none of the protection recommended by NIST is considered to be acceptable for aircraft carrying passengers flying over oceans, fire resistive high rise buildings protected by highly reliable sprinkler systems ought to be considered "reasonably safe".* "

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From: "D. Alexander Floum" <afloum@williams-law-firm.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : D. Alexander Floum
Affiliation :
Email Address : afloum@williams-law-firm.com
Phone : 925-808-1702
Report Number : NCSTAR 1
Page Number :
Paragraph : All
Comment : NIST must address the evidence of exposives in, and controlled demolition of, world trade center buildings 1, 2 and 7, as demonstrated by the information accessible directly by the following internet links.

(1) NY Fire Department Chief of Safety stated there were "bombs" and "secondary devices", which caused the explosions in the buildings (http://terrorize.dk/911/witnesses/911.wtc.reporter.1.wmv); high-quality audio here (http://www.whatreallyhappened.com/IMAGES/SecondaryDevices.mp3)

(2) NYC firefighters who witnessed attacks stated that it looked like their were detonators (i.e. bombs) in the buildings (http://www.letsroll911.org/discussion_in_firehouse.mpg NYC)

(3) NYC firefighter stated "On the last trip up a bomb went off. We think there was bombs set in the building" (http://web.archive.org/web/20010914230246/ (http://people.aol.com/people/special/0,11859,174592_3,00.html)

(4) British newspaper stated some eyewitnesses reported hearing another explosion just before the structure crumbled. Police said that it looked almost like a "planned implosion" (http://www.guardian.co.uk/september11/story/0,11209,600839,00.html)

(5) A facilities manager in the north tower "was convinced that there were bombs planted all over the place and someone was sitting at a control panel pushing detonator buttons" (http://www.thememoryhole.org/911/veliz_bombs.htm)

(6) Indeed, Larry Silverstein, the leaseholder of the World Trade Center, said in a PBS documentary that Building 7 was "pulled" on September 11th. (http://www.infowars.com/Video/911/wtc7_pbs.WMV) "Pulling" is apparently a construction industry term for "intentionally demolishing", as shown in discussing the demolition of world trade center building 6 many weeks after 9/11 (http://thewebfairy.com/911/pullit/pull_it2_lo.wmv).

Moreover, there is evidence that substantial explosions occurred well BELOW the area impacted by the planes, and - in at least one case - they occurred BEFORE the plane had hit:

(7) World trade center employee stated "the bottom of our building was blown out" (http://xrl.us/gsji)

(8) Employee of insurance company in south tower heard an explosion from BELOW the impact of the airplane, an "exploding sound" shook the building, a tornado of hot air, smoke and ceiling tiles and bits of drywall came flying UP the stairwell, and the wall split from the bottom UP (http://www.csmonitor.com/2001/0917/p1s1_usgn.html)

(9) A Port Authority Police Department officer, who was intimately familiar with the World Trade Center from his years of police duties patrolling there, described how the hallway began to shudder as a "terrible deafening roar" swept over him, then a giant fireball exploded in the street seconds before the south tower collapsed (http://www.bowhunter.com/feature_articles/BN_FromTheRubble)

(10) Stationary engineer who worked in world trade center one described more consistent in nature and timing with a bomb than with damage from an airplane (http://www.chiefengineer.org/article.cfm?seqnum1=1029 tremendous damage in the basement of the building)

(11) 9/11 hero, last man out of the north tower, said there was a massive explosion in the basement of the North tower BEFORE the plane hit (http://www.arcticbeacon.com/articles/article/1518131/28031.htm; and radio interview at
http://radiodialect.net/qcms4/m3u.php?
title=William+Rodriguez&mp3path=http://radiodialect.org/archive/2005/06/20050602_william_rc

(12) Janitor who worked in the basement of north tower also witnessed explosion (http://www.arcticbeacon.com/articles/article/1518131/29079.htm)

There is also substantial indirect evidence of explosives in the world trade center:

(13) MSNBC reporter stated "I heard a second explosion ... And then a fire marshal came in and said we had to leave, because if there was a third explosion this building might not last" (http://www.whatreallyhappened.com/IMAGES/911.wtc.msnbc.2.wmv)

(14) Rescue worker discussing "secondary explosions" before the collapse of one of the twin towers (http://www.911blimp.net/videos/FDNY_explosions.mov)

(15) Fire chief from a nearby town heard a "high-pitched noise and a popping noise" right before the collapse of the South tower (http://september11.ceenews.com/ar/electric_broadway_electrical_supplys/)

(16) BBC reporter stated "There was a huge bang and the building physically shook . . . Seconds later there were two or three similar huge explosions and the building literally shook again" (http://news.bbc.co.uk/1/hi/world/americas/1537500.stm)

(17) Reputable astrophysicist wrote in an email that, immediately before the collapse of each of the twin towers, he heard explosions and then low-frequency rumbles (http://research.amnh.org/users/tyson/essays/TheHorrorTheHorror.html)

Comment Reason : Lack of information.

Revision Suggestion : Undertake a new study based upon the actual blueprints of the world trade centers, including their strong steel cores.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: "D. Alexander Floum" <afloum@williams-law-firm.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/1/2005.

Name : D. Alexander Floum
Affiliation :
Email Address : afloum@williams-law-firm.com
Phone : 925-818-1702
Report Number : NCSTAR 1
Page Number : ALL
Paragraph : ALL
Comment : NY Fire Department Chief of Safety stated there were "bombs" and "secondary devices", which caused the explosions in the buildings: http://terrorize.dk/911/witnesses/911.wtc.reporter.1.wmv; high-quality audio here: http://www.whatreallyhappened.com/IMAGES/SecondaryDevices.mp3

NYC firefighters who witnessed attacks stated that it looked like their were detonators : i.e. bombs in the buildings : http://www.letsroll911.org/discussion_in_firehouse.mpg NYC

NYC firefighter stated "On the last trip up a bomb went off. We think there was bombs set in the building" : http://web.archive.org/web/20010914230246/: http://people.aol.com/people/special/0,11859,174592_3,00.html

British newspaper stated some eyewitnesses reported hearing another explosion just before the structure crumbled. Police said that it looked almost like a "planned implosion" : http://www.guardian.co.uk/september11/story/0,11209,600839,00.html

A facilities manager in the north tower "was convinced that there were bombs planted all over the place and someone was sitting at a control panel pushing detonator buttons" : http://www.thememoryhole.org/911/veliz_bombs.htm

Indeed, Larry Silverstein, the leaseholder of the World Trade Center, said in a PBS documentary that Building 7 was "pulled" on September 11th. : http://www.infowars.com/Video/911/wtc7_pbs.WMV "Pulling" is apparently a construction industry term for "intentionally demolishing", as shown in discussing the demolition of world trade center building 6 many weeks after 9/11 : http://thewebfairy.com/911/pullit/pull_it2_lo.wmv.

Moreover, there is evidence that substantial explosions occurred well BELOW the area impacted by the planes, and - in at least one case - they occurred BEFORE the plane had hit:

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Employee of insurance company in south tower heard an explosion from BELOW the

AUG 4 2005

Society of Fire Protection Engineers

August 4, 2005

Dr. Shyam Sunder
Deputy Director
Building and Fire Research Laboratory
National Institute of Standards and Technology
100 Bureau Drive
Gaithersburg, MD 20899

Dear Dr. Sunder:

We appreciate the opportunity to review and comment upon the draft "Final Report of the National Construction Safety Team on the Collapses of the World Trade Center Towers." The Society of Fire Protection Engineers fully supports recommendation #28, which states:

> "NIST recommends that the role of the 'Design Professional in Responsible Charge' should be clarified to ensure that: (1) all appropriate design professionals (including, e.g., the fire protection engineer) are part of the design team providing the standard of care when designing buildings employing innovative or unusual fire safety systems, and (2) all appropriate design professionals (including, e.g., the structural engineer and the fire protection engineer) are part of the design team providing the standard of care when designing the structure to resist fires, in buildings that employ innovative or unusual structural and fire safety systems."

Fire protection engineers, as well as engineers of other disciplines, bring unique strengths to the design process. Fire protection engineers are the only design professionals that have a detailed understanding of fire, how fire impacts people and buildings, how fire protection technologies can be used to protect people and property, and how to integrate fire protection systems with other building features.

Just as specialized expertise is needed to design innovative or unusual buildings, the same specialized expertise is required to determine what constitutes an "innovative" or "unusual" design. For fire protection design, only fire protection engineers bring the required expertise to determine if a traditional, prescriptive design approach is suitable or if more in-depth analysis is required. It is our position that all engineering designs should be prepared under the supervision of the appropriate type of engineer (e.g., fire protection, structural, etc.), and we would suggest that recommendation #28 be expanded accordingly.

In the case of structural fire resistance design, the current prescriptive design techniques do not require an analysis of fire behavior, heat transfer, and structural response. While this design

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approach has served society well for quite some time, it may not be suitable in all design situations. Moreover, the current prescriptive structural fire resistance design techniques are frequently applied by professionals who have limited or no training or experience in fire behavior and who may not recognize circumstances where more in-depth analysis is required. Combining the strengths of fire protection engineers and structural engineers in the design of structural fire resistance brings a number of advantages. These include:

- Understanding the damage that could result in the case of fire
- Ensuring that the structure can respond to the fire conditions to which it may be subjected
- Providing fire resistance commensurate with stated design goals for a structure

We have assembled a team of over 20 of the world's leading fire protection engineers with a goal of providing NIST with constructive feedback. Comments developed by our review team are attached in the appendix to this letter.

We would suggest that many of the problems that are addressed in your recommendations are international in scope. Therefore, we would recommend international collaboration in development of solutions to these problems.

Please note that due to the volume of the draft report (~10,000 pages) and the brevity of the public review period (six weeks), we were not able to review the entire report. Therefore, tacit agreement should not be inferred where we did not comment. Similarly, our submission of comments does not imply that we have "peer reviewed" the report.

Thank you again for the opportunity to review the draft report. We would be happy to provide additional detail regarding the contents of this letter or the appendix should you desire.

Sincerely,

For Samuel S. Dannaway, P.E.
President

General Comments

1. There seems to have been little or no attempt to compare findings and results with other published work. Additionally, any information that was derived from published literature should be properly referenced.

2. Differences were found in performance for similar assemblies tested in different furnaces (ULC and ULN). We recommend that NIST examine the reason for this further. To be comparable between tests (repeatability) and comparable among all tests (reproducibility), and to provide data for analytical methods, fire resistance test methods should include a requirement for specification, measurement, and reporting of furnace heat flux. Heat flux measurements are required in ASTM E-1529 but not in ASTM E-119 and standards similar to ASTM E-119.

3. Having heard comments at briefings by NIST that a "code review" was not conducted as part of this study, it's inappropriate for NIST to make comments that the building met code. Either a code review should be conducted, with any/all deficiencies reported, or the report should be silent on the issue. As is, statements that the building met code have no technical basis.

4. Use of the word "conservative" needs to be defined in the context of a forensic study that usually is interested in replicating "what happened", rather than be conservative in the sense of an analysis for a design in order to implicitly include a factor of safety.

5. Each of the Recommendations, and their supporting text, should be revised based on their risk-significance and cost-benefit.

   NCSTAR 1 and other NIST reports related to the WTC incidents do not indicate the level of risk reduction to be derived or the benefit to be gained by implementing the recommendations based on the cost to implement the recommendations.

   Executive Order 12866 requires that federal agencies consider cost and benefit in changes to regulations. Agencies must consider the degree and nature of risks to assure that regulations are cost-effective. In assessing costs and benefits, agencies must assure that regulations impose the least burden on society taking into account the consequences and costs of intended regulations.

   It is recognized that NIST is not implementing any regulations with the recommendations in NCSTAR 1, but it is clear that NIST is recommending changes in regulations that, if implemented, will likely result in significant societal costs. Neither the costs to implement nor the reduction in risk to the public have been identified, quantified, or analyzed.

   While NIST may not be subject to E.O. 12866 because it is not implementing any regulations, NIST is recommending the implementation of recommendations to change regulations or create new regulations at some levels. Section 9 of Public Law 107-231, National Construction Safety Act, states that NIST shall promote the adoption by the Federal Government of the recommendations for specific improvements to building standards, codes, and practices. The intent of E.O. 12866 for cost-benefit analysis of significant regulations should be followed. Irrespective of the Executive Order, cost-benefit analysis and risk significance information from NIST are necessary to support the recommendations and to assist standards-making organizations in making informed decisions to implement the recommendations in codes and standards.

While it might be possible to implement the recommendations, it is not clear that it is necessary to implement the recommendations based on their cost-effectiveness, risk-effectiveness, response to credible risks, need for implementation for all tall or low-rise buildings, and their overall societal impact.

Comments on NCSTAR 1

Location	Comment
Page xliv, 1st full bullet on page	In last sentence, which compares differences in failures between WTC 1 and 2, shouldn't there be some mention of the 'eccentricity' caused as a result of damage in one structure being predominantly on one side, while the other had damage nominally in the middle?
Page 5, footnote	The style adopted for this report is unacceptable for a technical report. Without references, it is impossible to understand the basis for a particular comment, whether from fact, eyewitness observation, simulation, expert judgment or an assumption. The lack of citations weakens the report, since the basis for statements requires a substantial expenditure of effort of pouring through hundreds of other pages to identify the source for a particular comment.
Page 12, 3rd sent. of 2nd para under Figure 1-8	This construction is not so commonly regarded. Type X gypsum is needed (or type C), not any type of gypsum wallboard. Further, this assembly is only regarded as being fire resistant if it is properly constructed per a listed design.
Page 8	It is noted that structural steel with yield stresses ranging from 36 to 100 ksi were used. Typically with very high strength steels, there is little variation between yield and tensile failure and maximum yield stresses which are well below the reported yield stress are used in the design to prevent brittle failure (for example $F_U = 82$ ksi, $F_Y = 80$ ksi; use $F_Y = 60$ ksi in design). This would have resulted in larger members with more capacity vs. that in which the full F_Y was used. Was this done in the WTC design, and if not, could it have been a factor?
Page 12	What is the basis for the estimate of automatic sprinkler being capable of controlling a fire of 4,500 ft^2? The design area of the sprinklers should be cited, if any specific area is to be identified. Insight into the basis for this comment appears on p. 24 (last paragraph) to indicate 1,500 ft^2 is attributable to sprinklers (was this the design area?) and then an estimate of the capability being to triple this amount. The noted factor of 3 is not supported in any technical reference in the literature and appears arbitrary. These rough estimates should be clearly identified, so as to appreciate which comments are based on such rough (arbitrary?) estimates and when comments have a strong basis.
Page 15, 1st para	Additional code deficiencies with the egress system include the absence of stairs discharging directly to the outside. In the case of WTC 1 and 2, all stairs discharged within the building.
p. 25, 1st para, 4th sent	While it may be true, this sentence is pure conjecture. It adds nothing to the paragraph and should be removed.
Page 29	"At temperatures above 500° C, the steel <u>further</u> weakens, …" Add the word further to clarify that it has already started to weaken prior.
Page 31, Figure 2-11	A label or improved caption is needed to understand what this figure is indicating or what is the orientation of the diagram (i.e. is it a plan view, cross-section, etc.).

Page 117, sect 6.9.3, 2nd sent., 4th para	Use of the word "conservative" needs to be defined in the context of a forensic study that usually is interested in replicating "what happened", rather than be conservative in the sense of an analysis for a design in order to implicitly include a factor of safety.
Page 118, section 6.10	The University of Maryland Department of Fire Protection Engineering has performed reduced-scale modeling of the fires in the WTC buildings. Although not published in the open literature, a report on this work and its findings is available from UMD. Since the scale modeling yielded different results, we recommend the NIST investigators analyze the UMD work and attempt to resolve or explain any differences in findings.
Page 124, table 6-6	"Rubblized"? Surely, there must be an existing word that can be used rather than transforming the noun "rubble" into a verb.
Page 131, 2nd bullet	We suggest referencing Jeanes' paper (SFPE Technology Report 84-1, 1984) for this data. Jeanes' data was acquired while a Research Fellow at NIST.
Page 144, 1st bullet after "The four cases…"	If 2,000 to 3,000 gal of jet fuel was ignited in fireballs outside of the building, and only 10,000 gal was introduced into the building by the aircraft, then how did all 10,000 gal ignite hundreds of workstations?
Page 175, section 8.3.1	Quintiere et al. (*Fire Safety J.*, 2002) have published an alternate theory of the collapse mechanism for the WTC buildings. Has the investigation team considered this scenario?
Page 195, bullets under 8.6.2	This is a general wish list, without any analysis as to the effectiveness and reliability of these factors for this particular incident. We suggest either deleting this list or providing such analysis
Page 204, Rec. 4	Delete "(especially for tall buildings greater than 20 stories in height)." There is no technical basis for establishing a threshold of 20 stories in height. If it is important to evaluate and establish technical bases for construction classification and fire rating requirements for buildings, it is likely important for buildings of heights less than 20 stories.
Page 204, Rec. 4, footnote #21	Delete "which were originally developed for buildings with less than 20 stories in height" in the second sentence. Also, delete the word, "generally" in the second sentence and the last three sentences. There is no technical basis for establishing a threshold of 20 stories in height. There is no technical evidence presented in the NIST WTC reports that fire resistance rating requirements developed for buildings less than 20 stories are inappropriate for buildings greater than 20 stories. The use of the descriptor, "generally" makes this a very vague statement. The statement in this footnote that there is "considerable conservatism in those requirements" indicates that the requirements are adequate for safety and that requirements that have "generally decreased" are not insufficient. The statement that consequences to occupants on upper floors (20 stories and above) is a generality which is unsupported. Depending on specific circumstances, occupants on lower floors could be more severely impacted by

	a given fire than those on upper floors.
Page 204, Rec. 4	Add a footnote to Bullet No. 4 as follows: "A Maximum Credible Fire Scenario includes conditions that can be reasonably anticipated related to building construction, occupancy and fire loads, ignition sources, compartment geometry, fire control methods, and similar factors as well as reasonably anticipated adverse conditions. A Maximum Credible Fire Scenario does not include highly unlikely, although possible, events or combinations of events." In bullet No. 6, replace "unusually large" with "large but reasonably credible"
Page 206, Rec. 6	Based on this study, does NIST have any recommendations for either minimum recommended densities, or the loads and impacting geometry used in impact testing for SFRM?
Page 207, Rec. 7	Generally, the when the term "structural frame" is used in the context of structural fire resistance, it is used to mean that the frame behavior of the structure is analyzed under conditions of elevated temperatures. It is noteworthy that doing so requires conducting a performance-based design that consists of three steps: (1) estimation of fire boundary conditions, (2) calculation of thermal response to the fire boundary conditions, and (3) estimation of structural response. Is it intended by this comment that this type of analysis should be performed? If so, this should be clarified. If the comment is intended to apply to the current prescriptive approach to structural fire resistance design, codes presently require that primary horizontal members such as girders, beams and trusses that have direct connection to columns (and thereby provide lateral support to the columns), have the same fire resistance rating as the columns. However, the floor construction, including secondary beams and joists, often require one hour less fire resistance, as was the case in WTC. When exposed to fire, primary steel horizontal members will sag considerably (even with adequate SFRM) and can create large lateral loads on columns, as opposed to provide resistance. Particularly in the case of exterior columns and beams perpendicular to exterior walls, there is no similar structural member on the opposite side of the column to provide resistance. This can result in the exterior columns pulling in, which was reported to have happened with WTC 1 and 2. Floors can act in compression to provide resistance to lateral forces, and had the floors and secondary framing been designed for 3 hours fire resistance also, columns may have remained stable longer. This recommendation should be modified to recommend that floors and secondary structural members have the same fire resistance rating as the columns.
Page 207, rec #8	Delete "tall" in the second sentence and add "required by the building code to have a fire resistance rating" at the end of the sentence. The need for a building to sustain burnout without collapse is not unique to tall buildings. It is not necessary that all buildings be capable of sustaining burnout without collapse. Small or inconsequential buildings of ordinary construction need not be required to sustain burnout without collapse. The societal need for some buildings to sustain burnout without collapse will be reflected in the model

	buildings codes. Thus, the recommendation should be addressed toward those buildings for which the building code requires fire resistant structural ratings.
Page 207, rec #8 & page 208, rec #9	The proper designation of "ASCE 29" is ASCE/SFPE 29.
Page 207, Rec. 9	We would note that the Society of Fire Protection Engineers has already begun the development of guides and standards to facilitate the performance-based design of structural fire resistance. Specifically, we have published a guide on determining fire boundary conditions for purpose of structural analysis, and we are presently developing a standard in the same area. However, standards on thermal response calculation and structural response calculation are still needed.
Page 208, Rec. 10	The development of new fire resistive coating materials for enhanced performance and durability is proposed. Comment should be made on the use or acceptability of reinforced concrete encasement for steel columns as an alternative to wraps or coatings.
Page 209, Rec. 12	It is unclear what is meant by "redundancy of active fire protection systems." Is it meant that additional, redundant systems should be provided, or that additional redundancy should be built into the systems that are already required?
Page 218, Rec. 30	It is noteworthy that the Society of Fire Protection Engineers presently has two short courses on computational fluid dynamics modeling. These were developed for classroom delivery, but they could be converted to a distance-learning format.

Comments on NCSTAR 1-6

Location	Comment
General	It is very difficult to find out what fires were used for analyzing the various components and subsystems. Reference is often made to Project 5, which is an excellent summary of what was done, but it does not clearly state what went into Project 6. Some sections used a ramped up temperature with no cooling phase, and others used the very detailed output from Project 5, with fires of different temperatures moving about each of the fire-affected floors. Summaries of fire exposure are given in various places, the best perhaps buried in Appendix A to the Global Structural Analysis supporting technical report. There may be other locations where it is better described, but like so much else it is very difficult to find. This is one aspect which will make it difficult for others to check and validate the structural analysis results at a later date.
General	The comments on fire testing and some of the structural analyses give insufficient consideration to the expected structural behavior during the cooling phase of the fire. This is a particular problem where high levels of axial restraint cause large tensile forces to develop in beams and slabs as the fire goes out and the floors contract on cooling. The effect of the cooling phase is mentioned in Figure E-11 but not elsewhere in the Executive Summary or Recommendations of Project 6. The discussion of fire resistance testing should address this issue because it is ignored in standard testing procedures (ASTM E119).
p. l (note 'L', not one), footnote	What is the basis for assuming that the adherence of concrete to a steel member is the same as that for the CAFCO product (or any other material)? With the lack of any data to compare the adherence characteristics of these two materials, using the performance of the concrete is inappropriate.
p. lxx, 2nd bullet	Instead of saying that there was "effectively no wind" – why not say what it was, i.e. 10 mph and then conclude it was negligible?
p. lxxii, finding 11	More explanation is needed as to why the unexposed surface temperatures are so different to result in a 30 minute difference in fire resistance. In terms of the unexposed surface temperature measurement, the tests with the 17 and 35 ft spans should have been very similar except for the size of the furnace.
p. lxxiii, finding 14, last sentence	Given the well-known importance of moisture content of concrete on fire resistance, if the noted appreciable differences in performance are attributable to a difference in moisture content, it begs the question as to how such was monitored prior to the test to confirm that the test would be representative, i.e. a valid comparison with other samples.
p. lxxiii, finding 18	Was there any photographic evidence of the large deformations and buckling of the spandrels? Given the reliance of the photographic

	evidence to confirm the accuracy of the modeling, this predicted behavior would seem to be noteworthy and worthy of confirmation via the photographs. If it's not present in the photographs, doesn't that question the validity of this calculated result?
p. lxxiv, finding 22	Define "conservative".
p. 17, last sentence	What tests are referred to here? These tests should be described and identified. Did they follow a standard protocol or an ad-hoc method? Also, define "slightly better". Why can't the definitive comparison (e.g. 5%) be presented? Further, how (i.e. relative to what performance characteristics) was the material better?
p. 19, 2.2.7, 1st para	The upgrades were only provided on the floors identified? Granted, these are the only ones relevant to this study, but the statement doesn't provide that caveat. On p. 24, 18 floors in WTC 1 and 13 floors of WTC 2 are identified as have been completed. The two statements should be consistent.
p. 22, Table 2-1	NCSTAR 1, p. 12, indicates that the term "fireproofing" will not be used in that report, given the implication of performance provided by this term. Why is it ok to use the term in NCSTAR 1-6 and not NCSTAR 1?
p. 24, 2nd sent., 3rd para.	Being that the measurements are so much different than that obtained from the interpretation of photos, why is there so much error associated with the photo analysis? This wouldn't be such a significant issue if so much weight wasn't placed on visual and photographic evidence being used to calibrate models or to confirm appropriateness of simulations.
p. 30, section 2.6	Why wasn't data from Harmathy ("Properties of Building Material at Elevated Temperatures, NRCC 20956, March 1983) or data from Jeanes' (SFPE Technology Report 84-1, 1984) referenced for the BLAZE-SHIELD DC/F thermophysical properties? Jeanes report is based on his work while the AISI/NBS Research Associate. The thermal conductivities in this report are approximately 10% less than that determined by Jeanes, except at 1100 °C, where the current report notes the conductivity to be approximately twice that of Jeanes' data.
p. 31, section 2.6.2	The previous page provides the data collected for thermal conductivity. Why isn't a similar table provided for specific heat?
p. 31, section 2.6.3	Because the UL listings for BLAZE-SHIELD address the density of the material using an "untamped" sample, how was the density measured that is reported in this paragraph?
p. 32, sect 2.6.4	We recommend providing the obtained here.
p. 32, section 2.7, penultimate sent	ASTM E760 could be consulted for performance criteria.
p. 32, sect 2.7.1, 2nd sent, 1st para	What strength is referred to here? Adherence? Coherence? Other?
p. 33, section 2.7.2, 1st sent	What criteria were applied to judge acceptability?
Page 34, section 2.7.3 and Table 2-4	These areas note that the adhesive strength of the SFRM decreased considerably when applied over primer paint. The specific primer paint used in the test, and at WTC if known, should be noted, as well as whether

	or not it was one recommended for use by the SFRM manufacturer. When primer paint is used, it must be compatible with the specific SFRM used. Primer paints are generally not required, but it is required that the steel surface be free of dirt, oils or loose mill scale. As tests noted in this document confirm (see page 34, second to last paragraph), adhesive strength can sometimes be negligible when primer paint is used. This is evidenced by test data for other locations. In the tests done for this study, "Two-thirds of the samples with the thicker SFRM had no adhesion to the coated steel plates." In Table 2-4, for the 1-1/2 in. thick samples with primed steel, the standard deviation is considerably higher than the average. This issue is covered in Rec. 6 on page 206 of NCSTAR 1, but it would seem that the presence of primer paint on the structural steel at WTC may have been as significant a factor as debris impact. This was not obvious in the summary report and should be elaborated on in the "Findings" section.
p. 37, section 3.1.1, line 6	The innovative nature of the floor system seems to be provided as an excuse for the inadequate behavior or lack of testing. Innovative systems are often the subject of testing. Systems that have been used for many years and that have already been tested do not need to be the subject of additional tests. Innovative or not, a fire resistance test should have been performed on a prototype (that was the common practice at the time, as identified in the 2nd sentence of section 2.1).
p. 39, next to last line	"Flame spread" has a specific meaning in the fire protection field, meaning propagation of a flame along a solid surface. In the context of fire resistance considerations the typical terms used are "flame propagation" or "fire spread". (see also: p. 43, 3rd line)
p. 40, section 3.3.3, 2nd sent	How does the referenced report, published in 2002, provide an indication of furnaces available in 2004?
p. 45, last line of para 2	The ratings are included in section 3.6.2, not 3.6.1
p. 58, sect 4.1.1, para 2, last sent	What was the basis for the estimate of the concrete strength in the WTC slabs?
p. 60, 1st bullet of section 4.1.2	What is the basis for the property data? The noted reduction in the modulus of elasticity is much greater than that reported in ASCE Manual 78 (Lie, *Structural Fire Protection*, 1992) which indicates that a conservative estimate is about 50% (not 75%). In this publication, Lie's use of the word conservative means that the greatest that the strength would be reduced is 50%. Buchanan indicates a similar proportion. Many times, mechanical data at elevated temperatures includes creep behavior as an integral part of the measurement? How were creep effects isolated in the data reported here?
p. 61, 1st bullet	What is the basis for the property data? The noted reduction in the yield strength is much greater than that reported in ASCE Manual 78 (Lie, *Structural Fire Protection*, 1992) which indicates that a conservative estimate is about 38% (not 80%). Harmathy (NRCC 1993 publication cited previously) indicates a reduction of about 44%.

Page 63, Figure 4-3	What is the basis for the property data? No reference is cited, nor is any indication provided to suggest that this data is a result of research conducted as part of this study.
Page 69, section 4.2.2	One area which has not received as much attention as necessary is the type of connection between the floor trusses and the surrounding structure. It appears that the connections were originally designed only for vertical loads without consideration for the tensile forces which could occur in fire conditions. The actual tensile forces could have been greater if the fires had occupied only one floor of the building, leading to possible tensile failures and progressive floor collapse. It is shown that they have limited strength in both the vertical and horizontal directions. Determination of the horizontal forces on these connections results from a complex interaction between the floors and perimeter frame, which has not been analyzed in as much detail as possible. The main item missing is a proper analysis of the magnitude of pull-in forces through the full development of fire, including the cooling phase. The full floor subsystem analyses (Section 7.3) are based on boundary conditions assumptions which are not accurate because these depend strongly on the horizontal stiffness of the supports which in turn depend on the behavior of the floors above and below the fire floor. Because this interaction was not properly evaluated, the exterior wall subsystem analysis (Section 7.4) had to be based on an assumption of a constant horizontal force which was evaluated empirically in order to match the failure conditions. The global model (Chapter 8) had to be based on further assumptions deduced from the above incomplete sets of analyses. This is not a major criticism, because a more detailed analysis would have been more complicated and would probably have not resulted in any different conclusions. An advanced structural analysis such as this requires a judicious balance between simplicity and complexity, and that balance seems to have been set at about the right level considering the accuracy of the input data and the need to get realistic answers in a reasonable time.
p. 87, group of bullets	Are the noted temperatures relative to the scenarios considered in this incident? If so, it should be noted what conditions each of the temperatures are relevant to. If they are randomly chosen to demonstrate behavior of a range of temperatures, that should be noted.
p. 150, line 1	Define "conservative".
p. 186, last sent of 2nd para	Case A is identified as being correct for one aspect, and case B for another. These are two significantly different cases. Which is to be believed?
p. 192, line 8	Concerning the concrete material model, assuming the same strength in

	tension and compression means that only 3 ksi can be carried in tension?
p. 196, 2nd para, last sent	If there was only a modest reduction in stiffness, how did the deflection increase to 37" on that side?
p. 196, 3rd para, 2nd sent	Vertical deflection was found to be insignificant, but the south side experiences major deflections per Table 7-1.
p. 196, 3rd para, 6th sent	"Restraint" is the more common term instead of "constraint"
p. 197, Tables 7-1 and 7-2	Several of the maximum displacements noted occur 10 minutes after aircraft impact, implying that the displacement decreases with fire exposure. This is surprising given the decline in the modulus of elasticity and creep effects. This is also contrary to the visual observations of increasing sag in floors and may be an indication of the source of the underestimation in floor deflections noted on p. 222 (see below).
p. 216, paragraph	Is this description absolutely the only mechanism possible to achieve the inward movement? Wouldn't heating from a fire exposure on only the inside cause the same effect, though maybe not for the magnitude observed? Could uneven heating contribute to overestimation of the pull-in forces? There's no evidence that the heating from a 1-sided fire exposure was considered.
p. 222, 2nd bullet, last sent	Given that the floor sagging was greater than that predicted, is it possible that neglecting cracking and spalling was significant, and should have been considered in the simulation?
Page 237, Figure 8-13	How does the predicted displacement compare with observations?
p. 272, 3rd bullet	The reference to the standard test is inappropriate. As indicated earlier in this report, the standard test is a comparative test. It cannot be used to predict performance from an actual fire in any way. A 15-minute fire from actual commodities has been observed to induce greater temperatures in steel members than a 3-hour fire exposure following the standard test procedure (see Seigel, *Fire Technology*, Nov 1970).

Comments on NCSTAR 1-6B

Location	Comment
Page 2, section 1.3	In this section, NIST infers that it has identified the important test variables and those are (1) fireproofing thickness, (2) constraint conditions, and (3) scale of the test. What NIST has missed is the most important variable in fire resistance testing, that being the difference in heating conditions. While ASTM E-119 specifies a standard temperature versus time profile, ASTM E-119 does not specify a standard heating profile. While the temperature indicates a potential for heating of a test specimen, it does not define the heat exposure to the specimen. Heating conditions can vary significantly from test to test within a particular test furnace (repeatability) and even more significantly from furnace to furnace (reproducibility). Tests performed on the larger ULC furnace might not be comparable to a similar test on the smaller UL furnace even though the same temperature versus time profile is reproduced. The measured temperature within a furnace is not a reliable measurement of the heat flux produced in the furnace. Heat flux drives the response of the specimen being tested. The size and geometry of the furnace, the thermal inertia of the furnace lining, and the emissivity of the furnace gases will greatly influence the heat flux that is experienced by the specimen. Kanury and Holve concluded (Kanury A. M., and Holve, D. J, A Theoretical Analysis of the ASTM E-119 Standard Fire Test of Building Construction and Materials, Menlo Park, CA, Stanford Research Institute, 1975): "Radiant heat transfer is the dominant heat transfer mode. Reradiation properties of the exposed material have an influence on the fire resistance time. Thus, the true measure of fire severity is given by the heat flux to the specimen, a function of both the furnace temperature and emissivity. The exact temporal distribution of temperature exposure has little effect on the fire endurance time as compared to the standard ASTM E-119 T(t) curve. Future improvements of the ASTM E-119 test should focus more on the control, measurement, and specification of the heat flux exposure condition rather than the furnace temperature history. Furnace emissivity has appreciable effect on endurance time, even though the relation is less than linear. An increase in emissivity from 0.2 to 0.6 increases the net flux by 80% and decreases the fire endurance time by 30%"

	We would suggest that Section 1.3, Test Variables, should be revised by NIST to indicate that all test variables have not been identified and isolated. The most significant variable in fire resistance testing is the heat flux in the furnace. The different heating conditions between the two test furnaces used in this evaluation have not been identified or analyzed.
Page 44, section 4.5	The report describes radiometers used to measure and characterize the furnace environment during the tests. It states that the location of the radiometers is given in Appendices D and F. However, the location of the radiometers is not clearly indicated in those Appendices. Pages 45 - 46 describe the instrumentation. For the most part, standard Type K pipe-shielded thermocouples were used for furnace control and information. In addition, plate thermocouples and aspirated thermocouples were placed on the bottom cord of main trusses (in part) and in the valleys (in part). Additionally, a few Gardon Gauges and Schmidt-Boelter gauges were provided. We recommend that the report include complete data output for the instrumentation, so that a more detailed investigation for the differences between the ratings obtained for the 17 and 35 foot assemblies could be conducted.
Page 95, section 6.1	The average furnace temperatures, as measured by the ASTM E-119 standard thermocouples, are shown. While this demonstrates that the furnace temperatures measured in the four tests were comparable, it does not demonstrate that the heating conditions were similar.
Page 96, section 6.1.2	Section 6.1.2, Furnace Temperature Environment, indicates that additional instrumentation was included to "further characterize the thermal environment of the exposing fire." While the measurements from the thermocouples reflect the temperature conditions in the furnace, the true thermal environment can only be assessed with the reporting of the heat fluxes measured by the radiometers. NIST failed to report the radiometer measurements in this section. Complete data from the radiometers should be reported in this section. Some, very limited information about furnace heat fluxes is reported, in part, in Chapter 5, Test Results. This information can be found only in Figures Nos. 5-11, 5-12, 5-48, 5-49, 5-64, and 5-65. This information is summarized below: <u>Test 1 ULC, 35 ft., Restrained</u> West Radiometer Heat Flux Range: 10-50 kW/m^2 Mean Flux: 20 kW/m^2 (estimated) East Radiometer Heat Flux Range: 10-60+ kW/m^2 Mean Flux: 40 kW/m^2 (estimated)

	Test 2 ULC, 35 ft., Unrestrained No radiation data reported Test 3 UL, 17 ft., Restrained South Radiometer Heat Flux Range: 20-135 kW/m^2 Mean Flux: 90 kW/m^2 (estimated) North Radiometer Heat Flux Range: 20-110 kW/m^2 Mean Flux: 70 kW/m^2 (estimated) Test 4 UL, 17 ft., Unrestrained South Radiometer Heat Flux Range: 5-40 kW/m^2 (prior to failure) Mean Flux: 25 kW/m^2 (estimated) North Radiometer Heat Flux Range: 20-100+ kW/m^2 Mean Flux: 95 kW/m^2 (estimated) There is clearly a significant difference in heating conditions between the ULC and UL furnaces despite the fact the both furnaces followed the same temperature versus time curve. Such a large difference in heating conditions would have a considerable effect on the response of the tested specimen. Figure 6-2 infers that the heating conditions between the two furnaces were similar. The data for two plate thermocouples were plotted only for Tests Nos. 2 and 4. Similar data for Tests Nos. 1 and 3 were not given or plotted to show correlation. Figure 6-3 clearly shows a significant difference in recorded temperatures for the south plate thermocouple in the range beyond 50 minutes. The lack of correlation among all of the plate thermocouples and the radiometers in the four tests on two different furnaces is unexplained and unresolved. The limited data based on three thermocouples, ignoring the non-corroborative data of one thermocouple and the wide variation in readings from the radiometers, does not support the conclusion in Section 6.1.2 that "The ASTM E-119 fire exposures for both furnaces used in this study were essentially equivalent." There is an attempt to infer that the heating exposures in the two furnaces were identical based on incomplete data and without mention or explanation of the variation in radiometer data. Based on the radiometer data, one cannot reasonably conclude that the heating conditions were identical even though the temperature profiles for two of the plate thermocouples are similar. NCSTAR 1-6B should provide some rational explanation for the discrepancies in data between the two furnaces or revise the statements about similar heating conditions in the two furnaces. There is a large difference in the thermal exposures between the large scale ULC tests and the smaller scale UL tests. The results of the tests on the

	two furnaces are not directly comparable. The NIST report fails to recognize or report on the difference in test conditions. The NIST report should clearly indicate the difference in heating conditions among the tests and comment on the lack of correlation between the ULC and UL tests. Comment on the fact that the specific, single tests performed for this investigation are neither repeatable nor reproducible would be appropriate.

From: "Allen Weidman" <Aweidman@socplas.org>
To: <wtc@nist.gov>
Subject: Response to NIST Recommendations regarding the collapse of the WTC Towers

Attached is SPI's response. Thank you for your review and consideration of our comments.

<<SPI response to NIST WTC Report.doc>> <<Response to NIST Recommendations re WTC.xls>>

Allen C. Weidman

Executive Director / Senior Director IT

The Society of the Plastics Industry, Inc.

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[AW-3WK4754]

SPI response to NIST WTC Report.doc

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Suite 1000
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Washington, D.C. 20006
202.974.5233 / aweidman@socplas.org

Allen C. Weidman
Executive Director

Friday, August 05, 2005

Dear Sir or Madam:

The Society of the Plastics Industry, Inc. (SPI) offers the following comments on the draft recommendations concerning the collapse of the World Trade Center. First, SPI compliments NIST on the incredible detail and thoroughness of its investigation into the events leading up to the collapse of WTC Towers 1 and 2. The amount and quality of the information generated by NIST during this exercise will surely lead to greater fire and impact safety in high rise buildings.

SPI is in complete agreement with the general recommendations made in the report. However, we believe that for the report to be self-consistent two additional detailed recommendations should be added as follows:

1) Enhanced Passive Fire Protection, and
2) Enhanced Fire Resistance of Building Components.

The attached spreadsheet indicates where these additions should be made, and why they are needed for the document to be more consistent.

SPI appreciates the opportunity to comment on the NIST recommendations prior to their publication. We believe the proposed additions would strengthen the document, allowing for the maximum breadth of technical solutions to the problems of fire propagation, heat release, loss of communications, burnout without collapse, issues of unusually large fuel concentrations, and redundancy in fire protection.

Sincerely,

Allen C. Weid

Section	Additions
Table 9-1 Crosswalk Recommendations <u>to Categories</u>	Add a new Category Entitled: <u>Enhanced Fire Resistance of Building Components</u>
	Category 4 - change to "Improved Active and **<u>Passive</u>** Fire Protection"
Table 9-2a. Standards Affected by the <u>Recommendation</u>	
NFPA 1 - Fire Prevention Code	Add - Enhanced Passive Fire Protection - Enhanced Fire Resistance of Building Components
NFPA 13 - Sprinkler Sys	Add - Enhanced Passive Fire Protection - Enhanced Fire Resistance of Building Components
NFPA 70	Add - Enhanced Passive Fire Protection - Enhanced Fire Resistance of Building Components
NFPA 72	Add - Enhanced Passive Fire Protection - Enhanced Fire Resistance of Building Components
NFPA 90A	Add - Enhanced Passive Fire Protection - Enhanced Fire Resistance of Building Components
NFPA 101	Add - Enhanced Passive Fire Protection - Enhanced Fire Resistance of Building Components
International Building Code	Add - Enhanced Passive Fire Protection - Enhanced Fire Resistance of Building Components
NFPA 5000	Add - Enhanced Passive Fire Protection - Enhanced Fire Resistance of Building Components
ASTM International	Add - Enhanced Passive Fire Protection - Enhanced Fire Resistance of Building Components
International Code Council	Add - Enhanced Passive Fire Protection - Enhanced Fire Resistance of Building Components
ISO TC92SC4 - Fire Safety En	Add - Enhanced Passive Fire Protection - Enhanced Fire Resistance of Building Components
National Fire Protection Associ	Add - Enhanced Passive Fire Protection - Enhanced Fire Resistance of Building Components

Justification (quoted from the body of the report)

"competition among different systems, **materials**, and **technologies**"
"burnout without collapse"
"Redundancy of fire protection"
"Sprinklers could be compromised, not operational or non-existent"
"To retard fire spread in buildings with large open floor plans" [areas]
"Containing unusually large fuel concentrations"

(Same as above)

In addition to the justifications noted above, there are many specific references within the report that speak of higher reliability/fire safety in the building's data/communications systems. Some examples are:

- "the fire alarm and communications systems in buildings should be developed to provide **continuous, reliable, accurate** information..."
- "...larger quantity of more reliable information from active fire protection systems..."
- "...steps to ensure that accurate emergency information is communicated in a timely manner..."
- "...more robust design of emergency public address systems..."
- "...improved emergency responder communications systems..."
- "...methods for gathering, processing, and delivering critical information through integration of relevant voice, video, graphical, and written data..."

From: "Hasan Gazi ICOZ" <yxkhasan81@hotmail.com>
To: wtc@nist.gov
Subject: Comments on NIST Draft Report NCSTAR1-1. The WTC......London

Dear Mr. Stephen Cauffman

National Institute of Standarsd and Technology
WTC Technical Information Repository
Stop 8610
Gaithersbutg, MD 20899-8610 USA

Attachhed pleasse find our Comments on WTC Disaster Scanario in relation to the above report. In principle we are in aggrement with NIST on certain major findings. There are a number of research cases where NIST have not spelt out in detail or missed out. Our contributions shall be considered as addudum to the above excellent report. We would appreciate if they may please be edited on the lines required by your final report. If you require our assistance at editing stage please do not hesitate to conctact the undersigned.

Prof. Dr. M.Y.H Bangash

Note: A CD containing all that has been given to you by e-mail is being sent to you with our compliments.

nist.doc

NIST NCSTAR 1 (Draft)

Federal Building and Fire Safety Investigation of the World Trade Center Disaster

Final Report of the National Construction Safety Team on the Collapse of the World Trade Center Towers (Draft)

For Public Comment

Prof. Dr. M.Y.H Bangash
BSc, BE, MSc, Ph.D, DSc(Eng), C Eng, FICE, FIStrutE, FASCE, MACI, FIE, C Eng, Fi Nucl E, MPCI, MBNES, MAIAA

Dr. T. Bangash
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Postgraduate Research Student on Explosion Related Structures
Imperial College of Science, Technology and Medicine, London

NIST

National Institute of Standards and Technology. Technology Adminitration – U.S. Department of Commerce

Introduction

Numerous case studies can be considered. A Literature Survey indicates that several structures had been subject to impact / explosion and fire. Various techniques of analyzing such structures have been fully described and as far as possible, several numerical models and analytical approaches are given to examine individual isolated cases and global structures which maybe subjected to aircraft / missile crashes, explosion aid fire. The reader has been given choices to intimate cases, which need urgent considerations. At the time of writing of this comment, several more disaster scenarios might have occurred and which couldn't be recorded. It is intended to present some well-known case studies, which might have bearing on identical disaster scenarios.

The following well-known cases are identified:

- WTC Towers in New York, U.S.A.
- The Oklahoma City Building, Alfred hurrah Building, Oklahoma U.S.A.
- The Pentagon Building in Washington D.C., U.S.A.
- The HSBC Building in Istanbul, Turkey

It should be not noted that the current submission concerns the WTC Towers in New York:

The federal investigation into the collapse of the World Trade Centre towers on Sept. 11, 2001 has been unable to pinpoint what engineering elements were critical in the disintegration of the buildings or how best to resist a recurrence. Eve so, the six-month study - conducted by the American Society of Civil engineers and the Federal Emergency Management Agency (FEMA) has revealed some disturbing facts abort modem skyscrapers that are potentially worrisome for those who work or live in high-rise buildings around the country.

The most encouraging finding was that the impact forces of the huge jets that rammed into the towers were not the only ones, by themselves, to cause the collapse. Although the twin towers were designed to handle only the crash of a Boeing 707 flying at low approach speeds, the FEMA report indicates when put to the test on Sept. 11 they absorbed the shock of slightly heavier Boeing 767's flying at much higher speeds. Had no other stresses caused by explosion and fire been imposed on the structures, they could have remained standing indefinitely.

Unfortunately there was added stress effects, in the form of extremely hot fires that resulted when jet fuel ignited the contents of the buildings and planes. The flames softened the structural steel, triggering events that allowed the upper floors to cascade downward.

All three major defences against fire proved unequal to the task. The sprinkler systems were disabled by the impact of the planes. Firemen were unable to reach the inferno because emergency elevator's were damaged, and even if they had arrived in force, the sandpiper they needed were almost certainly disabled. Finally, the fireproofing material sprayed on steel beams and trusses to protect against overheating failed to do so, notably because most of it was blasted off by the planes' impact. Whether better insulation is needed, at least for the most critical structural elements, 11 be one focus of additional inquiry.

The experts appointed were unable to determine whether the fires alone, without the impact of the airplanes, could have brought the towers down. But it is to learn that an adjacent history building collapsed completely as a result of a fierce fire fed by diesel oil on the premises, and that another building suffered a partial collapse from fire. These are the first known instances pf protected steel-frame structures collapsing from severe fire, suggesting that many modern building may be more vulnerable than anyone realized.

The investigation has put a spotlight on longstanding practices that will surely need revision in the wake of his disaster. It seems absurd that steel beams are tested for fire resistance, whereas the steel connection that hold them together are generally not. Nor is analysis made of how an integrated structure, not just its individual components, will respond to fires, or impact how fires and structural damage interact.

A more through three-year invesitigation has been conducted by the Natinal Institute of Standars and Technology (NIST) and published a final draft NIST NGSTAR 1 for public comment in 2005 on the safety investigation of the World Trade Centre Disaster. The report contains excellent factual data and recommendations with some creative interpretation. Some of these require serious considerations with final comments from the contributors.

CS.2 A Background to Comments on the Report.

Since 9/11, 2001, the co-author Dr. T. Bangash and myself have been working on the WTC Twin Towers and their collapse scenarios. We were familiar with the design of towers by Mr.Yamasaky, the architect in 1961. When the FEMA Report was published on Twin Tower Collapse scenarios in May 2002, we did approach, the famous technical publishers SPRINGER-VERLAG of Heidedberg, Germany, our intentions of publishing our finding on Twin Towers. As a result, after working on the analytical, numerical, design evaluations and preparation of advance softwares for the pre and post processing of results, we have managed to produce the fallowing book on:

EXPLOSION RESISTANT BUILDINGS
Design, Analysis and Case Studies, Aug 2005

The flyer given as PLATE No.1 shows the major contents of the book and it is intended to be considered as part of our public comment as asked for by NIST.

The entire work hinges on two vital methods of analysis:

- Three-dimensional Hybrid Dynamic Finite Element Technique involving subroutines such: BANG FIRE, BANG – BLAST, BANG-IMP ETC; Flow charts given on PLATE No.2 will explain the mechanism of the MASTER BANG-F.

- Three dimensional Finite/Discrete Element Method of Analysis developed by Dr. T. Bangash for his Ph. D programme of the London University 2004. This is a much more simplified method incorporating all effects of blast, fire and impact as stated under 3D Hybrid Finite Element Technique. This method reduces CPU Time by 50% and has been fully tested with Finite Element and applied successfully to Alfred Murrah Building at Oklahoma, USA

Three modified and adjusted versions of the fallowing softwares were considered for individual case studies such as aircraft impact on containment vessels for PWR, Fire-cum-Thermal Effects on global buildings and building internals of a high rise building in U.K. and Blast Loading Effects on concrete and steel structures.

PLATE 1

Springer

M.Y.H. Bangash; T. Bangash

Explosion-Resistant Buildings

Design, Analysis, and Case Studies

2005. Approx. 450 p.
Hardcover. EUR 149.95; £ 115.50; sFr 254.-
ISBN 3-540-20618-3

This excellent book highlights all aspects of the analysis and design of buildings subject to impact, explosion and fire. It is a definitive reference book and contains 10 sections from a wide international prospective. Three-dimensional finite element and discrete element techniques are included. They are applied to buildings such as the World Trade Center (WTC Twin Towers) and the Federal Building in Oklahoma on the basis of the designers drawings, data and other information. Many small case studies are also included. The book has a comprehensive bibliography and a large appendix providing background analysis and computer subroutines of recently developed programs.

From the contents:
Explosion and Buildings.- A Review of Affected Buildings and General Criteria, Data and Management.- Blast and Explosive Loadings on Buildings.- Fire and Buildings With and Without Explosion/Impact.- Structural Response to Blast Loadings - Methods of Analysis.- Blast Response Resistance - Design of Structural Elements.- Contact or Gap Elements for Blast-Fire Structural Interaction.- Aircraft and Missile Impact - Data and Analysis.- Aircraft Hot Fuel-Structure Interaction during Impact Condition.- Flying Debris - Elastic Scattering Approach.- Building Global Analysis for Damage Scenario.

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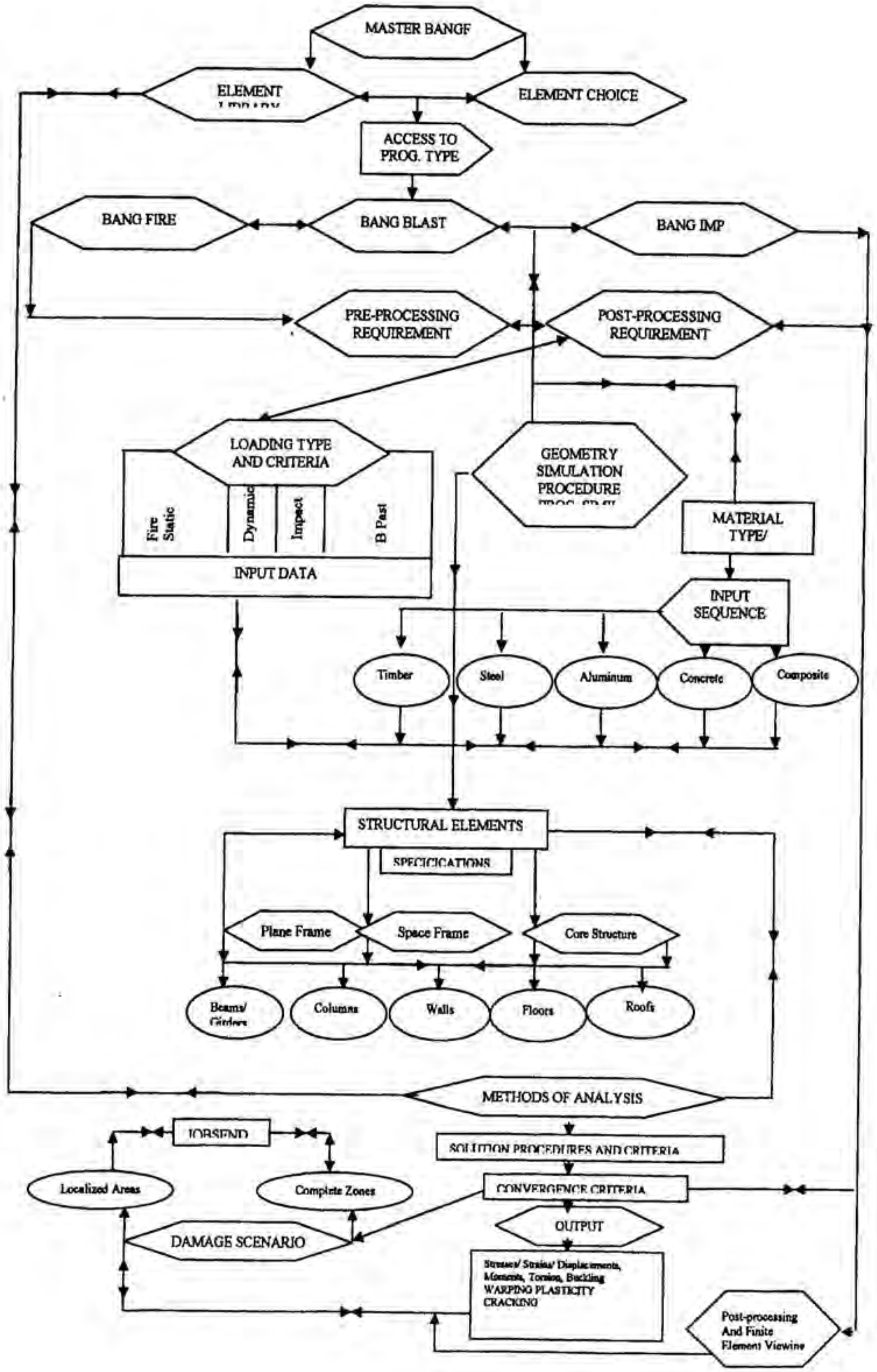
PLATE 2

FLOW CHART FOR PROGRAM BANGF (GLOBAL FINITE ELEMENT ANALYSIS)



(a) Program ISOPAR
(b) Program ANSYS
(c) Program LS DYNA
(d) Program Finit/Discrete

With FEMVIEW: For Viewing and PATRAN

Prior to the applications of these programs to WTC 1 and WTC 2, the analytical methods and software have been tested against known case studies fully collaborated with experimental results and wherever possible site monitoring.
In order to produce a disaster scenarios, the Master Program Bang-F asks for requisite any subroutines examined by the SUB PROGRAM EVOL, prior to passing on to program.

FEMVIEW or F.PATRON which maintain the numerous recorded pictures of the "Disaster Scenario" The function of the subprogram EVOL is also to check out whether or not BANG-F would scenario matches with the already stored scenario. If they are the same BANG-F would release all the numerical results and graphical disaster scenarios. Assuming they do not agree, they then go back as stated in the PLATE No. 2 to rediscover changed parameter and start all over again till the desired objective has been achieved. When the results are finally obtained, they either tabulated and or finally plotted. The same procedure is valid under debris impact, fire affected Components and Explosion on Structures or Structural elements.

This concept is the basis of the evolution of disaster scenarios of the WTC Twin Towers 1 and 2. It should be noted that the WTC Towers 1 and 2 have fallowed the NYC codes of building design:

- Each tower was designed to support dead loads (its own weight) consistent with the provisions in the 1968 NYC Building Code. The dead loads included the weight of the structural system and loads associated with architectural, mechanical, plumbing and electrical systems.
- Each tower was designed to support live loads (the combined weights of the people and the building contents) exceeding those specified in the 1968 NYC Building Code.
- The design wind loads used in the towers were higher than those required by the 1968 NYC Building Code and three other codes identified earlier.
- Each tower has not been tested as a sensitized design against withstanding the impact of a fuel-laden commercial jetliner, although the impact analysis had been carried out at design initial stages analysis with the impact of Boeing 707 aircraft flying at 600 mph against twin towers.

CS. 3 Problems Associated with the collapse of the towers – Initial Assessment

Various result are highlighted. Some these are briefly given below part of the overall discussions.

(a) When the. buildings WTC came down, as gravitational potential energy unloaded, and its value computed is around 6.8 x 10"7J. (Compared to this, the energy of a severe earthquake would be10^{17} J and thermal energy output of a reasonably large power station would be 10^{16} J). As a matter of fact, the collapse created an earthquake of 10 magnitude 2.4 on the Richter scale. However, unlike a normal earthquake, they were richer in low frequency energy and poorer in high frequency energy, the main reason for this being the gravitational potential energy due to the falling of building material. According to Prof. Mackin, of the University of Illinois at Urbana-Champaign, an aircraft has the equivalent power of a small-scale commercial power plant. The kinetic energy of a 767jet at impact is of the order of 40 mega joules as shown below:

$$KE = \frac{1}{2}mv^2$$

where m = mass = 204 x 10^3 kg
v = velocity = 19.7 m/s
KE = kinetic energy = 39.6 x 10^6 = 40 MJ

Though this energy is considerable, it is clear that the towers withstood this impact. Though damaged, two WTC managed to remain standing for approximately one hour, and one WTC for 90 minutes. The elemental analyses show that it was not to impact, but the energy in the fuel that affected the structural integrity of the building. The energy content of fuel is approximately 35 x 10^6 joules per litre. (Jet fuel may have even greater energy content). Assuming that the jet had 75,700 litres of fuel, (fuel capacity of 767 jet is 90,764 litres) and it detonated at once, the resulting energy would be 792 x 10^9 joules. This would amount to the equivalent of 2, 376, 000 sticks of dynamite (3 sticks of dynamite will have 1 mega joule of energy).

If one assumes that the jet liner with a weight of 205 tonne was traveling at cruising speed (850 km/hr) and dissipated all of its energy in one second, their torque on building shall be = F x moment arm = 857 x 10^3 KNm, where F = MV = momentum per second = 4018 KN. If the plane hits the 70^{th} floor, the torque at the base will be 857 x 10^3 KNm. Later on the global torque analysis given in the text could envisage the W.C. tower with standing this high impact. However, elemental analysis indicated that the impact of the plane crash destroyed a significant number of perimeter columns on several floors of the building, severely weakening the entire system. As the fire analysis indicates, as the fire raged in the upper floor, the heat gradually affected the remaining tower structure. The preliminary elemental analysis gives a firm belief that the steel core struts became weakened due to prolonged high temperatures fuelled by the large volumes of aviation fuel. The floor results showed from the elemental ad finite element program's due to the vertically directed 815 ^{O}C (1500 F°), the weakened struts collapsed collapsed mechanisms. This is the scientific explanation put forward for the catastrophic failure of the tower having intended to withstand an impact of aircraft such as that of a Boeing 767 jet aircraft.
The thermal environment within each tower is still a subject of discussion. Prior to the global analytical work on failure and collapsed scenario, it is essential the elemental analysis provided for components should be discussed in the light of Program BANG- FIR.

Based on preliminary assumptions and analysis, mathematical and numerical models have been used to estimate the behaviour of the fires in the twin towers of the World Trade canoe. The hijacked-plane collision with each tower produced significant structural damage, generated a spectacular external fireball, and started burning within the tower. The fuel consumed by the fireball was absorbed as an ignition source, but produced a pressure pulse that damaged windows and changed the ventilation for the fires. The subsequent are in each tower generated a quasi-static, wind-blown smoke plume. The fire and smoke behaviour were simulated using the program BANG-FIR (FDS). Comparison of the observed plume trajectory with the simulated one causes to estimate the rate of energy supplied by the fire to the plume which was of the order of magnitude of a gigawatt (GW). The rate of energy supplied to the plume, plus the energy-loss rate, determine the total heat release rate (I4RR), the most important single parameter for each tower fire. Two bounding scenarios for the interior damage and fuel distributions were considered by program BANG-FIR for the north tower. For each scenario, the simulated visible fire and smoke behavior outside the tower were compared with known photographing to determine which scenario seemed more appropriate. The simulations for the two scenarios also provided estimates of the likely thermal environment within each tower.

Because both towers were so completely destroyed when they collapsed, relatively little physical evidence remained for investigation. As a result, photographs have become the primary resource for providing initial estimates of the exterior damage to each building and of progression of the tire. These proved to be only source for comparing watts numerical models. Wind, pressure and temperature as functions of height, obtained from the records of the Aircraft Communications Addressing and Reporting System (AGARS), were also found to be critical input for the study. The finite element analysis provides program BANG-BLAST and program BANG-FIR have been examined.

CS4. Smoke Flame and Heat Analyses and Debris Release for Global Structures

The trajectory of the smoke plume convective energy convective energy parameters known to was used, in principle, to estimate the magnitude of per time contributed to the smoke plume by the tower fires. This rate, the wind speed and direction, and atmospheric stability are the govern a smoke-plume trajectory.

From photographs it was determined that the wind direction was almost exactly from the geographic north. We also established that the velocity of this wind was between 5 is and 10 is. The wind speed and direction were verified by data from the Aircraft Communications Addressing and Reporting System (ACARS), which also provided data on temperature and pressure as functions of height. From these data, assuming a perfect gas, one can also calculate air density as a unction of height, and these thermodynamic quantities determine the stability of the atmosphere. Commercial flights generally use ACARS to capture and retort temperature, pressure and wind speed and direction data as unction of altitude. It shows these quantities on the morning of 9/11 as obtained from three flights, one from JFK airport in New York and the other two from Newark International in New Jersey. Hence the analysis has used 5 is as the wind velocity and a lapse rate approximately one half the adiabatic lapse rate, which was -1.0 °C per 100 m.

As explained earlier, a full fuel load for each plane would be approximately 90,800 L or 74,500 kg of jet fuel, as noted earlier, the planes carried only approximately 31,000 to 34,000 L or 26,000 to 28,000 kg of jet fuel (density $\rho_{fuel} = 0.82$ kg/l. The area of one floor of either tower was 4025 m^2.

By contrast a second sophisticated analysis was uses a strictly Eulerian, mixture-fraction formulation to describe the combustion. In this model, the flame sheet was found where stoichiometry occurs, and the heat from the exothermic reaction is released into the flow along the flame sheet using BANG-FIR. The radiative transport is also handled in a more sophisticated fashion. An approximate solution to the full radiation transport equation, that accounts for local absorption and re-radiation by the material in the computational domain, is used to calculate radiative fluxes and, therefore, heat transfer by radiation. This formulation allows the radiation coupling that generates new gaseous fuel at solid surfaces. This method is applied for floors.

Detailed descriptions of the mathematical models used in both versions, and of the methods used to validate them are presented. The quality and ease of use of this tool have significantly improved the ability to understand fire behavior.

In the global analysis, the heat released per unit are in PROGRAM BANG-FIR is 2 MW/m^2. It assumed that plane dumped its whole fuel load over only one to two floors, smashing all material on those floors to an averaged depth of around 0.8 cm with fuel load of 6.2 kg/m^2 as part of the input to BANG-FIR. At the burning rate with heat release rate of 2 MW/m^2 the scenario established is the final attempt with time 10 minutes to spread over greater area. The estimate is consistent with that given in FEMA study Report. Throughout it is assumed in BANG-FIR that the jet fuel would be consulted quickly relative to the duration of the tower fire.

CS 5. PLUME-TRAJECTORY SCALING

The mass, momentum and energy equations stated earlier can be simplified by assuming a steady, non-zero horizontal wind blowing over a fire of heat release rate Q, assumed to be constant. Q is the most important parameter characterizing an outdoor fire.

Ambient stratification of the atmosphere, which is related to the meteorological concept of potential temperature, is included in this model. The atmospheric stability at any height is determined by the local density (or temperature) gradient and is specified by the local buoyancy frequency N = $\sqrt{(g / \rho(z))(d\rho(9z) / dz)}$. This frequency arises because the atmosphere is naturally stratified as a function of height, with the highest density air at ground level and smaller densities with increased height. The horizontal velocity is assumed to be uniform with height over the height of interest, although the more general theory allows for a velocity profile changing with height. Analytical scaling of the governing equations introduced in these papers yields the following important length scale:

$$L = \left(\frac{Q_g}{C_p T_a \rho_a V N^2} \right)^{1/3}$$

where U is the steady and uniform horizontal velocity, N is the buoyancy frequency defined above, Cp is the constant-pressure specific heat for air, and T_a are ρ_a are the ambient, ground-level temperature and density. This length must be interpreted as an estimate of the order of magnitude of the height above the fire to which the centerline of the plume will rise for the specified values of the fire size Q_l (GW) the wind speed V and the buoyancy frequency N. Because this relationship is derived from the governing equations, it should apply to the WTC tower fires as well as to oil-spill fires.

From BANG-FIR part I the characteristic length L is computed as a function of Q for different values of N and V for the tower of WTC. These plots indicate the sensitivity of the value L to changes in atmospheric stability and the wind speed.

Program banging - part 2 used the thermal element model and was performed over a domain, which included the top portions of both towers and horizontal lengths in each direction equal to a few tower heights. With these computations, we attempted to bound the total quasi-steady convective heat release from the fires in each tower by comparison of the observed smoke plume trajectory with that determined by the simulations.

Based on FEMA, for most of the simulations reported here, a grid of 108 nodes in each direction (1.26 x 10^6 total cells) was used. Computations required about 15 CPU hours on a 1 GHZ standard personal computer to simulate 500 s real time for the FDS1 computations and about 30 s real time for the FDS2 computations. The domain for the FDS1 computations was taken to be 600 m in both horizontal directions by 800 m in the vertical directions evaluating a cell size of 5.6 m by 5.6 m by 7.4 m. The domain for the FDS2 simulations was approximately 84 m by 84 m by 70 m, giving a cell size of 0.78 m by 0.78 m by 0.65 m. It was noted from the calculations the steady slate plume height increased very quickly with down wind distance. Where the rate of magnitude became smaller, the plume height was slow with down wind distance.

CS 6 Fire Simulation in the Global Analysis

After the aircraft impact occurred, it is important to simulate fire in postulating interior and exterior damage of a WTC tower.

For both undamaged towers, we modelled a story as having a total height for the initial assessment of 3.66 m, with a floor/truss thickness/ceiling combination of 1.04 m. Only a portion of the height for the initial assessment of each tower was included in the simulations. The model started two stories below the damaged ones and ended ten stories above, because buoyancy N causes the smoke and hot gas to rise. For the north tower, the model began at the 92nd story and included the 108th story. The south tower began at the 76th story and ended at the 93rd story. The outside wails of the undamaged stories of each tower were impenetrable, whereas the core was assumed to be open at both the top and bottom allowing gases to flow freely in and out. These were taken from the FEMA Report. A reference is made to the following data from FEMA Report.

The core modelled by two vertical shafts each extending 42 the core, one having a width of 2.5 m and the other a width of 14.6 m with a 7.4 m aisle separating the two. The larger shaft was taken to be hollow, with a slit of 3.2 m running vertically up the centre of both long faces of the shaft. These slits were constructed to represent openings shown by connecting floors vertically through the core, and can be regarded as a combination of designed vertical connections and damage produced connections. ne core shaft was open at both the bottom and the top of the model. The slit size in the core shall changes the interior ventilation for the model, and this interior ventilation should be varied systematically to determine its importance to the spread of smoke, hot gases and the fare. Only two cases were simulated, one with no slits in the core and the other with the 3.2 m slits as described above.

Damage and the fuel distribution on the inside of the tower must be postulated. As an attempt to bracket the interior damage, two very different damage scenarios were considered for a segment of the north tower. For the first scenario, it was assumed that five floors were damaged and collapsed into a pile of combustible rubble from the force of initial impact, the north face, to the core. Therefore, the damage geometry was effectively one large open space with the rubble treated as a big rectangular block on the floor. We assumed that the internal combustible material was spread uniformly over all of the interior surfaces in the damaged area including the block, and all surfaces burned at the same rate.

In a second case, it was postulated that the plane penetrated to the core of the north tower and that the floors remained standing up to the damage hole produced by the plane. In this case, most of the floor area, except for the plane hole remained as it was before the collision, and the fire burned over these long, narrow floors.

The design load for one floor of such a building is usually taken to be 460 kg/m^2 with as 90 kg/m^2 due to partitions and 370 kg/m^2 regarded as movable. Of this movable load, the combustible portion is generally taken to be 14 to 18.5 kg/m^2, but possibly ranging up to 140 kg/m^2, with an average load of 46 kg/m^2 still being reasonable way to look at these fires is to consider burning jet fuel to be the igniter of the existing fuel within the building. It must also be noted that the fuel loads might vary considerably with spatial location in each building.

CS7. Conclusion and Future Recommendations

The comments examined what can be learned from the extreme events of 11 September 2001 for the future design of tall buildings and the appraisal of existing ones. The aim has been comprehensively examine the safety issues arising from such event and to direct and improve provisions for building infrastructure which can be sustain future malicious with reduced risk of loss of life.

A comprehensive study carried out, especially on WTC Towers gave an insight of the existing design and how it is related to the progressive collapse of the towers. Since no two buildings are identical, more case studies need to be examined using international collaboration amongst respective professionals are needed to optimise occupant safety in extreme events. The fallowing conclusions should be noted on the draft report.

(A) Analysis

1. A three-dimensional dynamics hybrid finite element analysis is required on tall buildings core and frames using the load-time functions of various known aircraft. In order to assist the designers we have prepared such load-time functions plotted for a number of known aircraft. This plot is given Plate No.3. The buildings are made up of materials can early be checked for the aircraft impact.
2. It is vital to analyse floors of steel, concrete and composite for damage scenarios presented by aircraft hot fluid interacting with these floor. The report is devoid by such recommendations.
3. From the hot oil structural interaction, after the building was subjected to heavy impact from the aircraft, debris can result, they in turn produce impulsive loads and cause an impact to the exterior of the columns/walls and core. It is essential to have a through investigation of the debris impact which causes holes and air ventilation, as such would generate instant fire. BANG-FIRE Program can take such a case of instant fire. The structural integrity is vital.
4. Passive and Active fire protection shall form the basis of analysis. The passive fire could not be simulated due to shortage of time and must be pursued in using specific analytical approach
5. During this analytical analysis at no stage thermal expansion is created any problem. Under such instant load, 2 to 3% of load caused by thermal expansion is in our view, insignificant.
6. Due to aircraft impact, prior to the hot-fuel interaction the joints, according to analysis, where heavily loosened and are failed and fire together with hot fuel interaction presented a desired scenario.
7. The three dimensional dynamic instability (elastoplastic) analyses has produced using FEMVIEW and PATRON, dejected structures elements. The maximum dejection of a column element 10 m at ground level. This analysis is important for dejection with debris dust is still in progress and the international community must show an interest in producing 3D model of Debris-Dust-Dejection of structural elements. RROGRAM IMP interacting with DDD program have produced extremely clear scenario.

(B) DESIGN

On the de sign and safety side, it is an excellent draft and raised there in same important issues. Looking at the various recommendations we have reasons to believe that the fallowing needs urgent attentions;

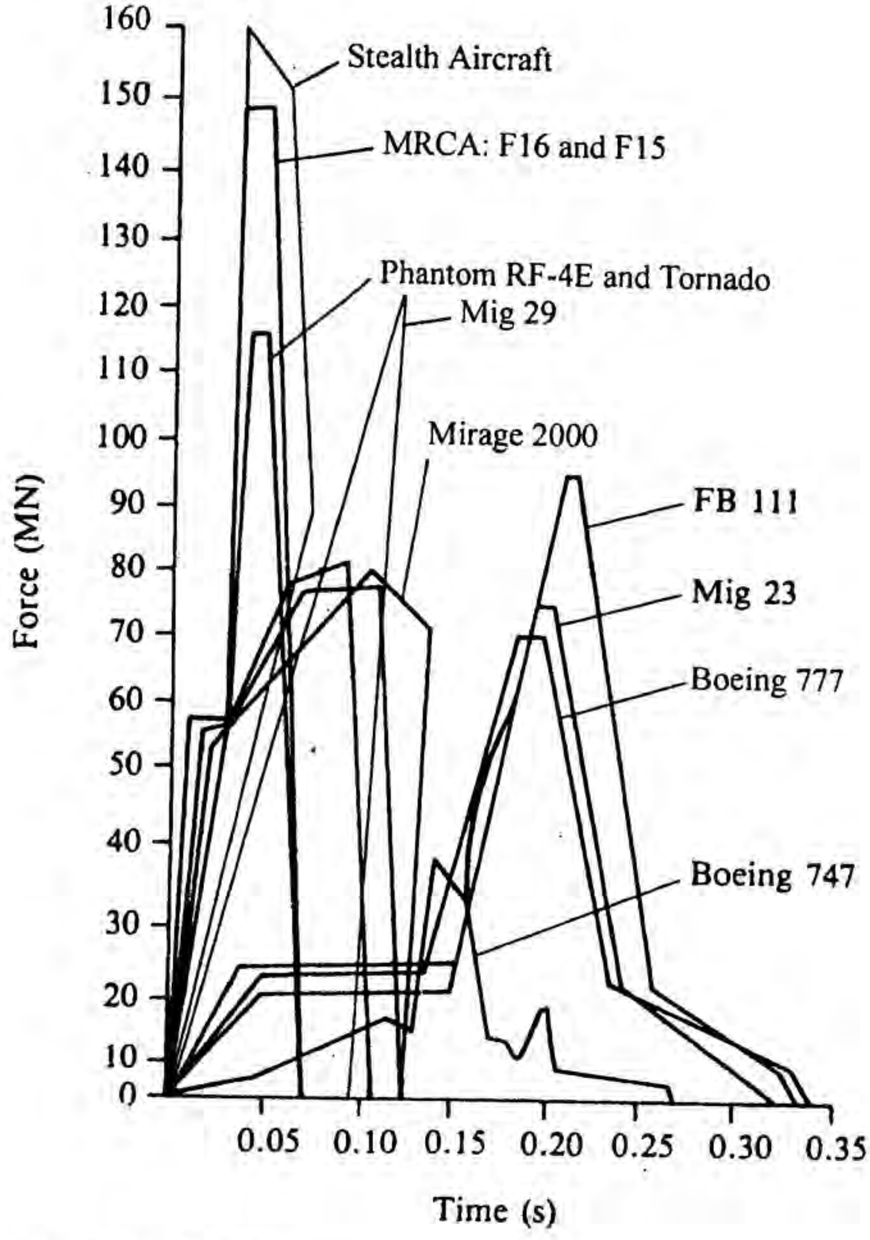
1. Safety Cladding: Our analysis indicates that use of laminated or toughened glass with fixing shall be designed to take into account of the potential explosion loading. Wherever is possible SIFCON Layers are employed which have improved load-deflection characteristics and stress-strain properties in comparison with normal concrete. The SIFCON panel between laminated

glasses subjected to blast loading provides 35% additional safety factor cladding and glazing of such a system cause less human injuries.

2. A comprehensive test program is need to design in solutions against with and without fire.
3. Security and Safety of Building Services : Design procedures supported by comprehensive and experimentation must produce robust and protected building services systems. The building must service complete "burn out" of contents.
4. Safety of Human Beings and Building Design: In order to reduce the probability of occurrence of extreme events, all designs must be carried out on time-load basis so as they have the potential to cause progressive collapse. Buildings above 25 storeys must be designed against impact and explosion with and without fire. Any height above 25 storeys buildings shall be provided with sky bridges, especially the buildings standing in parallel or any axis. The sky bridges above 25 storeys shall be on the basis of 4 No: floors/sky bridge. In order to make the building robust, the sky bridge would provide "stiff frame" effects and offer opportunities to stay longer in order to carry out substantial evacuation. Using crises cross positioned escalators in between sky bridges must provide potential escape routes. The physical size of these sky bridges shall not be less than those of staircase widths. Entrances to buildings must have separate air distribution zones with separate air supply and extract. The layout of the building shall be such that terrorists cannot find escape routes on grounds. This will be treated as part of strategies of deterrence needed for the protection vital installations.

   It is vital to ensure compartments in a building are gas tight and seals are sound on building completion, if new, by inspection, testing and cerfication.

PLATE 3



Time–impact function.

Appendix I

Extracts of Chapter 10

Explosion-Resistant Buildings
Design, Analysis, and Case Studies

2005, Approx 450p.
Hardcover , Eur149.25: £ 115.50
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10.9. World Trade Centre (WTC 1 and WTC 2)

10.9.1. Data for three-dimensional finite element modelling

The following summarises the basic geometric data for WTC 1 and WTC 2:
(Note: the data is given for both towers. Where there is a difference, this has been identified).

- 1 Storey Height is generally 110 storeys plus 7 levels.
- 2 For WTC 1 roof height is 1368 ft (417 m) with 360′ or 110 m Television Tower
  For WTC 2 roof height is 1362 ft (415 m)
- 3 Square floor plate 207′-2″ (63.1 m): corners cham ford 6′-11″ (2.13 m) Long on each side
- 4 Floor space at each level 207′x 207′
- 5 Rectangular service core 87′ (26.5 m) x 137′ (41.75 m)
- 6 Bearing wall (exterior wall module) Ref: fig. 10.10

• 7	Welded columns Typical floor at each of the flat faces of the building	59 No columns 14″ (358 mm) square box section at 3′-4″ (1.06 m) closed spaces REF Fig. 10.15
• 8	Adjacent perimeter column interconnected at each floor level	52″ (1.321 m) deep spandrel plates
• 9	Plate thickness	Exterior walls = 1/4″ (6.3 mm) Base of the column = 4″ (100 mm)
• 10	Floor construction	(a) 100 mm light weigh concrete with 38 mm – 22 gauge non-composite steel deck open web joist floor system (b) Floor trusses In pairs with spacing 6′-8′ (2.03 m), Spanning 60′ (18.276 m) and 35.0′ (10.67 m) at the ends of each core

The following summarises carefully by studying literature and drawings of WTC 1 and WTC 2 the loads and material properties associated with these two towers:

• 1	Floor imposed load Building corner load	100 lb/ft^2 (4.788 KN/m^2) 55 lb/ft^2 3.79 KN/m^2)

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• 1	Floor imposed load Building corner load	100 lb/ft^2 (4.788 KN/m^2) 55 lb/ft^2 3.79 KN/m^2)

Section 10.3

• 2	Boeing 767 – 200ER Commercial Aircraft (a) Maximum rated take off load/weight	3.95×10^3 lbf (376672 kg)
• 3	Basic dimensions of the aircraft 767-200 ER	159′ (48.45 m) length x 156′ (47.85 m) wide x 53′ (16.155) high from ground
• 4	Rated cruise speed	530 miles/hr Actual for WTC 1 470 miles/hr Actual for WTC 2 590 miles/hr
• 5	Tower Impacted floors	WTC 1 – Between floors 94 and 98 WTC 2 – Between floors 78 and 84
• 6	Impact Duration as reported (approx)	WTC 1 → 10 seconds Average WTC 2 → 8-10 seconds Average
• 7	Area Impacted	30 m^2 for WTC 1 35 m^2 for WTC 2

SEA LOAD-TIME FUNCTION FOR AN AIRCRAFT IN APPENDIX I

• 8	Collapsed after impact	WTC 1→After 102 minutes in 5 seconds WTC 2→After 56 minutes in 10 seconds
• 9	Approx. sealing gas temperature	1000 °C – 1100 °C
• 10	Approx. dead load	88 lb/ft^2 (4.213 KN/m^2)
• 11	Floor beams	Exterior: W24x61 Interior: W18x50
• 12	Steel plate thickness through out in bolded joints	3/8″ (9.5 mm) thick 12″ (305 m) x 6 ½″ (65 mm) PL
• 12	Bolts (as evident from drawings)	¾″ (19 mm) spaced along rows 3 ½″ (90mm)
• 13	Weld material	Nominal yield strength = 50 Ksi (342 MN/m^2)
• 14	Steel Grades 12ND	42 Ksi (289.6 MN/m^2) to 100 Ksi (684.5 MN/m^2)
• 15	Metal Deck spanning (a) Parallel to the main trusses	13′-4″ (4.064 m)

	supported by transverse bridging trusses	
	(b) Intermediate deck, support angles, spacing from transverse trusses	6'-8" (2.03 m)
	(c) Core concrete fill on metal deck supported by floor framing of rolled sections, in turn, supported combined wide shaped flanges and columns of box sections	14" (350 mm) x 36" (915 mm) deep
• 15	Outrigger truss system for stiffening of frames	103 floor – 110 floor
• 16	Structural tube framing base of the exterior wall frame	3ND columns 14" (358 mm) box each joint to form base columns
• 17	Cantilever transfer girder detail	46' (14 m) span, 2 to column continuous down. At continuous down = 4'-6" (1.37 m) 9 ft (2.74 m) depth near ranger with spacing 6'-9" (2.057 m)

Note: For other material properties reference is made to Tables (10.1) to (10.8). In the finite element analyses where stresses, strains for each element reached. The limit values, the element has yielded. This is discussed later on in this section.

Table (10.1) Heat Release Rate for Office Module

Heat Release (KW)		Time (seconds)
0		0-1200
1000		420↑
2000	Slow - Rate	↑450-600
4000		↑480-660↓
6000		0550↑↓
7000		600

Section 10.5

Table (10.2) Temperature – Time ASTM E119

Temperature °C	Time Minutes
25	1.5
200	2.0
400	4.0
600	7.5
800	20
1000	60

Table (10.3) Stress-strain curve structured steel ASTM A36 steel at 600°C (1112 F°)

Stress N/mm^2 σ	Strain ε in/in
0	0
100	0.08
130	0.02
150	0.12

Table (10.4) Critical Temperature for various types of steel

Steel	Temperature
Columns	538 °C
Beams	593 °C
Open-web steel joists	593 °C
Reinforcement	593 °C
Pre-stress steel	426 °C

Table (10.5) Strength – Reduction factor Fyt/Fy at Elevated Temperature °C

Fyt/Fy	Temperature °C
1	0
0.9	200
0.8	300
0.7	400
0.4	600
0.2	700

Section 10.6

Table (10.6) Young's modulus at Elevated Temperature °C Reduction values

E/E_0	Temperature °C
1	0
0.97	50
0.95	100
0.85	300
0.82	400
0.63	500
0.20	600

Table (10.7) Box columns 14" x 14" Temperature versus time based on E119

Temperature °C	Time (minutes)
100	5.0
200	7.5
300	10.0
400	12.5
600	15.0
700	20.0

Table (10.8) Warping and Buckling

Warping Wvc_b	M_1/M_2
1.0	-1.0
1.25	-0.5
2.25	+0.5
2.75	+1.0

10.10. Finite Element Modelling of WTC-1 or WTC-2

10.10.1. Introduction

In order to make more efficient use of the inelastic response of the building system and its damage scenario, the relevant numerical analysis and analytical work should be based on keeping in mind where the damaged areas were visible and where columns and floors statistical data in the FEMA Report have shown as disaster areas. This will be quite useful to check also the analytical results. Where the classification of the damage scenario is not clear, the normal course of finite element analysis shall be carried out. This section is entirely based on the WTC1 and WTC2 building collapse analysis. For the dynamic finite element analysis, a reference is made to Appendix I where derivations of various cases have been studied and analytical formulations are recorded.

Finite Element Analysis of WTC1 and WTC2: Basic Philosophy

Plate No 10.2 shows a typical 3D finite element mesh scheme, comprising of 3D line elements and series of these elements are connected by nodal points through out in the WTC1 framed building. The concrete floors have 4-Noded is o parametric elements and their nodes are linked with 2 noded truss rods of the trusses. The same scheme is continuous for the supporting trusses in transverse directions.

Both towers and their cores are modelled explicitly. The steel connections such as moment and shear connections are spandrel – column connections in all major framing are also explicitly modelled. In the intermediate framing, beams are in corporated as grids.

Typical mess schemes are given in figures (10.09) to (10.12) for individual local F.E. analysis for buckling, warping and interactive analyses when members are under loads caused by either impact – cum – blasts.

Basic formulations for the steel deck slab system are complex. In this analysis the system was modelled at each floor level as composite with clear material properties. T he elements refined systematically to obtain key out put data, specifically in the regions of heavy damage where F.E. mesh schemes were refined. PROGRAM BANG-BLAST has been used to carry out damage analysis using different models.

(a) Impact from 767-200 ER.
(b) Assessment of loose joints buckling and plasticity zones.
(c) Blast load defined for WTC1 and WTC2.
(d) (b) + (c) algebraically added results: check for any damage scenario defined by members crushing, yielding and cracking with and without buckling / warping.
(e) (b) + (c) + fire ball loads. The fire ball investigation includes fuel – structural interaction. BANG-FIR is called upon in the main program. The out put is algebraically added to (a) + (b). Check by FLAG, whether or not damage scenario has further intensified or spread to other elements.

The jet fuel has been distributed over multiple floors, and some have been transported to other locations. Some have assumed been absorbed by carpeting or other furnishings, consumed in the flash fire in the aerosol, expelled and consumed externally in the fireballs, or flowed away from the fire floors. Accounting for these factors, it is believed that all of the jet fuel that remained on the impact floors was consumed in the first few minutes of the fire. The wind speed at heights equal to the upper stories of the towers was in the range of 10-20 mph. The outside temperatures over the height of the building were 20-21 °C (68-70 °F). These effects are considered in the loading cases.

The modelling suggests a peak total rate of fire energy output on the order of 3-5 trillion Btu/hr, around 1-1.5 gigawatts (GW), for each of the two towers. From one third to one half of this energy is assumed to flow out of the structures. This vented energy is the force that drove the external smoke plume. The vented energy and accompanying smoke from both towers combined into a single plume. The energy output from each of

Section 10.8

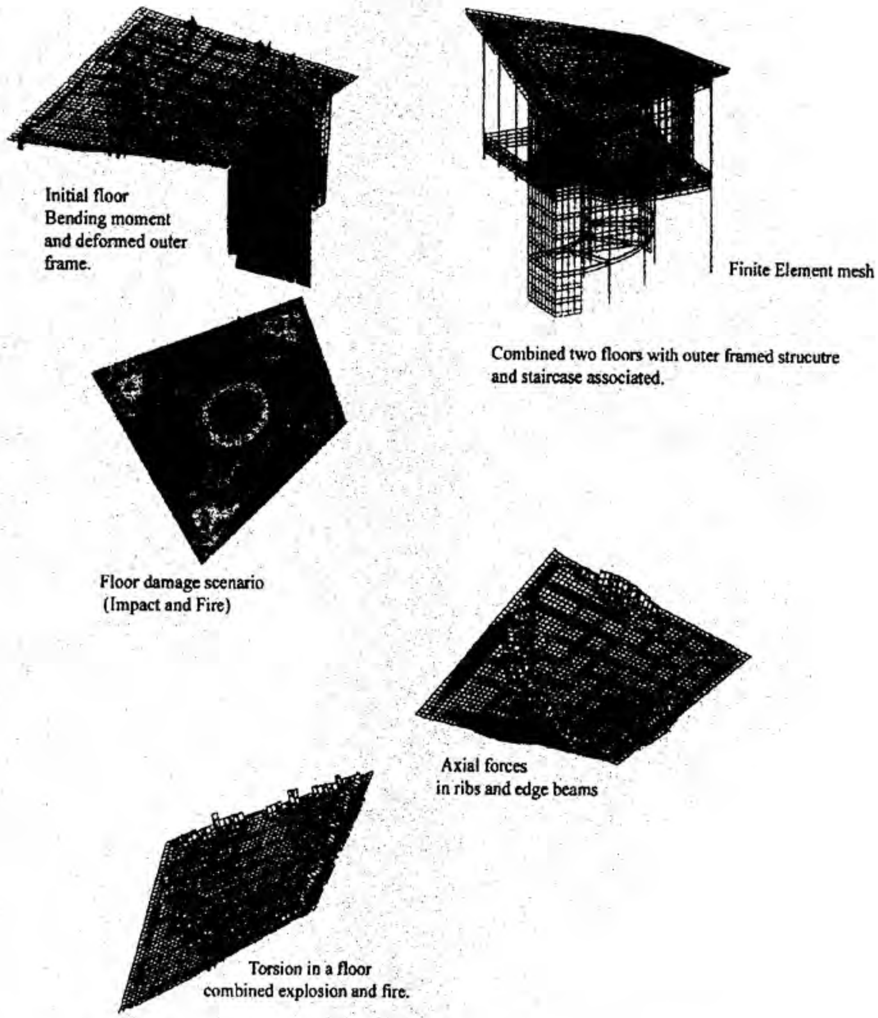
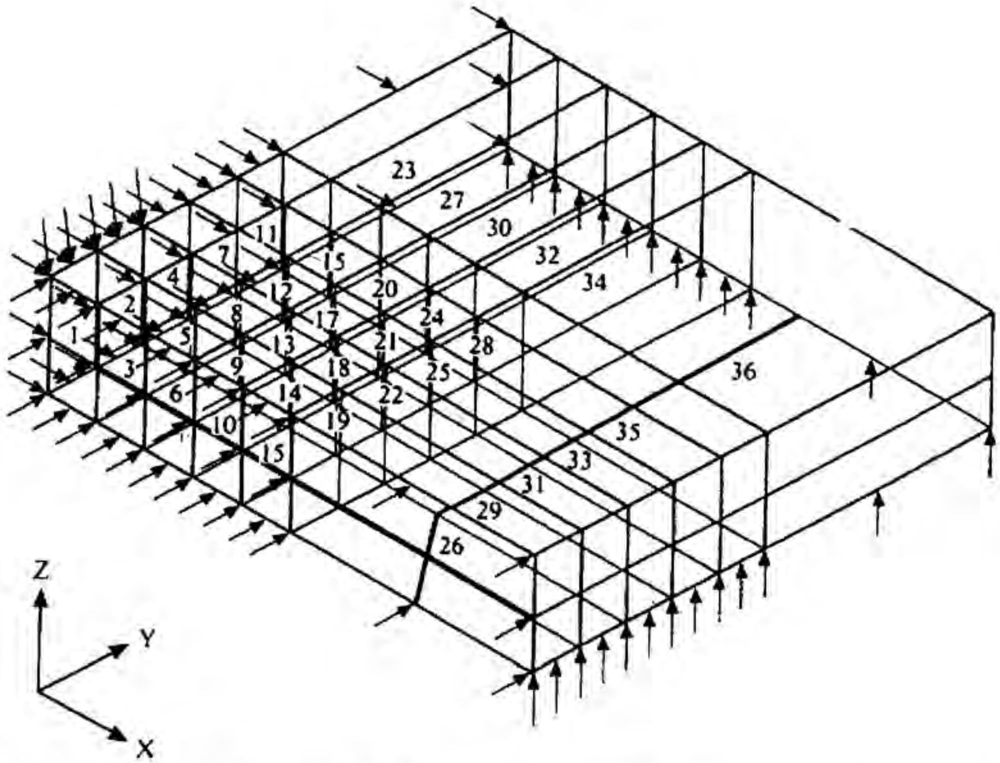


Fig.(10. 9) Typical floor-core deformations

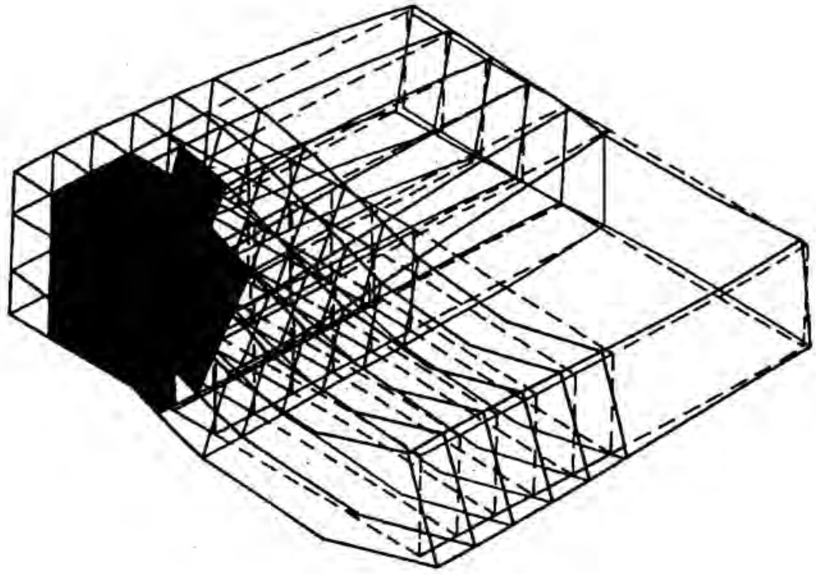
PLATE 4



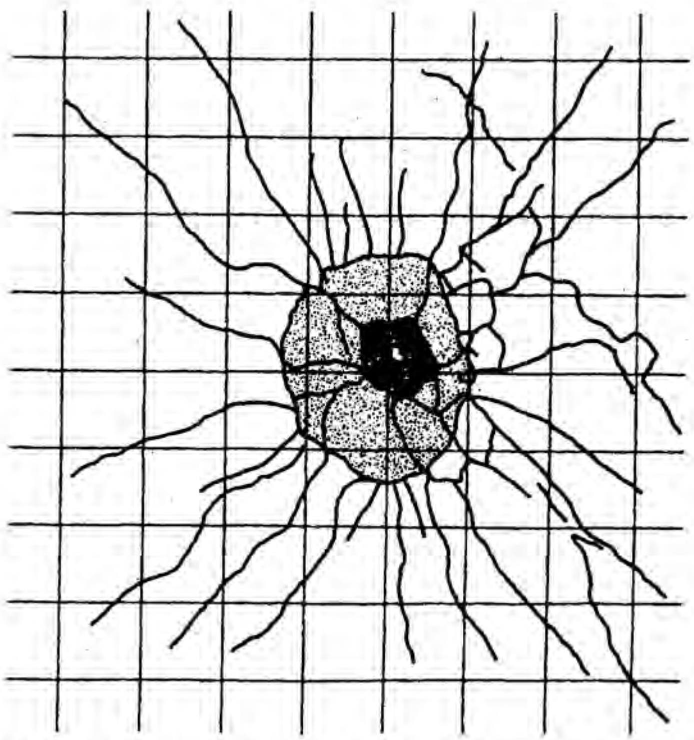
Model of one-quarter of the slab showing support condition load.

Section 10.10

PLATE 5



pluggea-out zone in three dimensions.



Final element results for shear cone and cracking.

Section 10.11

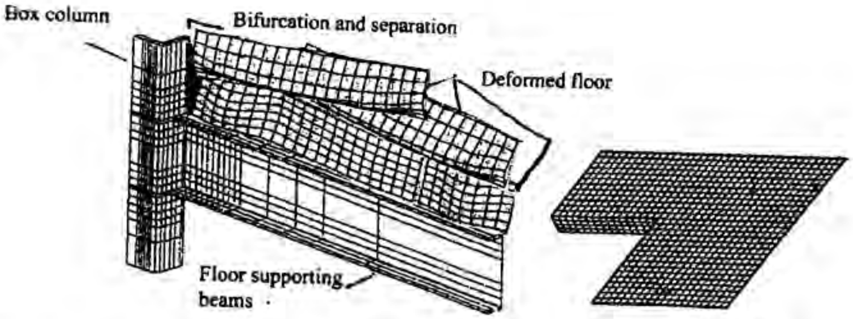


Fig.(10.10)(a) Floor on floor supporting beams with Box columns -Finite Element Mesh scheme

Fig.(10.10)(b) Undeformed Deck -Mesh Scheme 4 noded Isoparametric Elements

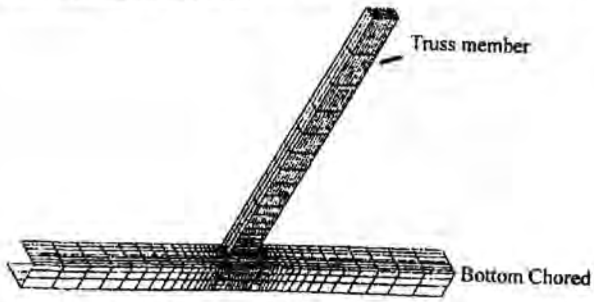


Fig.(10.11) Finite Elemet Mesh Scheme for trusses

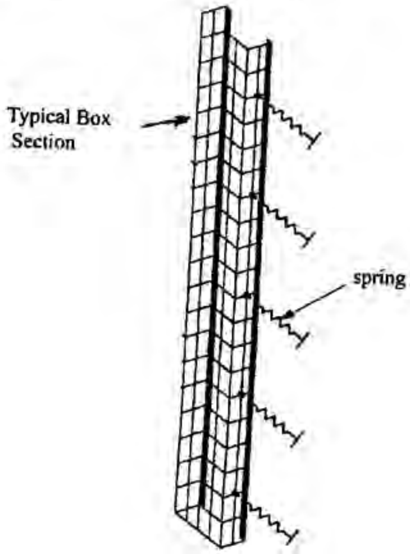


Fig.(10.12) Box section column interacting with floors

Section 10.12

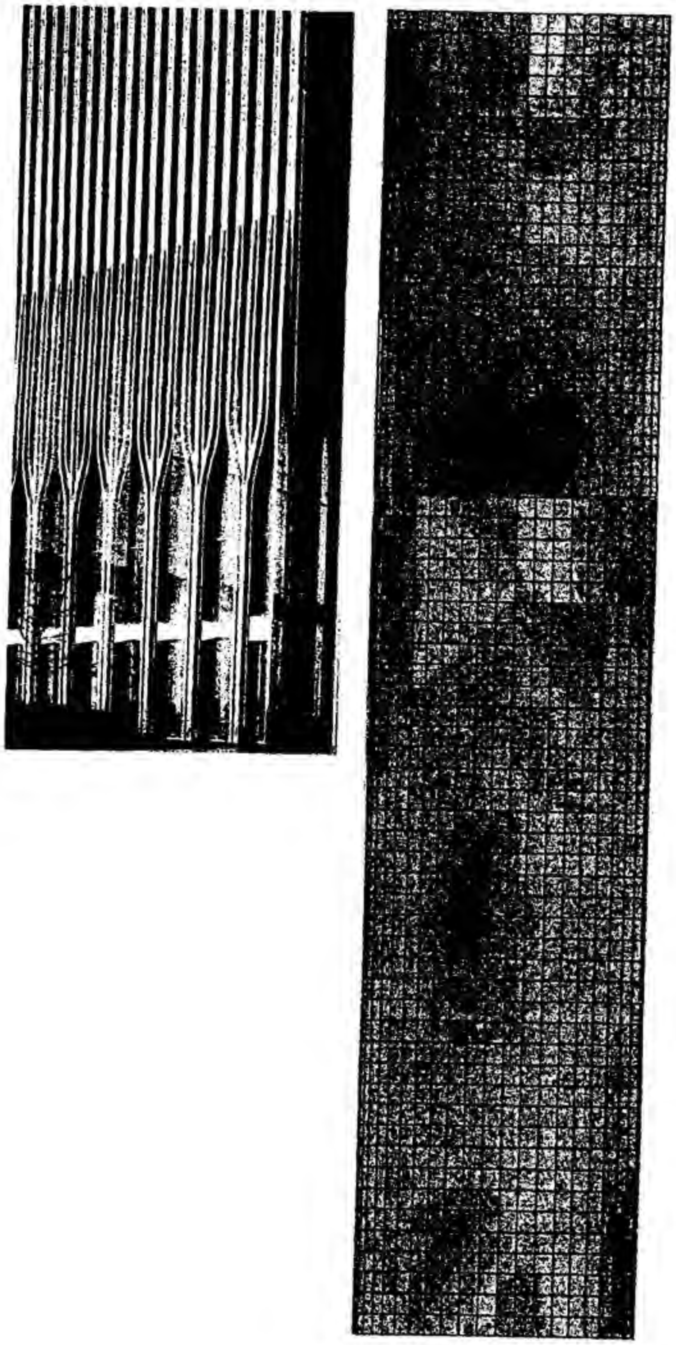


Fig.(10.13) A damage scenario of WTC1 at and around Impact area the two buildings is similar to the power output of a commercial power generating station. The modelling also suggests ceiling gas temperatures of 1,000 °C (1,800 °F), with an estimated value of plus or minus 100 °C (200 °F) or about 900-1,100 °C (1,600-2,000 °F). A major portion of the uncertainty in these estimates is due to the scarcity of data regarding the initial conditions within the building and how the aircraft impact changed the geometry and fuel loading. Temperatures may have been as high as 900-1,100 °C (1,700-2,000 °F) in some areas and 400-800 °C (800-1,500 °F) in others.

The viability of a 3-5 trillion Btu/hr (1-1.15 GW) fire depends on the fuel and air supply. The surface area of office contents needed to support such a fire ranges from about 30,000-50,000 square feet (2787 m^2 – 4645 m^2) depending on the composition and final arrangement of the contents and the fuel loading present. Given the typical occupied area of a floor as approximately 30,000 square feet, it can be seen that simultaneous fire involvement of an area equal to 1-2 entire floors can produce such a fire. Fuel loads are typically described in terms of the equivalent weight of wood. Fuel loads in office-type occupancies typically range from about 4-12 psf (0.191/0.0515 kN/m^2) with the mean slightly less than 8 psf (0.382 KN/m^2). File rooms, libraries, and similar concentrations of paper.

Based on photographic evidence, the fire burned as a distributed collection of large but separate fires with significant temperature variations from space to space, depending on the type and arrangement of combustible material present and the available air for combustion in each particular space. Consequently, the temperature and related incident heat flux to the structural elements varied with both time and location. This information is not currently available, but has been modelled with advanced CFD fire models.

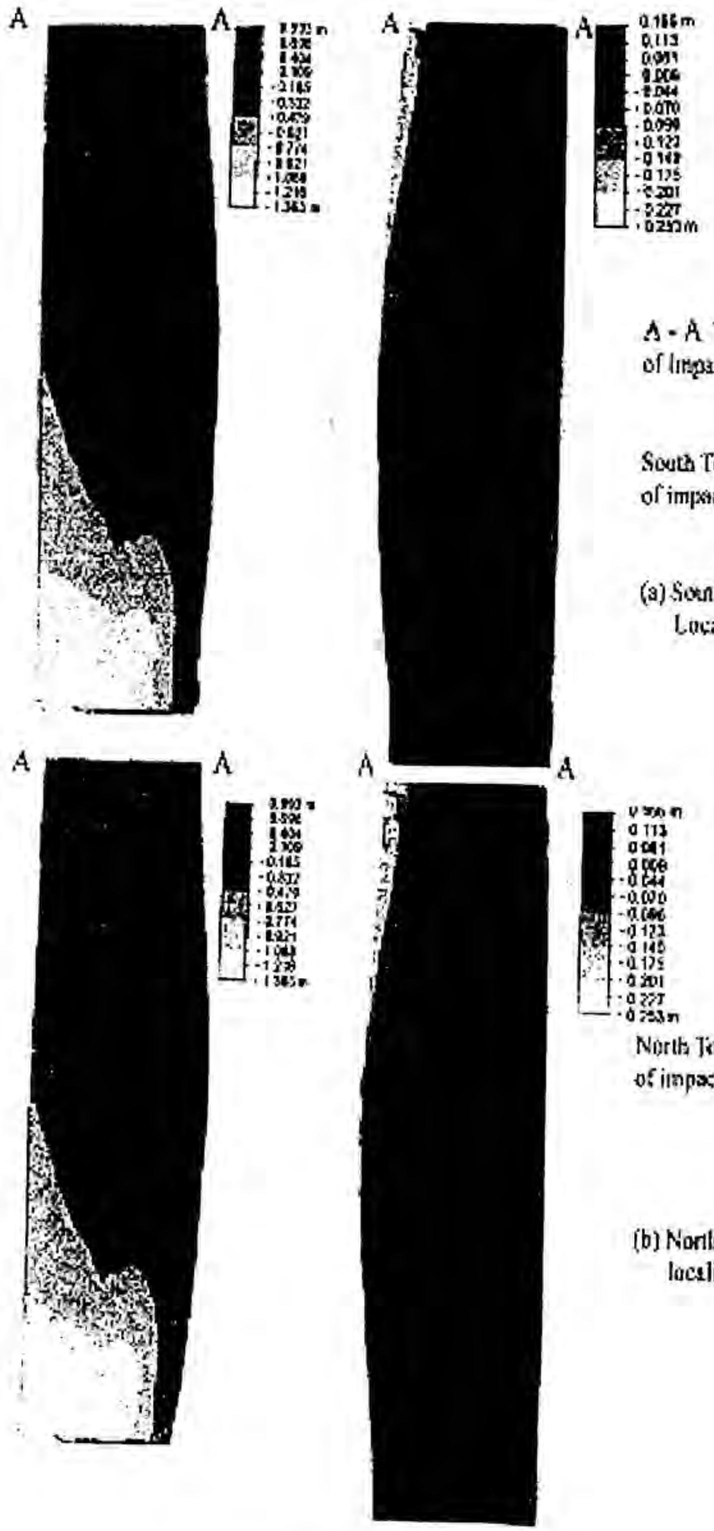
Damage caused by the aircraft impacts is believed to have disrupted the sprinkler and fire standpipe systems, preventing effective operation of either the manual or automatic suppression systems. Even if these systems had not been compromised by the impacts, they would likely have been ineffective. It is believed that the initial flash fires of jet fuel would have opened so many sprinkler heads that the systems would have quickly depressurised and been unable to effectively deliver water to the large area of fire involvement. Further, the initial spread of fires was so extensive as to make occupant use of small hose streams ineffective.

It is assumed that the structural joints, at the level of impact, are 95% in effective is the joints have failed. Areas outside impact zone, the strength reduction factor is, for the purpose of analysis, is 50% assumed to be 50%.

As stated earlier the impact of the aircraft into WTC 1 substantially degraded the strength of structure to withstand additional leading and also made the building more susceptible to fire-induced failure. Among the most significant factors:

1. The force of the impact and the resulting debris field and fireballs probably compromised spray-applied fire protection of some steel members in the immediate area of impact. The exact extent of this damage will probably never be known, but this likely resulted in greater susceptibility of the structure of fire-related failure.

Section 10.14



A - A Top Boundary level of Impact

South Tower from the level of impact.

(a) South Tower damaged zone Localised area.

North Tower from the level of impact.

(b) North Tower damage zone localised areas.

Section 10.15

2. Some of the columns were under elevated states of stress following the impact, due to the transfer of load from the destroyed and damaged elements.

3. Some portions of floor framing directly beneath the partially collapsed areas were carrying substantial additional weight from the resulting debris and, in some cases, were likely carrying greater loads than they were designed to resist.
As fire spread and raised the temperature of structural members, the structure was further, stressed and weakened, until it eventually was unable to support its immense weight. Although the specific chain of events that led to the eventual collapse will probably never be identified, the following effects of fire on structures may each have contributed to the collapse in some way discussion of the structural effects of fire.

4. As floor framing and supported slabs above and in a fire area are heated, they expand. As a structure expands, it can develop additional, potentially large, stresses in some elements. If the resulting stress state exceeds the capacity of some members or their connections, this can initiate a series of failures.

5. As the temperature of floor slabs and support, framing increases, these elements can lose rigidity and sag into catenary action. As catenary action progresses, horizontal framing, elements and floor slabs become tensile elements, which can cause failure of end connections and allow supported floors to collapse onto the floors below. The presence of large amounts of debris on some floors of WTC 1 would have made them even more susceptible to this behaviour. In addition to overloading the floors below, and potentially resulting in a pancake-type collapse of successive floors, local floor collapse would also immediately increase the laterally unsupported length of columns, permitting buckling to begin. As indicated in Appendix B, the propensity of exterior columns to buckle would have been governed by the relatively weak bolted column splices between the vertically stacked prefabricated exterior wall units. This effect would be even more likely to occur in a fire that involves several adjacent floor levels simultaneously, because the columns could effectively lose lateral support over several stories.

These factors 1 to 5 taken from the FEMA report are in line with the analysis presented in the text.

Progression of Collapse
As in WTC 1, a very large quantity of potential energy was stored in the building, during its construction. Once collapse initiated, much of this energy was rapidly released and converted into kinetic energy, in the form of the rapidly accelerating mass of the structure above the aircraft impact zone. The impact of this rapidly moving mass on the lower structure caused a wide range of structural failures in the floors directly at and below the aircraft impact zone, in turn causing failure of these floors. As additional floor plates failed, the mass associated with each of these floors joined that of the tower above the impact area, increasing the destructive energy on the floors immediately below. This initiated a chain of progressive failures that resulted in the total collapse of the building.

A review of aerial photographs of the site, following the collapse, as well as identification of pieces of structural steel from WTC 2, strongly suggests that while the top portion of the tower fell to the south and east, striking Liberty Street and the Bankers Trust building, the lower portion of the tower fell to the north and west, striking the Marriott Motel (WTC 3). Again, the debris pattern spread laterally as far as approximately 400-500 feet from the base of the structure. These effects are not considered in two towers.

Construction of WTC 1 resulted in the storage of more than $4x10^{11}$ joules of potential energy over the 1,368-foot (417 m) height of the structure. Of this, approximately $8x10^{9}$ joules of potential energy were stored in the upper part of the structure, above the impact floors, relative to the lowest point of impact. Once collapse initiated, much of this potential energy was rapidly converted into kinetic energy. As the large mass of the collapsing floors above accelerated and impacted on the floors below, it caused an immediate progressive series of floor failures, punching each in turn onto the floor below, accelerating as the sequence progressed. As the floors collapsed, tins left tall freestanding portions of the exterior wall and possibly central core columns. As the unsupported height of these freestanding exterior wall elements increased, they buckled at the bolted column splice connections, and also collapsed. Perimeter walls of the building seen, to have peeled off and fallen directly away from the building face, while portions of the core fell in a somewhat random manner. The perimeter walls broke apart at the bolted connections, allowing individual prefabricated units that formed the wall or, in some cases, large assemblies of these units to fall to the street and onto neighbouring buildings below.

10.10.2. WTC 2

10.10.2.1. Initial Damage From Aircraft Impact

United Airlines Flight 175 struck the south face of WTC 2 approximately between the 78th and 84th floors. The zone impact extended from near the southeast corner of the building across much of the building face (Figures 2-4 and 2-5). The aircraft caused massive damage to the south face of the building in the zone of impact (Figures 2-6 and 2-7). At the central zone of impact corresponding to the airplane fuselage and engines, six of the prefabricated, three-column sections that formed the exterior walls were broken loose from the structure, with some of the elements apparently pushed inside the building envelope. Locally, as was the case in WTC 1, floors supported by these exterior wall sections appear to have partially collapsed. Away from this central zone, in the areas impacted by the outer wing structures, the exterior steel columns were fractured by impact. Evidence shows from 27 to 32 columns over a 5-storey range were destroyed along the south building face. Partial collapse of floors occurred over a horizontal length of approx. 70 ft (214 m) while floors in the other portions were intact. A landing gear from the aircraft crashed through the roof of WTC 2. The roof was located six blocks to the North. A portion of the fuselage was lying on the roof of WTC 5. There was a lot of debris in WTC 2 as well. This effect is not taken in the analysis.

The same types of structural behaviours and failure mechanisms previously discussed are equally likely to have occurred in WTC 2, resulting in the initiation of progressive collapse, approximately 58 minutes (3360 seconds) after the aircraft impact. Review of footage of the WTC 2 collapse suggests that it probably initiated with a partial collapse of the floor in the southeast comer of the building at approximately the 80th level. This appears to have been followed rapidly by collapse of the entire floor level along the east side as evidenced by a line of dust blowing out of the sidle of the building.

As this floor collapse occurred, columns along the east face of the building appear to buckle in the region of the collapsed floor, beginning at the south side and progressing to the north, causing the top of the building to rotate toward the east and south and to begin to collapse downward. It should be noted that failure of core columns in the southeast corner of the building could have preceded and triggered these events

10.10.3. Analysis of Results from the global Analysis

The full simulation of he aircraft 767-200ER with a fuel-filled wings impacting WTC-1 Tower has been carried out. The key components were meshed out together with exterial walls columns wall panels and composite floors. The aircraft engine has a fine mesh of hybrid elements. At the impacting level both mesh schemes are provided with contact / gap elements For the purpose of interactive analysis Hallquist et al method of master slave and nodes have been adopted. The slave modes are constrained to slide on master segments after impact occurs and must remain on the master segment until tensile interface force develops. A zone in which a slave segment exists is known as SLAVE ZONE. A void exists between slave and master line. At impact level whether it is due to the aircraft or debris, it is necessary to update the location of each slave node by finding its closet master node or the one on which it lies. In the collapse analysis it becomes necessary that for each master segment one must find out the first slave zone that overlaps. Generate finally the existence of the tensile interface force. Constraints are imposed on global equations by the transformation of the nodal displacement components of the slave nodes among the contact interface. The slave nodes will have no normal degrees of freedom and the normal force components are distributed near by master nodes using explicit time integration in the finite element solution procedures.

There after the impact and release conditions are imposed. This method in the finite elements analysis identifies the contact point that can become trivial during the execution of the analyses. The impact of the aircraft developed a hole of not less than ≤ 30 m^2 by breaking the exterior columns and the floor slabs. The analysis shows, the area filled with hot fuel (800 – 1000 °C) completely developed failure zones and some cases rupture columns and floors. The debris formed impacted the walls and created large spaces for ventilation, allowing 70 seconds to produce flume and fire, initially in the impacted areas. The fuel structure interaction analysis showed continuous damaging and enlarging deformations, particularly to the floors with exterior columns bowed inward. The impact analysis further showed that the aircraft wing segments were fragmented (fy > 550 MN/m^2) and penetrated. Columns and floor zones filled with spraying hot fuel moving down from floor to floor. The hot fuel-cum-debris was sufficient to create a surge of rapidly filling the floors (93rd-97th floors). Debris integrate at this level to dust ridden plume. The ventilation created in the wall (east and south side of the tower) due to debris impacted as well created plume and ignited mist out the entrance gash and blown out window elements. The fire ball resulted. The finite elements analysis, using 3D FEMVIEW and PATRON, indicated continuous debris filled smoke for around 6000 second after which the entire structure collapsed. When the instability analysis performed, the exterior columns showed more "bowing in" at least 25% more than the combined load conditions. Where the exterior columns are not affected (outside impacted zone), they displayed enough residual capacity. The impact analysis re-evaluated the results and vertical approach angle below horizontal 13.6 °C (heading down ward) for WTC 1 Tower while maintaining 180° lateral approach angle and the vertical approach by 8° (heading downward for WTC 2 Tower. In both cases the average roll angle taken to be 32 °. The total time for load-time function diagram was 0.6

seconds for both towers. The progressive analysis of collapse involved different timings for the WTC-1 and WTC-2. The same aspect time, $\Delta t = 200$ seconds plus, was considered. Not having enough information on the damage to the thermal insulation, it was assumed that aircraft and debris impact have damaged and dislodged the insulation due to inertia forced developed as a result.

BANG-FIRE results when algebraically added to those obtained from aircraft and debris impactive forces indicated that the floors influenced initially by such forces, the hot jet fuel interaction with steel and steel-concrete composites have damaged zones more than the temperature expansion phenomenon which was around 2 to 3 %. The fuel temperature could not be less than 900°C for one hour at least, thus bringing the steelwork taking not more than 600°C would have contributed to the melting of the structural elements, the zones above the impact zone would be solid and undamaged, thus bring about the vertical collapse scenario. Since the ventilation created would have injected oxygen, thus causing fire which also created high temperatures to cause certain zones of WTC-1 and WTC-2 building structures the initiation of collapse. The temperature modelling alone without impact took almost twice the time of the collapse of WTC-1. Under combined impact fuel and fire loads generated the total collapse of WTC 2 in the specified time. This indicates that aircraft impact had substantially weakened the tower structures and joints welds etc. The impacts have caused greater instability without creating total collapse. The sagging of the floors had increased. Although the floors on the north side of the tower had sagged first, when the fuel plus fires moved toward south. Now the south side floors had sagged to the point where the south perimeter columns bowed inward. The finite element analysis showed that the south exterior wall had bowed inward by 1350 mm.

The robustness of the towers with that truss in particular was designed for normal loads with wind and earthquake effects. After seeing the tower WTC-1 with the core the floors and perimeter walls weakened major instability exhibited in the south wall. The hat truss could not be transferred the loads thereby causing the columns collapsed and the load via spandrels could not have been transferred. The upper section as predicted by the finite element like a high section started tilting and the upper section collapsed on to the floor in WTC-1. Top sway around 675 mm to the north. For maximum displacement value of the tower was achieved using hybrid finite element at 2.5 seconds. The impact position of UA Flight 175 was 7 m from the east corner of WTC-2. This is the off-centre called oblique impact produced torsion in the upper part and caused counter clock movement. The floors considered under direct impact were 77 to 85. The bulk of impact damage was according the finite element analysis was confirmed to six floor. The aircraft wing laden with fuel struck the tower WTC-2.

The heavier damage was discovered in 79th floor due to sheltering of aircraft engine and wings, especially damaged the floor slabs down to the building core. The fuselage when interacted with 80th and 81st floors, the damage scenario was worse. The impact showed the collapsed spandrels and cruised part of the 82nd floor slab with severed columns and the core. The photographs showed as within about one half of a second, dust and debris flew out of windows on the east and the north faces. Several small fireballs of atomized jet fuel burst from windows on the east face of the 81st and 82nd floors loading a large fireball that spanned the entire face. Almost simultaneously, three fireballs came from the east side of the north face. The largest came from the 80th through 82nd floors. A second, somewhat smaller one came from the 79th floor.

The finite element analysis showed only the same fuel-structure-interaction. The results were quite similar to WTC-1 except the physical conditions of the tower determined with inward bowing of columns. The tower lost in half the time the ability to support upper solid floors. The progressive analysis showed that the top of the tower continual tilted to the east and south. Using the aspect time $\Delta t = 200$ s, the tower began to collapse at earlier time when compared with the WTC-1 tower. Due to oblique impact the impact damage was more severe to the WTC-2 core. The causes can be due jet fuel spray into the interior of the building causing rapid fire, sagging of the east floors, pulling forces to the east perimeter columns with reduced load carrying capacity and heavily weakened and unprotected steel yielded and plastic hinges developed at various positions.

10.10.4. A Comparative Study of WTC-1 Tower Results

An independent assessment of the validity of tower step-by-step collapse scenarios is tabulated using both observed and computed od simulated phenomena. The insulation ate assumed ineffective in floors covering impact zones.

WTC- 1 Tower		
	Observation	**BANG-F Results**
1	The aircraft impact did occur at the tower and the tower did not collapse and with stood the impact at the initial time.	The computer simulation after impact showed no sign of major collapse. At increments, the tower still stood and resisted design loads on exterior column. In 20^{th} incremental process, the results showed around 8% reduced margin.
2	The south wall bowed at 10.23 am inward along the entire south face of 94^{th} floor to 100^{th} floor. The maximum bowing based on FEMA Report was 55" on the 97^{th} floor.	The instability part of the analysis indicated that buckling occurred at the level of 97^{th} floor around 1.375 m along with the tilt angle of around 10° in the direction of south. The total time registered to be 60,000 seconds.
3	At the structural collapse due to impact and fire, the top building section above impact zone tilted enormously in the south and no discernable east and west component in the tilt.	The analysis showed that thermal expansion was resisted by that truss. Core to the external walls, exterior columns splices and spandrel completely failed the hot fuel structural composite slab interaction initiated the collapse of six floors. Debris impact created ventilation holes and fire analysis took over from fuel analysis, thus created maximum load on core and external walls which exceeded when the process reached at 750°C where this intervened and make the components declared failed and (major parts) when $T_\theta = 600°C$, the solid part of the building above impact zone tilted and the bottom structure acted as like "magma" thus creating opportunity for nearly vertical collapse.
4	As clouds and dust obscured. The view the building section began to fall down nearly vertically. At 102 minutes from the impact of the air craft, the collapse initiated	The global instability segment within Program BANG-F, supported by program F-PATRAN to register viewing instantly, reached the limit over 1. South side bowed significantly. The program stopped at 6200 seconds from the time of impact. All elements collapsed. Flickering occurred at that level in F-PATRA indicating the program collapsed and non-functional and finally stopped.

Section 10.20

10.10.5 A Comparative Study of WTC-2 Tower Results

A similar approach was adopted for WTC-1 towers. The tower remained upright –with significant reserve capacity after aircraft impact and the initiation of hot-fuel structural interaction. The east perimeter wall, as indicated by BANG-F showed inward bowing of around 250 mm at floor 80. The bowing was extended and instability to 78th to 83rd floors. When BANG-F called upon the instability and F-PATRON, the results showed a greater tilt +8° to the east prior to the significant downward movement of the building section above the level of impact. Around θ = 30° tilt was registered by the instability analysis. The time of collapse initiation registered by program BANG-F together with sub programs duly intervened for component failure at different times was 2880 seconds.

10.10.5.1 Practical Solution to Twin Towers

The geometry of the twin tower is assumed to alter. Sky bridges of intervals of 4 floors were introduced between WTC-1 and WTC-2. A total number of 25 sky bridges were adopted. A rigid frame concept was introduced. The aircraft impact plus fire plus hot fuel loads apart from usual design loads were considered. Various impact angles on south and north sides were considered for the aircraft impact while keeping the roll angle to be 32°. The collapse of one tower took 5 hours and 25 second when aircraft was only considered. On combined loading the disaster scenario for one of the rigid towers reached 2 hours and 25 minutes. The analyses was repeated by introducing the rigidity of escalators or moving walks, placed inclined positions to pave the way for the quick removal of the population. The new factor of safety against impact alone was 15, against – collapse time of 15-2 = 13 hours when instability analysis intervened. In association with the blast loading effects, the margin of safety was reduced to 7 against 5 hours and 35 minutes and 30 seconds. Only one tower failure phenomenon was considered with the out come showed five sky bridges failed. When escalators and moving walkways were ignored, it is concluded that sky bridges need to be introduced at suitable levels.

From: Nico Haupt <nicohaupt2@yahoo.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/4/2005.

Name : Nico Haupt
Affiliation : team8plus.org
Email Address : nicohaupt2@yahoo.com
Phone :
Report Number : NCSTAR 1
Page Number :
Paragraph : all paragraphs
Comment : CC: hratch@nist.gov

Mr Sunder, Mr. Semerjian and anyone whom it may concerns,

i'm taking now the opportunity, as promised to you, to repeat my questions, which i presented at the NIST meeting on 06/23 and which got broadcasted by C|Span.

Here paraphrased and revised:

1) Why did NIST not publicly release a proper response to a letter of Kevin Ryan (ex-Underwriter Laboratories) to NIST, who was fired for his criticism of the NIST WTC investigation?

2) Why did NIST not investigate on Larry Silverstein's remark on PBS TV to "pull" WTC 7?

3) When will NIST properly disclosement the list of participants in all pre-9/11 OEM drills about "building collapses" and "plane crashes", according to May 2004 statement of ex-NYPD commissioner Kerik?

4) Where is NIST's proper Response on ex- Bush administrative Morgan Reynolds accusing the US Government of cover-up of an Inside Job of 9/11 and controlled demolition of the Twin Towers

5) When will NIST properly disclose the Video tapes of ex-FEMA Videographer Kurt Sonnenfeld, who was arrested on New Years eve 2002, but meanwhile relocated to Argentina?

6) Where are NIST's reasonable explanations on free fall scenarios of WTC 7 compared with only minor fires etc..., WTC 1, 2

7) Where is NIST's proper response on any other irregularities reg. Twin Tower facts
(non-functionable MOTOROLA radios incl. a dismissed
lawsuit by firefighters against MOTOROLA), infrared

photos of fire of Towers, which show temparature to
low to melt steel etc...

8) Where is NIST's proper response on a worldwide grass roots 9/11 truth movement and their follow-up questions and accusations reg. 9/11?

Furthermore, what kind of non-commercial aircraft do you think, hit the towers regarding the fact, that Flight 11 did not exist during Sep11th in the database of BTS/ACARS and flight 175 had a different wheels-off time and was reported as still missing during the afternoon by United Airlines?

Comment Reason : Deception of public, whitewash and treason

Revision Suggestion : immediate public answer

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

WTC Conference, MS 8610
100 Bureau Drive
Gaithersburg, MD 20899-8610, USA

ATTN: Co-Chairs S. Shyam Sunder and William L. Grosshandler

Gentlemen,

At the onset I want to go on record supporting the fine work of NIST and all of their employed associates. I commend the effort that you all have done and are continuing to do.

It is my understanding that NIST has made the assumption, that the existing fireproofing became dislodged primarily due to the flying debris generated by the aircraft impact. In my opinion, over reliance on this assumption is not only invalid, but is not supported by the known facts.

My presentation argues that the condition of the existing sprayed fire resistive materials, both the initial installation and the continued maintenance, must be investigated for the role they may have played in the collapse, a role perhaps greater than that of the plane's impact.

What we know.

We know:

1. That the determination of thermal restraint was dubious at best.
2. That the ½" thickness as measured and reported by FEMA was grossly underprotected.
3. That the test records have disappeared.
4. That apparently no maintenance records exist to speak of.
5. Steel substrate has been prime painted.

There also is ample evidence that the means and methods of fireproofing installations of today are not that different from 35 years ago. Therefore the pressures that exist today probably existed back then as well. With a reasonable degree of confidence we know:

6. That there were cost pressures.
7. That there were schedule pressures.
8. Environmental pressures.
9. That there were human fallacies.

None of these 9 conditions bode well for a compliant installation of fire resistive materials.

Difficulties with the impact theory.

I am uncomfortable with over reliance on the impact theory based on several issues:

1. To rely on the flying debris argument, we have to assume that the original application was at least reasonably compliant, and that proper maintenance had been exercised over the years.
    a. At this point in time we simply don't know, and although there is not much to suggest compliance or maintenance, the truth is that we probably will never know.
    b. There is an abundant support (photographs and field measurements) to suggest that it was not a compliant installation from the beginning.
    c. I understand that there are apparently no test or maintenance records available, further weakening a well maintained and compliant installation of fire resistive materials.

If we accept the flying debris theory as the primary cause for dislodging the existing fireproofing, we have to assume that it was compliantly installed in the first place. If the existing fire resistive material was not installed correctly or compliantly then the question becomes how much of a role did the non-compliant installation play in the collapse?

2. Secondly, if we are to assume that the impact force of the plane's was the primary cause of the dislodged fireproofing, then we would have to assume that it was sufficient in magnitude, totally geographic over the footprint of the building, multidirectional, and abrasive (sandblast like) enough to remove the critical spray applied fireproofing, thereby allowing failure. I have removed supposedly bad fireproofing with air and jackhammers. It is quite a job. At this point there is nothing to suggest that the force of the plane was that equally distributed through out the footprint of the building, with sufficient 200 lbs/sf of perpendicular force in all directions, to remove the fireproofing.

3. Finally the collapse of buildings, essentially straight down, suggests that the failure was global across the footprint of the floor and not radiating away from a single impact point. Maybe it was poorly sprayed, maybe it was the prime paint, maybe it was something else, but I doubt that the total floor failure radiated from a single point.

I do not think the documentation supports all three assumptions.

The argument

My argument is quite simple

1. The investigation data of the collapse does not support the plane's impact as the sole cause, or even the primary cause in my opinion, for the failure of the fireproofing to perform.

... with known and measurable documentation, strongly suggests that the condition of the fireproofing, pre-impact, must be studied as a cause of failure from an initial application perspective and a maintenance perspective.

3. The condition of the existing spray applied fire resistive material, and the causes that allow such conditions to exist, must be studied and remedied, as a pertinent part of this investigation.

The Recommendations.

My recommendations are:

1. Establish the role the conditions of the existing fireproofing had in the collapse.
2. Identify the "means and methods" that allowed a poor installation to exist,
3. Determine the extent of the problem in current installations and in other buildings.
4. Develop criteria to prevent future misapplication.
5. Create a link of responsibility for the verification of rating achievement and maintenance.

Opportunity

Most of us have seen, either live or on TV the images of the collapses. Out of the dust, dirt, and tragedy some of us see an opportunity. An opportunity not to criticize others, but an opportunity to set a course of expertise, a course of education, a course of deliberation, a course of responsibility, and if necessary a course of enforcement for compliant passive fire protection. Ultimately the goal of all of us must be safer building for the occupants and the general public. That is the opportunity that lies before us, and it is up to use to accept that challenge.

Respectfully submitted,

Tim Vellrath

Tim Vellrath, P.E.
Timove@aol.com

To: wtc@nist.gov
Subject: Comments on Draft Reports on the Federal Building and Fire Safety Investigation of the World Trade Center Disaster
From: Ganesh.Rao@us.ul.com

To: Stephen Cauffman
National Institute of Standards and Technology

Please see attached comments from Underwriters Laboratories Inc. on the draft reports on the "Federal Building and Fire Safety Investigation of the World Trade Center Disaster". Please contact the undersigned with any questions.

Best Regards,

Ganesh Rao
Manager Government Affairs
Underwriters Laboratories Inc.
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UL Comments-1 - NIST WTC Investigation Recommendations.doc

UL Comments-2 - NIST WTC Investigation Recommendations.doc

UL Comments-3 - NIST WTC Investigation Recommendations.doc

UL Comments-4 - NIST WTC Investigation Recommendations.doc

UL Comments-5 - NIST WTC Investigation Recommendations.doc

COMMENTS ON THE FEDERAL BUILDING AND FIRE SAFETY INVESTIGTION OF THE WORLD TRADE CENTER DISASTER

NAME: J. Thomas Chapin
AFFILIATION: Underwriters Laboratories Inc.
CONTACT INFORMATION: J.Thomas.Chapin@us.ul.com
REPORT NUMBER: NIST NCSTAR1 Draft
PAGE NUMBER: 204
PARAGRAPH/SENTENCE: Recommendation 4
COMMENT: Balanced Approach Underwriters Laboratories Inc. (UL) supports a balanced approach to fire protection that includes both passive and active systems to promote building safety. UL will continue to work with various organizations in preparing and supporting revisions to codes and standards that support the balanced approach.
REASON FOR COMMENT: Underwriters Laboratories Inc. (UL) is committed to a continual improvement in standards, systems, and processes for fire protection and public safety.
SUGGESTION FOR REVISION: None

August 4, 2005

COMMENTS ON THE FEDERAL BUILDING AND FIRE SAFETY INVESTIGTION OF THE WORLD TRADE CENTER DISASTER

NAME: J. Thomas Chapin
AFFILIATION: Underwriters Laboratories Inc.
CONTACT INFORMATION: J.Thomas.Chapin@us.ul.com
REPORT NUMBER: NIST NCSTAR1 Draft
PAGE NUMBER: 204
PARAGRAPH/SENTENCE: Recommendation 5

COMMENT:

Areas of Future Research

The effect of scale of test assemblies, end-restraint conditions and structural connections on the fire resistive performance of a test assembly requires more investigation. This research could be sponsored by public safety stakeholders and conducted by the North American Fire Test Labs.

Standards

Underwriters Laboratories Inc. (UL) will propose revisions to the UL 263 Standard Technical Panel (STP) regarding loading requirements, deflection limits and time-temperature curve. Likewise, UL intends to work with the fire protection industry and NIST to revise requirements in ASTM E119 based upon the knowledge gained by research cited above. UL will continue to support the efforts of the North American Fire Test Laboratories (NAFTL) to develop data to determine reproducibility of inter-laboratory test results.

Fire Test Data

UL routinely collects various types of data such as structural member deflection and temperature, unexposed surface deflection, and temperature and time to structural failure for inclusion in test reports. However, currently there is no requirement to publish this information. Publication of further data would require code and/or standards revisions. UL will work with all interested parties to determine the need for publication of additional information.

REASON FOR COMMENT: Underwriters Laboratories Inc. (UL) is committed to continual improvement in standards, systems, and processes for fire protection and public safety.

SUGGESTION FOR REVISION: None

August 4, 2005

COMMENTS ON THE FEDERAL BUILDING AND FIRE SAFETY INVESTIGTION OF THE WORLD TRADE CENTER DISASTER

NAME: J. Thomas Chapin
AFFILIATION: Underwriters Laboratories Inc.
CONTACT INFORMATION: J.Thomas.Chapin@us.ul.com
REPORT NUMBER: NIST NCSTAR1 Draft
PAGE NUMBER: 206
PARAGRAPH/SENTENCE: Recommendation 6
COMMENT: **Durability** Underwriters Laboratories Inc. (UL) has proposed a new standard, UL 2431, that addresses the durability of fire resistive materials and the retention of their fire resistive properties after exposure to simulated in-service conditions. It is anticipated that the new standard will be available for ballot by the first quarter of 2006. **Inspection** The on-site inspection of in-place fire resistive materials is a critical step toward obtaining the intended material performance in a fire. UL agrees with the need to develop a means to ensure that the in-place fire resistive materials perform as they would in the laboratory.
REASON FOR COMMENT: Underwriters Laboratories Inc. (UL) is committed to a continual improvement in standards, systems, and processes for fire protection and public safety.
SUGGESTION FOR REVISION: None

August 4, 2005

COMMENTS ON THE FEDERAL BUILDING AND FIRE SAFETY INVESTIGTION OF THE WORLD TRADE CENTER DISASTER

NAME: J. Thomas Chapin	
AFFILIATION: Underwriters Laboratories Inc.	
CONTACT INFORMATION: J.Thomas.Chapin@us.ul.com	
REPORT NUMBER: NISTNCSTAR Draft	
PAGE NUMBER: 209	
PARAGRAPH/SENTENCE: Recommendation 12	

COMMENT:

These recommendations make a general reference to enhancing the performance and providing for redundancy of active fire protection systems for certain structures.

Underwriters Laboratories Inc. (UL) will continue working with the National Fire Protection Association (NFPA) committees responsible for NFPA 1, NFPA 12, NFPA 72, NFPA 90A and NFPA 101. Its important to consider whether these enhancements would substantially increase the costs associated with installing these systems and could have the potential to discourage their use. The diverse knowledge and expertise of the technical committees along with a consensus standard/code development process will provide the appropriate for a to fully consider these issues.

REASON FOR COMMENT: Underwriters Laboratories Inc. (UL) is committed to a continual improvement in standards, systems, and processes for fire protection and public safety.

SUGGESTION FOR REVISION: None

August 4, 2005

COMMENTS ON THE FEDERAL BUILDING AND FIRE SAFETY INVESTIGTION OF THE WORLD TRADE CENTER DISASTER

NAME: J. Thomas Chapin
AFFILIATION: Underwriters Laboratories Inc.
CONTACT INFORMATION: J.Thomas.Chapin@us.ul.com
REPORT NUMBER: NIST NCSTAR1 Draft
PAGE NUMBER: 213
PARAGRAPH/SENTENCE: Recommendation 19
COMMENT: Recommendation 19 contains a reference to making the emergency public address systems more robust. It is our opinion that unless the public address systems employ standby power and supervision of the wiring/equipment per NFPA 72, making the public address system "more robust" will not necessarily make the systems more reliable.
REASON FOR COMMENT: Underwriters Laboratories Inc. (UL) is committed to continual improvement in standards, systems, and processes for fire protection and public safety.
SUGGESTION FOR REVISION: None

August 4, 2005

WTC PUBLIC COMMENTS

PART # 2

Comments on NIST NCSTAR 1 Draft

July 27, 2005

James Quintiere, Prof
Fire Protection Engineering
University of Maryland
College Park, MD 20742
jimq@umd.edu
With suggested changes in red to NIST report by Arthur Scheuerman

General Comments

These comments pertain to the NIST summary chapter of the NCSTAR 1 Draft report, and are based on statements also from the June 2005 progress report. My comments will be annotated (Appendix A) to indicate their source and to provide additional information.

My comments address the fire analysis, the heating of the steel and issues pertaining to such. In summary, I list the issues and concerns that I have with the NIST presentation and findings:

1. I do not believe that NIST has presented a convincing argument for their collapse hypotheses for WTC 1 and 2. NIST had repeatedly stated that they would list all likely collapse scenarios in terms of their probabilities based on uncertainties in the analyses. That seems to have been abandoned in the final report. Their collapse hypothesis is based on damage done by the aircraft impacts, particularly in removing insulation from the core columns is key, together with brief local fire heating of above 1000 oC for about 15 minutes. NIST has not made a sufficient case for the removal of the steel insulation, and the fire analysis is based on a light fuel

load that is shown to be in error. I suggest an alternative hypothesis based on longer fire duration, and on the insulation staying primarily in place.

2. NIST claims that if the insulation had stayed in place, the computed fire was not able to cause building collapse. Therefore, they conclude that the insulation applied in design was adequate: "The WTC towers would likely not have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact." [p172] I have not seen sufficient evidence to indicate that the insulation was removed, nor that the insulation applied, had it remained in place, was adequate.

3. NIST was not able to document the WTC design process with respect to the selection of the steel insulation or its basis: "NIST was not able to find any evidence that there was a technical basis to relate SFRM thickness to a fire resistance rating, nor was there sufficient prior experience to establish such thickness requirements by analogy." [p 55] the lack of findings is a tragedy of this investigation as it goes to the core of fire protection design and its dependence on regulations. If we do not know how the process worked for these buildings, how do we know it is being done satisfactorily now.

4. The report represents more of a scientific analysis rather than an investigation to find all of the relevant facts. NIST held no hearings to ascertain testimony, used no subpoenas, and enlisted no investigative team to gather information. NIST was very late in acquiring witness accounts due to the federal government bureaucracy requirements on public surveys. Steel remnants were collected as they were available, and reports from the PA or others involved were taken as fact without corroboration. An example is the acceptance of insulation applied to the trusses in renovation to the north tower, WTC1, impact area as 2.5 inches compared to the

specification of 1.5 inches over the original 0.5 inches. This is an incredible difference, realizing that they reported up to 4 inches applied to a 1- inch diameter rod. ("The Port Authority provided NIST with the records of measurements of SFRM thickness on upgraded floors in both towers. The average thickness and standard deviation on the main trusses was 2.5 in. ± 0.6 in. NIST analysis of several Port Authority photographs from the 1990s of the upgraded 31 st floor of WTC 1 indicated an average thickness and standard deviation on the main trusses of 1.7 in. ± 0.4 in.") [p 70] Had more steel been examined from the fire floors, NIST may have been able to establish proof for its hypothesis that key core columns were denuded of insulation and therefore significantly heated to cause their reduction in strength. NIST found no evidence to corroborate that finding. "None of the recovered steel samples showed evidence of exposure to temperatures above 600 C for as long as 15 min. This was based on NIST annealing studies that established the set of time and temperature conditions necessary to alter the steel microstructure. These results provide some confirmation of the thermal modeling of the structures, since none of the samples were from zones where such heating was predicted." [p 176] Had NIST recovered steel from the areas where steel was predicted to have been heated, could have given them key evidence to support their claim. As the steel was expeditiously sold to Asia, before the fire floor steel could be identified from its markings and saved, was a significantly blunder in the investigation. Since NIST has jurisdiction over future investigations, a protocol for protecting evidence and securing the site must be established. Moreover, the rationale for the speedy elimination of the steel in this incident, NIST fails to document. Spoliation of fire scene evidence can border on a crime.

5. The NIST report is difficult to read due to its length and tedious style. It does not clearly show cause and effect. Standard analyses of fires attempt to give a time line. While the actual

timeline is clearly known in this case, the predicted timeline and its cause and effect listing is not presented. There are vague references that the predicted fire looked right. Dr. Sunder indicated that a timeline was not predicted, as difficulties exist with the nonlinear creep structural model. Only a mechanistic analysis was presented [NFPA meeting at NIST, July 12, 2005]. The report needs to clearly indicate the scientific reasons for the NIST description of the collapse scenarios and tie them to the results of their computations and assumptions. This needs to be done with footnoted annotations so a reader can find the details. This 10,000- page report will only serve as a smoke screen unless it is fully documented for easy reference.

6. NIST has never acknowledged of answered comments in the past, so it is doubtful that these comments will have any impact. I urge them to be more responsive. I am attaching my unanswered November 22, 2004 comments for background. (Appendix B)

Specific comments:

1. Collapse Hypothesis

<u>Structural Failure</u>

NIST contends that the collapse is due the floors pulling in the external columns that in turn lose stability [p 171,2]. This occurs on the south of WTC 1 and the east of WTC 2. They say WTC 2 collapses earlier because it received more damage from the aircraft.

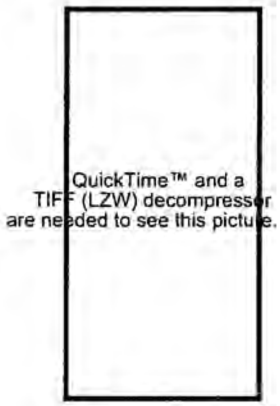
I find an alternative hypothesis that can be supported by relatively simple computations on the heating of the steel trusses with their specified insulations in place [Quintiere et al, Fire Safety J. 2002, and Quintiere, Interflam 2004]. This analysis does not include the heating of the core columns, as they would never get hot enough to fail if their insulation remained intact. Table 1 summarizes the results, and shows computations for a fire of 800 °C, and indicates the time for the steel to reach 600 °C where it falls to 20 % of its original strength. The truss at this temperature would fail due to the deflection pulling in the external columns as indicated by Usmani [FSJ 2003], and by NIST [June 2004 Progress report, Vol 1, p 81, 120] by either this column buckling or by failure of the connections. Buckling can occur at steel temperatures as low as 400 °C while the seat failure occurs at 650 °C.

It is noted that the predicted times to reach the critical failure temperature of the truss steel of 55 -73 minutes for WTC 2 and 111 minutes for WTC 1 in Table 1 is consistent with the building collapse times of 56 and 102 minutes, respectively. These predicted heating times are also consistent with the NIST measured heating times (to 66 to 86 minutes, although the reduced scale 17 ft span tests compromised heat transfer) in the UL furnace tests at fire temperatures comparable to 800 °C shown in Table 2 taken from NIST. Indeed, the UL time to reach 1100 °F (593 °C) for the 35 ft span ranges from 66 to t6 minutes which is consistent with 73 minutes in Table 1 and an extrapolated time of 50 minutes for the UL temperature conditions. (See Figure 1.)

Table 1. Time for steel elements to reach 600 °C in an 800 °C fire (Interflam 2004).

Element	Insulation Thickness mm	Time to Reach 600 °C with insulation, min.	Time to Reach 600 °C with no insulation, min	E119 Rating Requirement min.
27.7 mm rod, 54 kg/m^2 WTC 2	12.7	55	8	120
N WTC 2	19.1	73	8	120
N WTC 1	38.1	111	8	120
14WF43, 43 kg/m^2 core	44.5	213	6	180
55.8 cm box column, 7.6 cm thick, 513 kg/m^2 core	28.6	1640	75	180

Table 2. UL test results form NIST



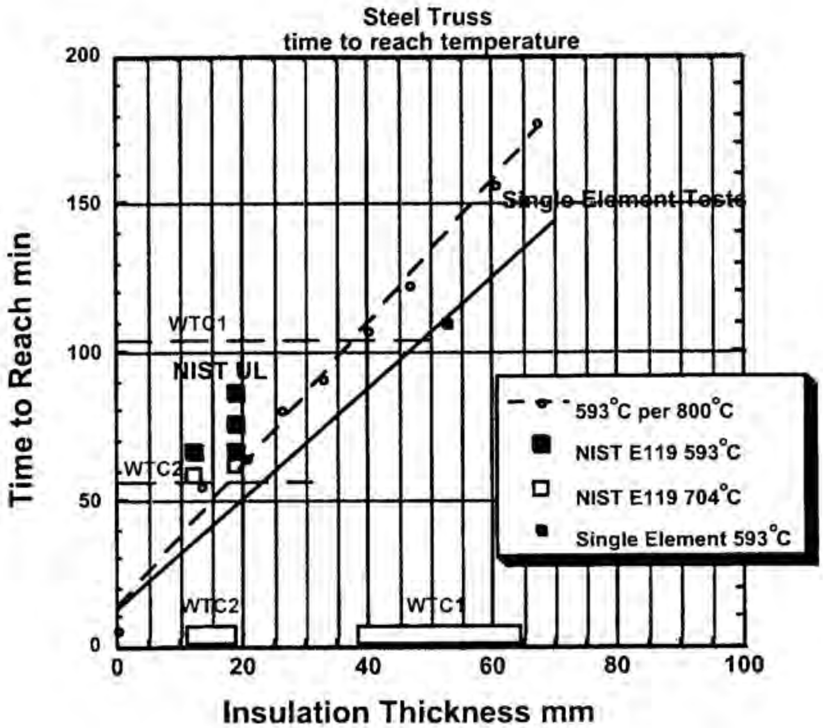


Figure 1. UL and Isolatek results.

Consequently, if the truss elements with specified insulation levels of ½- ¾ in. for WTC 2 and 1 ½ in. for WTC 1 can be heated to about 600 °C in an 800 °C fire at computed times of 55-73 minutes and 111 minutes, respectively, and NIST and others determined that the truss would cause either column buckling or connection failure at 600 °C or below, then this mode of collapse cannot be discounted. This is especially compelling since the collapse times are consistent at 56 and 102 minutes. Moreover, it is commonly known that floor sections were collapsing up to 20 minutes before the full collapse of each of the buildings. NIST has not addressed those early failures.

Fire Simulation

The results of the NIST fire predictions are based on a fuel loading of 4-5 psf. These levels are based on data from the impacted floors of Marsh & McLennan in WTC 1. NIST says this has "high" accuracy [p 119]. They find for WTC 1 that a given floor did not have uniform temperatures. "At any given location, the duration of temperatures near 1,000 °C was about 15 min to 20 min." [p 127] Upper layer temperatures are shown in Figure 2 for WTC 1 97th floor [NIST]. Temperatures generally exceeded 600°C for about 30 minutes, and for about 60 minutes in the core. In contrast, a scale model test conducted at the University of Maryland, representative of the 96th floor with a simulated fuel load of 11.5 psf, shown in Figure 3 indicates temperatures are generally over 6000C(typo?, 600C) for 100 minutes, by(typo?) are much cooler in the core. These results are distinctly different from the NIST simulation. One may be dubious of scale modeling, but it is a tried and true technique.

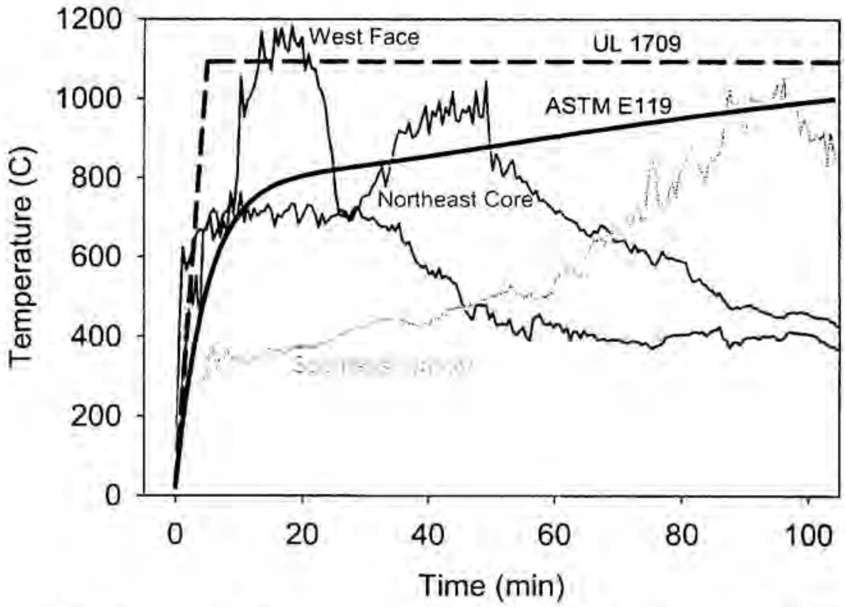


Figure 2. Predicted upper layer temperatures at various locations on the 97th Floor.

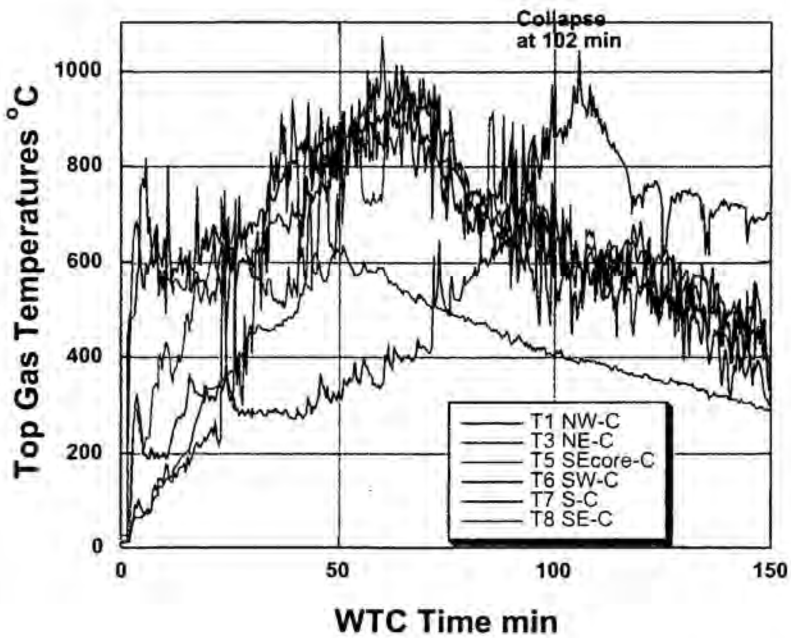


Figure 3. Temperatures in a scale model of WTC 1 96th floor

The heavier fuel load in the scale model was based on traditional office loadings and on anecdotal interviews of people familiar with the floors. Subsequently, we conducted a fuel load survey of the 96th floor based on architectural plans obtained from the furniture installer. This led to a conclusion that a loading of 10 psf or greater was the case. Appendix C contains the details in a report. Figure 4 shows a section of the architectural plans used for the 96th floor. A handwritten notation indicates a section of common files that ringed the core of the office space. There were 170 of these 4-drawer lateral files. NIST completely ignored this fuel load (and others) in their assessment. We assigned 100 lbs of paper per draw (a sub-capacity level) giving 68,000 lbs for this contribution. In addition, there were other common files and a storage room that gave a grand total of 95,400 lbs not included by NIST. In the survey conducted by Kate Stewart, estimates of paper and personal items were included in the workstation loads based on typical office conditions. Our total floor combustible loading was estimated at 302,062 lbs compared to 134,640 lbs determined by NIST. Taken over the office floor space area (31,013 ft^2), this computes to 9.7 psf and 4.3 psf for NIST. Our paper extimat per file draw is well below

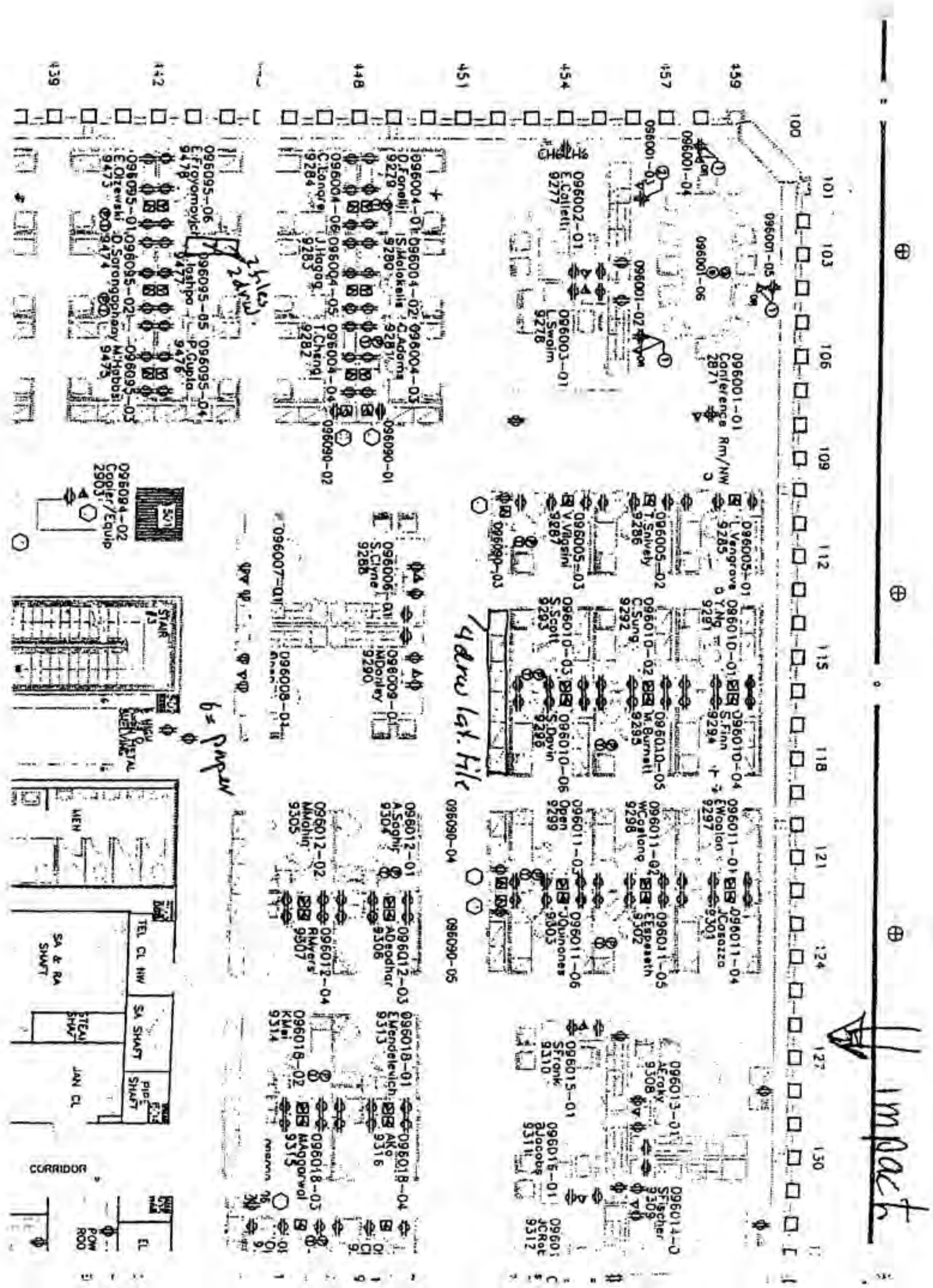


Figure 4. Section of furniture layout WTC 1 96th floor

capacity, so the loading we determine is likely too low. Indeed, it was told to us that Marsh was a "paper hog" and "kept everything". Paper fuel in closed files is de-rated in fire design considerations, but the aircraft impact could have opened the file draws.

It is generally expected that fully developed fires achieve nearly uniform temperature of over 800ºC, and are expect to persist for hours. Hence, we have the standard rating of structures at 2 to 3 hours of endurance. Had NIST used higher fuel loadings, they would have had longer hot fire conditions and this would impact their input into the structural modeling. The discrepancy in the fuel load raises some questions. Moreover, the large differences in the fuel loading found by us and NIST on the Marsh floors raises more questions. Incidently, our independent check of the workstations exclusively counted by NIST gave us a combustible load of 133,694 lbs compared to their count of 134,640 lbs. In addition, while NIST claims high accuracy for the loading in WTC 1, they do not for WTC 2. Moreover, it appears that the fire simulation in WTC 2 is only about half the size of WTC 1. More needs to clarified here.

2. *Insulation Lost on Impact*

NIST has not presented clear and sufficient evidence that the aircraft impacts caused the elimination of insulation, especially from the core columns. According to NIST [Sunder, July 12, 2005 NFPA committee meeting], the planes disintegrated on impacting the exterior columns. This debris and its momentum is alleged to have removed the insulation. Heavy item, such as an engine or landing gear, could cause structural damage to a column in the core: "If the engine missed the floor slab, the majority of the engine core remained intact and had enough residual momentum to sever a core column upon direct impact. " [p 105] This suggest that hitting a floor slab, which is very likely due to the diameter of the engine, then less damage would be done. Moreover, the accuracy of the impact calculation is not high as other compute different damage results. Specifically on the insulation loss, NIST says it could be shook off due to vibrations, or eroded off due to pulverized debris impact. On the former NIST concludes: "The analyses were not sufficient to establish justifiable, general criteria for a coherent pattern of vibration-induced dislodging." [p 117] ON the erosion, NIST did static tests on the insulation adhesive strenth, but never coupled these results to a computational model. Instead, "NIST assumed that the debris impact dislodged insulation if the debris force was strong enough to break a gypsum board

partition immediately in front of the structural component. Experiments at NIST confirmed that an array of 0.3 in. diameter pellets traveling at 350 mph stripped the insulation from steel bars like those used in the WTC trusses." [p 117] These pellet tests need more amplification, as they are the only test simulation of the erosion effect. Moreover, the test speed of 350 mph is not consistent with the average speed of debris traversing the buildings. The debris took about 0.7 s [sunder, July 12, 2005] to exit, giving an average speed of 205 ft/0.7s or 200 mph. As momentum depends on the square of the velocity, NIST has overestimated the momentum in these pellet tests by a factor of 3.

It is crucial to the NIST collapse hypothesis that the insulation is removed on impact. It begs more support.

3. WTC Fire Resistance Design

From the outset of its construction, fire safety was a concern for the WTC. From the records, clearly cost, time and safety were involved. For NIST not to have probed these facets, and to assess, in the least, the disparate range of insulation thickness assigned to the floor assembly truss system a dereliction of the intent of this investigation. NIST cites historical facts [p 69 +], but not the underlying rationale for decisions. Although an extensive civil suit on the insulation deficiencies occurred in the 1990's, NIST appears to have not examined those records.

How can on justify a specification of ½ in., a change to 1 ½ in. in the 90's, an ICBØ recommendation of 2 in. [p 192], and an actual upgrade to 2.5 +/- 0.6 in. on the impact floors of the WTC 1? The extensive over-application up to 3 in. on a round 1 in. diameter bar-joist is difficult to accept based solely on a report from the PA when photographic evidence for other upgraded floors shows only 1.7 +/- 0.4 in. according to NIST [p 71].

Whether this insulation on the truss was key as I believe, or not, is not the issue here. The process of fire resistance regulations and their interpretation is the issue. This needs to be scrutinized. It should have been at the heart of the investigation, and that is why NIST has proceeded as a scientific body rather than an investigative agent. Civil lawyers would have

pushed this, whereas the Commerce lawyers seemed more concerned to restrict the scientists, and block information from the public.

4. Lack of In Depth Investigation

The NIST report reads like a scientific enterprise using computer simulations that have never been used (or validated) in this way before. [119] Other government agencies that have investigative authority operate differently. The NTSB has time scene presence, press briefings, and formal hearings with testimony. The ATF has a National Response Team that is on the scene within hours of the event. They secure the scene, question witnesses, and gather evidence. NIST has operated in near secrecy, has had a low public profile, and has gathered facts as in a library search. Although they have held public forums, these have been very controlled, under publicized, and dominated by NIST. They have not appeared to have aggressively, or with corroboration in mind, pursued evidence. The Commerce lawyers could have helped here. With the amount of funding that they received they could have conducted a full-scale test of a floor. They could have given more support to their purely mathematically modeling results. As scientists are sometime stereotyped as being out of touch with reality, NIST cannot afford that stigma as an investigative body as NCSTAR.

5. On the Recommendations

Thirty recommendations are listed. They all are general and imply more research is needed. One cannot fault NIST fro trying to expand its research base, as they have not been properly funded in the fire and building areas since the 1970's. The fire funding with NSF and industry support ran as high as $ 10 million in the mid- 70's. Its comparable level in today's dollars is much lower. But the funding issues should not cloud the work of the NCSTAR. Yet the NCSTAR is only authorized to proceed and funding for its continuation is doubtful. So perhaps funding is the real issue.

The recommendation areas cover:

1. Increased structural integrity, including methods for preventing conditions that could result in progressive collapse (when a building or a significant portion of a building collapses due to disproportionate spread of an initial local failure), standardizing the estimation of wind loads that frequently govern the design of tall buildings, and enhancing the stability of tall buildings.

2. Enhanced fire resistance of structures, including the technical basis for determining construction classification and fire resistance ratings, improvements to the technical basis for standard fire resistance testing methods, adoption of the "structural frame" approach to fire resistance ratings, and in-service performance requirements and conformance assessment criteria for spray-applied fire resistive materials.

3. New methods for designing structures to resist fires, including the objective of burnout without collapse, the development of performance-based methods as an alternative to current prescriptive design methods, the development and evaluation of new fire resistive coating materials and technologies, evaluation of the fire performance of conventional and high performance structural materials, and elimination of technical and standards barriers to the introduction of new materials and technologies.

4. Improved active fire protection, including the design, performance, reliability, and redundancy of sprinklers, standpipes/hoses, fire alarms, and smoke management systems.

5. Improved building evacuation, including system designs that facilitate safe and rapid egress, methods for ensuring clear and timely emergency communications to occupants, better occupant preparedness for evacuation during emergencies, and incorporation of appropriate egress technologies.

6. Improved emergency response, including better access to the buildings and better operations, emergency communications, and command and control in large-scale emergencies.

7. Improved procedures and practices, including encouraging (legislating?) code compliance by nongovernmental and quasi-governmental entities, adoption and application of egress requirements in available code provisions for existing buildings, and retention and availability of building documents over the life of a building.

8. Education and training programs for fire protection engineers, structural engineers, and architects.

I generally support NIST in all of these areas, as they are important areas to pursue for research. Recommendation that can lead to immediate code changes need to go more slowly, as they require consensus and checks and balances. NIST as part of its name suggests can play an important role in "Standards" for fire safety, but they must be enabled to do that successfully. The fire and building programs at NIST have atrophied, and must be brought back to full competence. These and other programs at NIST must rely on outside funding to support their staffs. That effort, in particular, takes away form the fire program, as industry does not wish to fund safety regulations. For other programs in NIST where standards benefit industry and grease the market place, those programs find fertile support in industry. Fire safety is different, and the congress needs to appreciate that, and direct its funding accordingly.

I would like to offer some more specific comments to the NIST recommendations # 29 and 30 that pertain to education. They advocate "continuing education curricula" for structural and fire engineers and architects on modern principles and on the use of computational methods. While this is good, it is not enough; and it could produce people who think they have expertise, but do not. The education in fire protection engineering is sorely lacking in the US. Only about 50 engineers are produced a year at institutions granting a recognized engineering degree (U of MD, WPI) and technology degrees (OSU, U of Akron, etc.). The US likely needs 500 engineers a year. While a careful study of the need has not been done, the training received in continuing education courses currently indicates the lack of fire protection engineer in the field of fire investigation and in the protection of nuclear plants as stark examples. In addition, the population that makes up the regulators and participate in the code and standards making process generally lack degrees. The estimate I cite comes from the fact the University of Lund program in Sweden place all of their graduates at a rate of 2 in million of population per year in the private sector and 2 more in the fire service profession. This gives a benchmark of 2 to 4 per million of population. If the fire service in the US began to hire fire protection engineers, the estimate for the US would be 1000 per year.

The Congress needs to bring the education level of fire protection engineering up to a level that fill the infrastructure needs for the country. This can be fulfilled with NSF providing funds to this field. The Congress needs to further recognize that NIST is under funded in these areas, and

the country needs a better way of getting the proper technical input into the regulatory process for fire safety. It cannot be dependent on voluntary efforts and special interest actions. After the tragedy of 9/11, a better process of fire safety needs to be created. Unfortunately, the NIST NCSTAR draft report does not dramatically demonstrate the deficiencies in the fire process for the design and collapse of the WTC buildings.

Appendix A: NIST NCSTAR 1 Draft Source Material

Collapse Cause

Why the collapse, p171,2

Objective 1: Determine why and how WTC 1 and WTC 2 collapsed following the initial impacts of the aircraft. • The two aircraft hit the towers at high speed and did considerable damage to principal structural components: core columns, perimeter columns, and floors. However, the towers withstood the impacts and would have remained standing were it not for the dislodged insulation and the subsequent multifloor fires. The robustness of the perimeter frame-tube system and the large size of the buildings helped the towers withstand the impact. The structural system redistributed loads without collapsing in places of aircraft impact, avoiding larger scale damage upon impact. The hat truss, which was intended to support a television antenna atop each tower, prevented earlier collapse of the building core. In each tower, a different combination of impact damage and heat-weakened structural components contributed to the abrupt structural collapse. • In WTC 1, the fires weakened the core columns and caused the floors on the south side of the building to sag. (this sentence should read "The fires caused the floors on the South side of the building to sag and weakened the core columns.") The floors pulled the heated south perimeter columns inward, reducing their capacity to support the building above. Their neighboring columns quickly became overloaded as the south wall buckled. The top section of the building tilted to the south and began its descent. The time from aircraft impact to collapse initiation was largely determined by how long it took for the fires to weaken the building core and to reach the south side of the building and weaken the perimeter columns and floors. (This sentence should read; "The time from aircraft impact to collapse initiation was largely determined by haw long it took for the fires to weaken the long span floors on the south side of the building. In WTC 1 the perimeter wall and the core were heavily damaged on the North side and if it were not for the South side floors sagging and failing, destabilizing the South perimeter wall and possibly the core, the building would have tilted to the North before collapsing.") • In WTC 2, the core was damaged severely at the southeast corner and was restrained by the east and south walls via the hat truss and the floors. The steady burning fires on

the east side of the building caused the floors there to sag. The floors pulled the heated east perimeter columns inward, reducing their capacity to support the building above. Their neighboring columns quickly became overloaded as the east wall buckled. The top section of the building tilted to the east and to the south and began its descent. The time from aircraft impact to collapse initiation was largely determined by the time for the fires to weaken the perimeter columns and floor assemblies (change to; "to waken the floor assemblies and possibly the perimeter columns") on the east and south (eliminate "east and") side of the building. WTC 2 collapsed more quickly than WTC 1 because there were early and persistent fires on the east side of the building, where the fireproofing was thinner and had not been upgraded and aircraft may have extensively dislodged insulation from the structural steel. Since the core columns on the lower floors in Tower 2 were much more robust than in Tower 1, it was unlikely there was more aircraft damage to the building core. • It is unknown whether the WTC towers would likely have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact. A full scale test of the 60 foot long span flooring assembly is needed to clarify thermal stability problems.

On WTC 1: p xliii-xliv

The two aircraft hit the towers at high speed and did considerable damage to principal structural components: core columns, floors, and perimeter columns. However, the towers withstood the impacts and would have remained standing were it not for the (add "deficient", "inadequate" or) dislodged insulation (fireproofing) and the subsequent multifloor fires.

The time from aircraft impact to collapse initiation was largely determined by how long it took for the fires to weaken the building core and to reach the south side of the building and weaken the perimeter columns and floors. (change to "... largely determined by how long it took to weaken the floors which sagged and possibly detached destabilizing the heat weakened perimeter columns and building core."

On WTC 2

n WTC 2, the core was damaged severely at the southeast corner and was restrained by the east and south walls via the hat truss and the floors. The steady burning fires on the east side of the building caused the floors there to sag. The floors pulled the heated east perimeter columns inward, reducing their capacity to support the building above. Their neighboring columns quickly became overloaded as columns on the east wall buckled. The top section of the building tilted to the east and to the south and began its descent. The time from aircraft impact to collapse initiation was largely determined by the time for the fires to weaken the floor assemblies and perimeter columns and on the east and the south sides of the building. WTC 2 collapsed more quickly than WTC 1 because there were early and persistent fires on the east side of the building, where there was less insulation on the structural steel. Whether there was more aircraft damage to the building core and aircraft had extensively dislodged the insulation is still questionable.

Also an analysis of the stability of the towers, assuming no damage to the core, gives the number of floors that need to be removed to cause global failure (June 2004, Vol. 1, p.81):

> The following presents some preliminary findings obtained from the preliminary stability analyses under service live loads and subject to the assumptions and the limitations of these models (see Appendix D): Linear stability analysis was used to examine the stability of the undamaged WTC 1 under service loads through increased un-braced column lengths (floor removal). The tower was stable when two complete floors including the core floors were removed. Two core columns buckled when three floors were removed, but the tower maintained its overall stability. The tower also maintained its stability when four columns buckled with four floors removed. The analysis suggested that global instability of the tower occurred when five floors were removed from the model. Assuming that all columns at the region of the removed floors reached a temperature of 600 °C (reduced modulus of elasticity), the analysis indicates that removal of four floors would induce global instability.

1. <u>Single truss analysis</u>: A model of a single truss and its connection shows that the truss fails at the interior column seat connection, and 'walks off' the seat. This occurs at 650 C. The web diagonals begin to buckle at 340 C, and the exterior columns bow inward at 560 C as the truss to acted as a catenary. (June 2004, Vol. 1 p. 120).

On steel inspected p 88,89

Examination of photographs showed that 16 of the exterior panels recovered from WTC 1 were exposed to fire prior to the building collapse. None of the nine recovered panels from within the fire floors of WTC 2 were directly exposed to fire. NIST used two methods to estimate the maximum temperatures that the steel members had reached: • Observations of paint cracking due to thermal expansion. Of the more than 170 areas examined on 16 perimeter column panels, only three columns had evidence that the steel reached temperatures above 250 °C: east face, floor 98, inner web; east face, floor 92, inner web; and north face, floor 98, floor truss connector. Only two core column specimens had sufficient paint remaining to make such an analysis, and their temperatures did not reach 250 °C. NIST did not generalize these results, since the examined columns represented only 3 percent of the perimeter columns and 1 percent of the core columns from the fire floors. • Observations of the microstructure of the steel. High temperature excursions, such as due to a fire, can alter the basic structure of the steel and its mechanical properties. Using metallographic analysis, NIST determined that there was no evidence that any of the samples had reached temperatures above 600 oC. These results were for a very small fraction of the steel in the impact and fire zones. Nonetheless, these analyses indicated some zones within WTC 1 where the computer simulations should not, and did not, predict highly elevated steel temperatures. 6.5

On the steel p 176

None of the recovered steel samples showed evidence of exposure to temperatures above 600 oC for as long as 15 min. This was based on NIST annealing studies that established the set of time and temperature conditions necessary to alter the steel microstructure. These results provide some confirmation of the thermal modeling of the structures, since none of the samples were from zones where such heating was predicted.

On single truss analysis p 96

Single composite truss and concrete slab section. A floor section was modeled to investigate failure modes and sequences of failures under combined gravity and thermal loads. The floor section was heated to 700 °C (300 °C at the top surface of the slab) over a period of 30 min. Initially the thermal expansion of the floor pushed the columns outward, but with increased temperatures, the floor sagged and the columns were pulled inward. Knuckle failure was found to occur mainly at the ends of the trusses and had little effect on the deflection of the floor system. Figure 6–11 shows that the diagonals at the core (right) end of the truss buckled and caused an increase in the floor system deflection, ultimately reaching approximately 42 in. Two possible failure modes were identified for the floor-truss section: sagging of the floor and loss of truss seat support.

Impact Damage

On damage to WTC1 pp20- 21

The 94 th floor was more severely damaged. The midsection of the left wing, laden with jet fuel, and the left engine cut through the building façade, severing 17 of the perimeter columns and heavily damaging four more. The pieces of the aircraft continued inward, severing and heavily damaging core columns. The insulation applied to the floor trusses above and the columns was scraped off by shrapnel-like aircraft debris and building wall fragments over a wedge almost 100 ft wide at the north face of the tower and 50 ft wide at the south end of the building core.

A 40 ft width of the 96 floor slab was broken 80 ft into the building. The insulation was knocked off nearly all the core columns and over a 40 ft width of floor trusses from the south end of the core to the south face of the tower.

On WTC1 p34

Dislodging of SFRM from structural members due to the aircraft impact, that enabled rapid heating of the unprotected structural steel;

On WTC2 78 flr p 40

Dislodging of SFRM from structural members due to the aircraft impact, that enabled rapid heating of the unprotected structural steel;

On WTC2 81 flr p 41

On the 81 st floor, the fuselage pulverized a section of the floor 40 ft wide that extended into the southeast corner of the core. The SFRM and gypsum fire protection on the full depth of the east side of the core and in the entire east side of the tenant space was stripped.

On impact p 105

The Investigation Team gained valuable knowledge from these component impact analyses, for example: • Moving at 500 mph, an engine broke any exterior column it hit. If the engine missed the floor slab, the majority of the engine core remained intact and had enough residual momentum to sever a core column upon direct impact. • The impact of the inner half of an empty wing significantly damaged exterior columns but did not result in their complete failure. Impact of the same wing section, but filled with fuel, did result in failure of the exterior columns.

On the accuracy of the impact model p 114

Two pieces of landing gear penetrated WTC 1 and landed to the south of the tower. The Case B prediction showed landing gear penetrating the building core, but stopping before reaching the south exterior wall. For WTC 2, a landing gear fragment and the starboard engine penetrated the building and landed to the south. The Case D prediction correctly showed the main landing gear emerging from the northeast corner of WTC 2. However, Case D showed that engine not quite penetrating the building. Minor modifications to the model (all within the uncertainty of the input data) would have resulted in the engine passing through the north exterior wall of the tower.

On damage to insulation, p 117

An intact ceiling tile system could have provided the floor trusses with approximately 10 min to 15 min of thermal protection 6.9.3 Damage to Thermal Insulation The dislodgement of thermal insulation from structural members could have occurred as a result of direct impact by debris and could have occurred by inertial forces due to vibration of structural members as a result of the aircraft impact. In interpreting the output of the aircraft impact simulations, NIST assumed that the debris impact dislodged insulation if the debris force was strong enough to break a gypsum board partition immediately in front of the structural component. Experiments at NIST confirmed that an array of 0.3 in. diameter pellets traveling at 350 mph stripped the insulation from steel bars like those used in the WTC trusses. Determining the adherence of SFRM outside the debris zones was more difficult. There was photographic evidence that some fraction of the SFRM was dislodged from perimeter columns not directly impacted by debris. NIST developed a simple model to estimate the range of accelerations that might dislodge the SFRM from the structural steel components. As the SFRM in the towers was being upgraded with BLAZESHIELD II (CAFCO II) in the 1990s, The Port Authority had measured the force required to pull the insulation from the steel. The model used these data as input to some basic physics equations. The resulting ranges of accelerations depended on the geometry of the coated steel component and the SFRM thickness, density and bond strength. For a flat surface (as on the surface of a column), the range was from 20g to 530g, where g is the gravitational acceleration. For an encased bar (such as used in the WTC trusses), the range was from 40g to 730g. NIST estimated accelerations from the aircraft impacts of approximately 100g. The analyses were not sufficient to establish justifiable, general criteria for a coherent pattern of vibration-induced dislodging. Thus, NIST made the conservative assumption that all other insulation remained adhered to the structural components.

Fire Modeling

Active Fire Protection: Active fire protection systems (i.e., sprinklers, standpipes/ hoses, fire alarms, and smoke management systems) should be enhanced through improvements to design, performance, reliability, and redundancy of such systems.

On Fireballs WTC1 p 24

Less than 15 percent of the jet fuel burned in the spray cloud inside the building. A roughly comparable amount was consumed in the fireballs outside the building. Thus, well over half of the jet fuel remained in the building, unburned in the initial fires.

On loading p 76

NIST estimated the fuel loading on these floors to have been about 4 lb/ft 2 (20 kg/m2), or about 60 tons per floor. This was somewhat lower than found in prior surveys of office spaces. The small number of interior walls, and thus the minimal amount of combustible interior finish, and the limited bookshelf space account for much of the differences.

On WTC fire in 1975 p 89

INFORMATION GAINED FROM OTHER WTC FIRES There had been numerous fires in the towers prior to September 11, 2001. From these, the Investigation Team learned what size fire WTC 1 and WTC 2 had withstood and how the tower occupants and the responders functioned in emergencies. While The Port Authority's records of prior fires were lost in the collapses, FDNY provided reports on 342 fires that had occurred between 1970 and 2001. Most of these fires were small, and occupants extinguished many of them before FDNY arrival. Fortyseven of these fires activated one to three sprinklers and/or required a standpipe hose for suppression. Only two of the fires required the evacuation of hundreds of people. There were no injuries or loss of life in any of these fires, and the interruptions to operations within the towers were local. A major fire occurred in WTC 1 on February 13, 1975, before the installation of the sprinkler system. A furniture fire started in an executive office in the north end of an 11 th floor office suite in the southeast corner of the building. The fire spread south and west along corridors and entered a file room. The fire flashed over, broke seven windows, and spread to adjacent offices north and south. The air conditioning system turned on, pulling smoke into the return air ducts. Telephone cables in the vertical shafts were ignited, destroying the fire-retarded wood paneling on the closet doors. The fire emerged on the 12 th and 13 th floors, but there was little nearby that was combustible. The fire also extended vertically from the 9th to the 19 th floors within the

telephone closet. Eventually the fire was confined to 9,000 ft2 of one floor, about one-fourth of the total floor area. The trusses and columns in this area had been sprayed with CAFCO D insulation to a specified 1/2 in. thickness. Four trusses were slightly distorted, but the structure was not threatened.

On modeling floor fires, p 119

6.10.2 Modeling Approach The time frame of the Investigation and the above requirements led to the use of the Fire Dynamics Simulator (FDS). Under development at NIST since 1978, FDS was first publicly released in February 2000 and had been used worldwide on a wide variety of applications, ranging from sprinkler activation to residential and industrial fire reconstructions. However, it had never before been applied to spreading fires in a building with such large floor areas. Figure 6–30 shows how FDS represented the eight modeled floors (92 through 99) of the undamaged WTC 1. A similar rendition was prepared for floors 78 through 83 of WTC 2. The layout of each floor was developed from architectural drawings and from the information described in Section 5.8. There was a wide range of confidence in the accuracy of these floor plans, varying from high (for the floors occupied by Marsh & McLennan in WTC 1, for which recent and detailed plans were obtained) to low (for most of the space in WTC 2 occupied by Fuji Bank, for which floor plans were not available).

On the fuel load effect p 124

6.10.3 The Four Cases Four fire scenarios (Case A and Case B for WTC 1 and Case C and Case D for WTC 2) were superimposed on the four cases of aircraft-driven damage of the same names (Section 6.9). A number of preliminary simulations had been performed to gain insight into the factors having the most influence on the severity of the fires. The most influential was the mass of combustibles per unit of floor area (fuel load); second was the extent of core wall damage, which affected the air supply for the fires. The aforementioned workstation fire tests had also indicated that the damage condition of the furnishings also played a key role. The scenario variables and their values are shown in Table 6–6. Table 6–6. Values of WTC fire simulation variables. WTC 1 WTC 2 Variable Case A Case B Case C Case D Tenant fuel

load a 20 kg/m2 (4 lb/ft2) 25 kg/m2 (5 lb/ft2) 20 kg/m2 (4 lb/ft2) 20 kg/m2 (5 lb/ft2) Distribution of disturbed combustibles Even Weighted toward the core Heavily concentrated in the northeast corner Moderately concentrated in the northeast corner Condition of combustibles Undamaged except in impact zone Displaced furniture rubblized All rubblized Undamaged except in impact zone Representation of impacted core walls b Fully removed Soffit remained Fully removed Soffit remained a. In addition, approximately 12,000 kg (27,000 lb) of solid combustibles from the aircraft were distributed along the debris path. b. In Cases A and C, the walls impacted by the debris field were fully removed. This enabled rapid venting of the upper layer into the core shafts and reduced the burning rate of combustibles in the tenant spaces. In Cases B and D, a more severe representation of the damage was to leave a 1.2 m soffit that would maintain a hot upper layer on each fire floor. This produced a fire of longer duration near the core columns and the attached floor membranes. FDS contained no algorithm for breaking windows from the heat of the fires. Thus, during each simulation, windows were removed at times when photographs indicated they were first missing. Damage to the ventilation shafts was derived from the aircraft impact simulations. For undamaged floors, all the openings to the core area were assumed to total 5 m 2 in area. 6.10.4 Characterization of the Fires

On the accuracy of spread p 126

The fire simulation results for Case A and Case B were similar, indicating only a modest sensitivity to the fuel load and the degree of aircraft-generated damage. This was because, in general, the size and movement of the fires in WTC 1 were limited by the supply of air from the exterior windows. Since the window breakage pattern was not changed in Case B, the additional and re-distributed combustibles within the building did not contribute to a larger fire. The added fuel did slow the spread slightly because the fires were sustained longer in any given location. Although there was generally reasonable agreement between the simulated and observed fire spread rates, there were instances where the fires burned too quickly and too near the windows. This resulted from an artifact of the model: the combustible vapors burned immediately upon mixing with the incoming oxygen. Simulations performed with doubled fuel loads slowed the

fire spread well below the observed rates. Combined with the above results, this suggested that the estimated overall combustible load of 4 lb/ft 2 was reasonable.

On the predicted fires in WTC1, p 127

The predictions of maximum temperatures (e.g., red zones in Figure 6–37) were consistent with those in the three-workstation fire tests. The use of an "average" gas temperature was not a satisfactory means of assessing the thermal environment on floors this large and would also have led to large errors in the subsequent thermal and structural analyses. The heat transferred to the structural components was largely by means of thermal radiation, whose intensity is proportional to the fourth power of the gas temperature. At any given location, the duration of temperatures near 1,000 °C was about 15 min to 20 min. The rest of the time, the calculated temperatures were near 500 °C or below. To put this in perspective, the radiative intensity onto a truss surrounded by smoke-laden gases at 1,000 °C was approximately 7 times the value for gases at 500 °C.

On the modeling of WTC2, p 127

WTC 2 Simulating the fires in WTC 2 posed challenges in addition to those encountered in simulating the fires in WTC 1. The aircraft, hitting the tower to the east of center, splintered much of the furnishings on the east side of the building and plowed them toward the northeast corner. Neither the impact study nor the validation experiments performed at NIST could be completely relied upon to predict the final distribution, condition, and burning behavior of the demolished furnishings. In addition, only the layouts of the 78th and 80th floors were available to the Investigation; the other floors were only roughly described by former occupants. As a result of these unknowns, the uncertainty in these calculations was distinctly greater than in those for WTC 1. To help mitigate gross differences between the simulations and the observables, NIST made floor-specific adjustments, based on the results of preliminary computations. In particular, the fuel load and volatility on the 80 th floor were reduced, and the fuel load on the 81st and 82 nd floors was increased. In contrast with WTC 1, in WTC 2 there was less movement of the fires. The major burning occurred along the east side, with some spread to the north. There was no significant burning on the west side of the tower. Also unlike WTC 1,

changing the combustible load in WTC 2 had a noticeable effect on the outcome of the simulations. Because so many windows on the impact floors in WTC 2 were broken out by the aircraft debris and the ensuing fireballs, there was an adequate supply of air for the fires. Thus, the burning rate of the fires was determined by the fuel supply. In the Case D simulation, the office furnishings and aircraft debris were spread out over a wider area, and the furnishings away from the impact area were undamaged. Both of these factors enabled a higher burning rate for the combustibles.

ON the heating of the structure by the FDS fire, p 139

Tables 6–8 and 6–9 summarize the regions of the floors in which the structural steel reached temperatures at which their yield strengths would have been significantly diminished. Instances of brief heating of one or two columns early in the fires were not included. Even in the vicinity of the fires, the columns and trusses for which the insulation was intact did not heat to temperatures where significant loss of strength occurred. Unlike the simulations of the aircraft impact and the fires, there was no evidence, photographic or other, for direct comparison with the FSI results. Table 6–8. **Regions in WTC 1 in which temperatures of structural steel exceeded 600 °C.** Trusses Perimeter Columns Core Columns Floor Number Case A Case B Case A Case B Case A Case B 93 – – – – – – 94 – – – – N, S NE, S 95 N N, S – – S NW, S 96 N N, S – S S W, S 97 N, S N, S – S N W, S 98 N N, S – – – – 99 – – – – – – Key: N, north; S, south; W, west; NE, northeast; NW, northwest. Table 6–9. **Regions in WTC 2 in which temperatures of structural steel exceeded 600 °C.** Trusses Perimeter Columns Core Columns Floor Number Case C Case D Case C Case D Case C Case D 79 – – – – – – 80 – – – – – – 81 NE NE NE NE – NE 82 E E E E E E 83 E E – E – E

On the fire duration predicted, p 144

Both the results of the multiple workstation experiments and the simulations of the WTC fires showed that the combustibles in a given location, if undisturbed by the aircraft impact, would have been almost fully burned out in about 20 min.

Insulation Saga

On insulation: p xlvi

NIST found no technical basis or test data on which the thermal protection of the steel was based. On September 11, 2001, the minimum specified thickness of the insulation was adequate to delay heating of the trusses; the amount of insulation dislodged by the aircraft impact, however, was sufficient to cause the structural steel to be heated to critical levels. • Based on four standard fire resistance tests that were conducted under a range of insulation and test conditions, NIST found the fire rating of the floor system to vary between 3/4 hour and 2 hours; in all cases, the floors continued to support the full design load without collapse for over 2 hours.

P55 on insulation

NIST was not able to find any evidence that there was a technical basis to relate SFRM thickness to a fire resistance rating, nor was there sufficient prior experience to establish such thickness requirements by analogy.

On insulation p 69

Floor Systems- At the time the WTC was designed, the ASTM E 119 test method had been used for nearly 50 years to determine the fire resistance of structural members and assemblies. However, The Port Authority confirmed to the Investigation Team that there was no record of fire endurance testing of the innovative assemblies representing the thermally protected floor system used in the towers. The floor assembly was not tested despite the fact that the Architect of Record and the Structural Engineer of Record stated that the fire rating of this novel floor system could not be determined without testing. Prior to construction, the Architect of Record had used information from (unidentified) manufacturers to recommend a 1 in. thickness of SFRM around the top and bottom chords of the trusses and a 2 in. thickness for the web members of the trusses. This was to achieve the fire endurance requirements for Class 1A construction (Section 5.3.3). In 1969, The Port Authority directed that a 1/2 in. thick coating of

CAFCO BLAZE-SHIELD Type D (CAFCO D), a mixture of cement and asbestos fibers, be used to insulate the floor trusses. This was to achieve a Class 1A rating, even though the preponderance of evidence suggests that the towers were chosen to be Class 1B, the minimum required by the NYC Building Code. NIST found no evidence of a technical basis for selection of the 1/2 in. thickness. This coating had been installed as high as the 38 th floor of WTC 1 when its use was discontinued due to recognition of adverse health effects from inhalation of asbestos fibers. The spraying then proceeded with CAFCO DC/F, a similar product in which the asbestos was replaced by a glassy mineral fiber and whose insulating value was reported by Underwriters Laboratories, Inc., to be slightly better than that of CAFCO D. On the lower floors, the CAFCO D was encapsulated with a sprayed material that provided a hard coat to mitigate the dispersion of asbestos fibers into the air. In 1994, The Port Authority measured the SFRM thickness on trusses on floors 23 and 24 of WTC 1. In all, average thicknesses were reported for 32 locations, and the overall average thickness was found to be 0.74 in. NIST performed a further evaluation of the SFRM thickness using photographs taken in the 1990s of floor trusses on (non-upgraded) floors 22, 23, and 27 of WTC 1 (Figure 5–5). By measuring dimensions on the photographs, NIST estimated the insulation thicknesses on the diagonal web members of trusses. (The thickness of chord member insulation could not be measured.) The average thickness and standard deviation of web members was 0.6 in. ± 0.3 in. on the main trusses, 0.4 in. ± 0.25 in. on the bridging trusses, and 0.4 in. ± 0.2 in. on the diagonal struts. These numbers indicated that there were areas where the coating thickness was less than the specified 0.5 in.

P 70

Chapter 5 Draft for Public Comment 70 NIST NCSTAR 1, WTC Investigation Note: Enhancement by NIST. Figure 5–5. Irregularity of coating thickness and gaps in coverage on SFRM–coated bridging trusses. In 1995, The Port Authority performed a study to establish requirements for retrofit of sprayed insulation to the floor trusses during major alterations when tenants vacated spaces in the towers. Based on design information for fire ratings of a similar, but not identical, composite floor truss system contained in the Fire Resistance Directory published by Underwriters Laboratories, Inc., the study concluded that a 1 1/2 in. thickness of sprayed mineral fiber material would provide a 2 hour fire rating, consistent with the Class 1B requirements. In 1999, the removal of existing SFRM and the application of new material to this

thickness became Port Authority policy for full floors undergoing new construction and renovation. For tenant spaces in which only part of a floor was being modified, the SFRM needed only to be patched to 3⁄4 in. thickness or to match the 1 1⁄2 in. thickness, if it had previously been upgraded. In the years between 1995 and 2001, thermal protection was upgraded on 18 floors of WTC 1, including those on which the major fires occurred on September 11, 2001, and 13 floors of WTC 2 that did not include the fire floors. The Port Authority reported that the insulation used in the renovations was CAFCO BLAZE-SHIELD II. In July 2000, an engineering consultant to The Port Authority issued a report on the requirements of the fire resistance of the floor system of the towers. Based on calculations and risk assessment, the consultant concluded that the structural design had sufficient inherent fire performance to ensure that the fire condition was never the critical condition with respect to loading allowances. The report recommended that a 1.3 in. thickness be used for the floor trusses. In December 2000, another condition assessment concluded that the structural insulation in the towers had an adequate 1 hour rating, considering that all floors were now fitted with sprinklers. The report also noted the ongoing Port Authority program to upgrade the fire resistive material thickness to 1 1⁄2 in. in order to achieve a 2 hour fire rating. The Port Authority provided NIST with the records of measurements of SFRM thickness on upgraded floors in both towers. The average thickness and standard deviation on the main trusses was 2.5 in. ± 0.6 in. NIST analysis of several Port Authority photographs from the 1990s of the upgraded 31 st floor of WTC 1 indicated an average thickness and standard deviation on the main trusses of 1.7 in. ± 0.4 in. NIST found no statistically significant difference in the average thickness of the upgraded insulation in the two towers.

Perimeter Columns In 1966, the contractor responsible for insulating the perimeter columns proposed applying a 1 3/16 in. thick coating of CAFCO D to the three external faces (Figure 5-6) to achieve a 4 hour rating, which is a Class 1A rating requirement (1 hour more than Class 1B). NIST found evidence of a technical basis for this decision. In the construction drawings prepared by the exterior cladding contractor, the following SFRM thicknesses were specified: • 7/8 in. of vermiculite plaster on the interior face and 1 3/16 in. of CAFCO D on the other three faces. • 1⁄2 in. of vermiculite plaster on the interior surfaces of the spandrels and 1⁄2 in. of CAFCO D on the exterior surfaces. Figure 5-6. **Thermal insulation for perimeter columns.**

Vermiculite plaster had a higher thermal conductivity and thereby increased heat migration from the room air to the column steel and, thus, could keep the steel temperature at 70 °F when the temperature was 0 °F outside. In October 1969, The Port Authority provided the following instructions to the contractor applying the sprayed fire protection, in order to maintain the Class 1-A Fire Rating of the NYC Building Code: • 2 3/16 in. of CAFCO D for columns smaller than 14WF228 11 and 1 3/16 in. for columns equal to or greater than 14WF228. • 1⁄2 in. covering of CAFCO D for beams, spandrels and bar joists. NIST's review of available documents has not uncovered the reasons for selecting CAFCO fire resistive material or the technical basis for specifying 1⁄2 in. thickness of SFRM for the floor trusses. As with the trusses, CAFCO DC/F was applied to the perimeter columns above the 38 th floor of WTC 1 and all the perimeter columns in WTC 2. Core Columns and Beams Multiple approaches were used to insulate structural elements in the core: • Those core columns located in rentable and public spaces, closets, and mechanical shafts were enclosed in boxes of gypsum wallboard (and thus were inaccessible for inspection). The amount of the gypsum enclosure in contact with the column varied depending on the location of the column within the core. SFRM (CAFCO D and DC/F) was applied on those faces that were not protected by the gypsum enclosure. The thicknesses specified in the construction documents were 1 3/16 in. for the heavier columns and 2 3/16 in. for the lighter columns. • Columns located at the elevator shafts were protected using the same SFRM thicknesses. They were not enclosed and thus were accessible for routine inspections. Inspection of the columns within the elevator shaft spaces in 1993 indicated some loss of SFRM coverage. As a result, new insulation was applied to selected columns within the elevator shaft space. Information provided to NIST indicated that a different SFRM, Monokote Type 2-106, was used. Thickness measurements for columns and beams below the 45 th floor indicated average thicknesses of 0.82 in. and 0.97 in., respectively. Information from The Port Authority indicated that the minimum required thickness of the re-applied SFRM was 1⁄2 in. for the columns and 3⁄4 in. for the beams. NIST was unable to locate information from which to characterize the insulation of the core columns and beams that were not accessible. Except as noted above, once completed, the core was generally not inspected. NIST was not able to locate any post-collapse core beams or columns with sufficient insulation still attached to make pre-collapse thickness measurements.

On the selection of insulation, p 192

No technical basis was found for selecting the spray-applied fire resistive material (SFRM) used or its thickness for the large-span open-web floor trusses of the WTC towers. The assessment of the insulation thickness needed to meet the 2 hour fire rating requirement for the untested WTC floor system evolved over time: – In October 1969, The Port Authority directed the insulation contractor to apply 1/2 in. of insulation to the floor trusses. – In 1999, The Port Authority issued guidelines requiring that insulation be upgraded to 1 1/2 in. for full floors undergoing alterations. – Unrelated to the WTC buildings, an International Conference of Building Officials (ICBO) Evaluation Service report (ER-1244), re-issued June 1, 2001, using the same SFRM recommends a minimum thickness of 2 in. for "unrestrained steel joists" with "lightweight concrete" slab.

Recommendations

On major rec's p xlvii

The eight major groups of recommendations are: • Increased Structural Integrity: The standards for estimating the load effects of potential hazards (e.g., progressive collapse, wind) and the design of structural systems to mitigate the effects of those hazards should be improved to enhance structural integrity. • Enhanced Fire Resistance of Structures: The procedures and practices used to ensure the fire resistance of structures should be enhanced by improving the technical basis for construction classifications and fire resistance ratings, improving the technical basis for standard fire resistance testing methods, use of the "structural frame" approach to fire resistance ratings, and developing in-service performance requirements and conformance criteria for spray-applied fire resistive materials. • New Methods for Fire Resistance Design of Structures: The procedures and practices used in the fire resistance design of structures should be enhanced by requiring an objective that uncontrolled fires result in burnout without local or global collapse. Performance-based methods are an alternative to prescriptive design methods. This effort should include the development and evaluation of new fire resistive coating materials and technologies and evaluation of the fire performance of

conventional and high-performance structural materials. ethecal and standards barriers to the introduction of new materials and technologies should be eliminated. • Improved ?????

Appendix B: November 2004 Comments

November 22, 2004

To: The National Construction Safety Team Advisory Committee
NCST Advisory Committee
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Gaithersburg, MD 20899-8610
NCSTAC@nist.gov

From: James G. Quintiere

RE: NIST conclusions on the WTC collapse mechanism reported on October 19, 2004

The October surprise in the NIST investigation was the assertion that all of the core column insulation was knocked off by the airplane impacts. To a lesser extent, reliance on NYNJPA audit insulation data solidified the NIST assertion that the failure of the core columns, and not the trusses, were to blame for the collapses of the South and North towers. That audit information was reported by NIST to have the fire floors of the north tower with truss insulation thicknesses as an average of 2.5 inches up to 4 inches instead of the prescribed 1.5 inches.

NIST needs to produce demonstrable and clear substantive information to support this rationale for its conclusions. The core-damage theory was put forth by the Weidlinger group in the Silverstein civil suit, and I heard it expressed at a local ASME meeting over a year ago by a NIST staffer. Therefore, I think it is incumbent on NIST to explain when and how they came to this conclusion. This collapse mechanism conclusion has profound influence on the recommendations brought from this investigation. The airplane-caused column collapse theory yields significantly, and almost diametrically, opposed recommendations than the fire induced truss collapse mechanism.

NIST needs to validate its conclusion by addressing the following:

1. The NYNJPA North tower insulation data needs to be authenticated. There is a long saga on the insulation coverage of the truss assemblies, and it should not end with an audit report that contains data that are extraordinary. The claim that up to 4 inches of insulation was sprayed onto 1-inch diameter truss elements needs testimony, photographic corroboration, or other tangible evidence to establish the accuracy of this information.
2. It needs to be clearly demonstrated how the core column insulation was removed. This cannot simply be based on an assumption or an extrapolation from impact calculations. It is too important to the conclusions to have modeling as the sole basis. Sandia has been experimenting with airplane crashes into buildings. Have they been consulted for supporting information or assistance? NIST needs to live up to the Daubert-rulling in civil case law, and demonstrate a clear methodology for their conclusion that the insulation was removed.

Finally, NIST needs to clarify inconsistencies that appear in their public information to date. These inconsistencies and apparent weakness lead me to question their collapse theory, and place the collapse cause more on the lack of sufficient truss insulation.

1. NIST metallurgical analyses show no core columns from the fire floors reached temperatures above 250 C. It is claimed that this information is consistent with computer modeling. Moreover, I was pleased to see that after many inquiries for microscopic analysis of the steel debris, it was done and reported in the October briefing. The importance of forensic evidence to document the temperatures reached of the steel cannot be overlooked. First, its consistency with the modeling has little significance since the modeling cannot have that level of detailed accuracy precise fire effects around the core columns. Secondly, the core column theory requires that the columns got sufficiently hot, say 500 C, and tangible evidence from metallurgical analysis is crucial in supporting the NIST conclusion. Unfortunately, that evidence has not been found by NIST. Thirdly, as a consequence, this crucial lack of evidence must indict the selling of the WTC steel debris before an investigation could be launched. Will NIST speak to this as they now have future investigative authority?

2. NIST computations show that floor truss assemblies can fail at temperature measured in the UL tests. UL fire tests showed for ½ and ¾-inch insulation that steel truss temperatures exceeded 1300 F (704 C) in roughly 58 minutes and 62-76 minutes, respectively. They reached average temperatures of 1110 F (593 C) in 66 and 66-86 minutes, respectively. My own data with Isolatek indicate that individual web elements can reach 593 C in about 35 to 50 minutes, respectively for ½ and ¾ inches. NIST's model for a single WTC truss (which is more accurate than the impact computations), predicts a truss would fail at the column connections at these temperatures. The NIST model for a single truss and its connection shows that the truss fails at the interior column seat connection, and 'walks off' the seat. This occurs at 650 C. The web diagonals begin to buckle at 340 C, and the exterior columns bow inward at 560 C because the truss acts as a catenary. Other independent work done by Usmani et al, and Burgess et al., show similar results. If one floor falls on the floor below while both are heated by fire, can the impacted floor carry the load? Is this a plausible global collapse mechanism? To me, this means that truss failure is likely, at least in the South tower; and in the North if the PA audit data are wrong. Collapses of the floors were seen in both of the towers well up to 20 minutes before the buildings collapsed. This indicates the presence of the floor collapse mechanism.

   Incidently, the NIST scaling criterion used for the ½-scaling in the UL tests should be examined, as it is thermally not to scale. The shorter truss members will cause lower temperatures as the web transfers heat into the concrete floor.

3. NIST has relied on state-of-the-art computer models that are at the forefront of their technologies. However, these models have not been proven comprehensively for less complex incidents than the WTC. Will NIST continue to invest in these modeling technologies, or are they proven and ready for general use? If they are ready, will NIST advocate their use in design, or will NIST continue to perform research to improve them? If the latter is true, will NIST articulate the uncertain aspects of the modeling, and comment on how they bear on the investigation's conclusions?

4. NIST has used workstations fire experiments as a basis for their modeling. The stated fuel load is 4 lbs/ft^2 and this loading has been questioned, as it appears very low in the spectrum of office loadings. Because our students are conducting a scale model experiment of the 96th floor of the North tower, it forced us to examine this loading. While we could not pursue our information in depth, I can relate some major concerns. NIST experimental photographs of the office modules show little paper, and NIST has told me that the paper load was reported as light. I was told by a WTC inspector that the load was heavy, storage areas were overloaded and floors were continually cited for having paper stacked on the window sills; a furniture installer of the Marsh floors gave me information that showed extensive file cabinets surrounding the cubicles and these were not included in the NIST fire experiments – he, too, said that the Marsh office spaces were heavy in paper; an anonymous Marsh employee said that the Marsh company were paper "hogs", and a family member said it was heavy as well. The fuel loading is crucial to the duration and the temperatures of the fires. A light fuel load in the modeling will lead to low temperatures and this would affect the overall results.

It is imperative that NIST get the cause of the WTC tower collapses correct. The legacy of its victims bears on future fire safety. The protection of buildings in fire and terrorists attacks will be impacted by these conclusions, so they need to be right. The Advisory Panel plays a clear role to sign off on these conclusions. I know of others that feel the NIST conclusions need, in the least, clarity, and in the main, more support. However, we are few in number, and it falls on you to insure the public that they got it right.

Recommendations that should come from this study are submitted in no priority order as suggestions for your consideration:

1. Experimental studies to establish temperatures and fire duration characteristic of modern facilities including office large plan spaces, places assembly, and underground structures should be undertaken to validate models and establish design methods. The current correlations are incomplete in terms of fuel type and building type.

2. The standard time-temperature structural fire tests should be examined in light of computational methods. Data for the tests yielding temperature and deflection should be integrated with computations to extrapolate to actual assemblies used in practice.
3. Sensor technologies integrated with alarm monitoring for building performance should be integrated into the emergency response network for assessing the nature of the hazard.
4. Forensic techniques and standards should be established to assess failure information from structural debris. The elimination of the steel structure from the WTC site should be fully addressed, and its consequences fully stated.
5. Fire and disaster planning should include full and proper analyses for safe egress and effective response. Responders and building planners need to have the benefit of analyses that quantitatively address these facets. Real time modeling of the fire effects based on sensor information are possible and should be integrated into special building designs and response actions.
6. Novel techniques need to be investigated to rescue people and to fight high-rise fires.
7. Current codes weaknesses, in light the WTC collapses, need to be fully addressed. Issues of lightweight construction designs that are vulnerable to catastrophic collapse of a structure need particular attention.
8. A nationally supported infrastructure is needed to insure that objective scientific input is placed into the code consensus process to bring fire safety to a proper level of engineering analyses. The current code process is lacking in scientific underpinning, and the WTC disaster should stand for change in this direction, especially if the scientific community cannot render a clear and decisive verdict.

October Review:

Review of NIST WTC Investigation
Addressing Tasks 3, 5 and 6.

J. G. Quintiere
September 11, 2004

Modified October 17, 2004

The following constitutes the NIST projects designed to reach the objective of the investigation.

NIST Projects: Federal building and fire safety investigation of the WTC disaster

Project No./Technical Area /Project Purpose

1. Analysis of Building and Fire Codes and Practices
   a. Document and analyze the code provisions, procedures, and practices used in the design, construction, operation, and maintenance of the structural, passive fire protection, and emergency access and evacuation systems of the WTC 1, 2, and 7.
2. Baseline Structural Performance and Aircraft Impact Damage Analysis
   a. Analyze the baseline performance of WTC 1 and 2 under design, service, and abnormal loads, and aircraft impact damage on the structural, fire protection, and egress systems.
3. Mechanical and Metallurgical Analysis of Structural Steel
   a. Determine and analyze the mechanical and metallurgical properties
4. Investigation of Active Fire-Protection Systems
   a. Investigate the performance of the active fire protection systems in WTC 1, 2, and 7 and their role in fire control, emergency response, and fate of occupants and responders.
5. Reconstruction of Thermal and Tenability Environment
   a. Reconstruct the time-evolving temperature, thermal environment, and smoke movement in WTC 1, 2, and 7 for use in evaluating the structural performance of the buildings and behavior and fate of occupants and responders.
6. Structural Fire Response and Collapse Analysis
   a. Analyze the response of the WTC towers to fires with and without aircraft damage, the response of WTC 7 in fires, the performance of open-web steel joists,

and determine the most probable structural collapse sequence for WTC 1, 2, and 7.

7. Occupant Behavior, Egress, and Emergency Communications
    a. Analyze the behavior and fate of occupants and responders, both those who survived and those who did not, and the performance of the evacuation system.
8. Fire Service Technologies and Guidelines
    a. Building on work done by the Fire Department of New York and McKinsey & Company, document what happened during the response by the fire services to the WTC attacks until the collapse of WTC 7;
    b. identify issues that need to be addressed in changes to practice, standards, and codes;
    c. identify alternative practices and/or technologies that may address these issues; and
    d. identify research and development needs that advance the safety of the fire service in responding to massive fires in tall buildings.

The NIST investigation objectives are:

1. To determine (a) why and how the WTC 1 and WTC 2 collapsed following the initial impact of the aircraft, and (b) why and how the 47-story WTC 7 collapsed.

2. To determine why the loss of life and injuries were so low or so high depending on location, including technical aspects of fire protection, occupant behavior, evacuation, and emergency response.

3. To determine the procedures and practices which were used in the design, construction, operation, and maintenance of the WTC buildings.

4. To identify, as specifically as possible, areas in national building and fire codes, standards, and practices that warrant revision.

Among the **specific questions that NIST is investigating** within the above four objectives are the following:

- How and why did WTC 1 stand nearly twice as long as WTC 2 before collapsing (103 min versus 56 min), though they were hit by virtually identical aircraft?
- What factors related to normal building and fire safety considerations not unique to the terrorist attacks of September 11, 2001, if any, could have delayed or prevented the collapse of the WTC towers?
- Would the undamaged WTC towers have remained standing in a normal major building fire?
- What factors related to normal building and fire safety considerations, if any, could have saved additional WTC occupant lives or could have minimized the loss of life among the ranks of first responders on September 11, 2001?
- How well did the procedures and practices used in the design, construction, operation, and maintenance of the WTC buildings conform to accepted national practices, standards, and codes?

I will address Tasks 3, 5 and 6 in the format indicated below:

Issue for the project
Approach taken by NIST
Questions on the Approach
Comments on ability to address objectives

3. Mechanical and Metallurgical Analysis of Structural Steel

Objective: Determine and analyze the mechanical and metallurgical properties

Issue

NIST has established the mechanical and thermal properties of the steel used in the WTC, and generally has found no remarkable departures from the literature for steel. However, an important aspect of this fire and large fires in general is the temperature reached by the fire, and that achieved by the steel.

NIST approach

In the December 2003 Public Update it states that part of this task objective is "estimating the maximum temperature reached by available steel" (p.8). In the May 2003 (p. 33) and June 2004 Vol. 1, p. 87), it appears that this objective is being done by examining paint degradation at 250 and 750 C.

Questions

A common forensic technique for determining the temperature reached by steel in a fire is to microscopically examine the grain size. It has been said that very precise determinations can be made if compared to an unheated similar steel sample. Why has NIST not used this method?

Comments

The importance of knowing the temperature achieved by the steel on the fire floors is crucial to establishing the cause of the buildings collapse. This is like a thermometer in the building, so its significance cannot be overlooked. The temperature of the fire and the steel are important in determining the time and the nature of the collapse of the buildings. NIST is using computational methods to predict these temperatures. It is incumbent on NIST to use all methods for ascertaining the steel temperatures to achieve confirmation of its predictions.

Also, NIST has steel samples salvaged from the dumpsite, and has said those samples were adequate. NYC made a unilateral decision to remove and sell the steel before the NIST investigation began. What is the NIST recommendation on how to preserve evidence in future investigations in order to render complete structural and thermal analysis to the debris samples? Was the steel prematurely discarded in the WTC before adequate analysis could occur?

5. Reconstruction of Thermal and Tenability Environment

Objective: Reconstruct the time-evolving temperature, thermal environment, and smoke movement in WTC 1, 2, and 7 for use in evaluating the structural performance of the buildings and behavior and fate of occupants and responders.

Issue

The accuracy of the computer modeling predictions for the fire environment need to be assessed, and their consistency with literature data for fully developed fires and with the factual evidence of the WTC fires needs addressing. A computation of this magnitude is beyond the state of the art for fire modeling, and although NIST and the investigators should be commended for their efforts at pushing the state of the art, they must not solely rely on computer-driven computations for estimating the fire temperatures. They have other sources from which to also draw information on the state of the fire: They include: conducted fire tests, correlations for fully developed fires in the literature, data on window breakage and the fire progress, and people reaction to the fire heat and smoke from potential interviews. Consistency must be assessed between the various sources of information and from alternative, albeit, simpler computational methods.

NIST Approach

Information about the fire can come from several sources. NIST has extensively examined and compiled the fire behavior and its effect on the building through the correlation of various photographic evidence. This task has been done with excellence it appears, and should offer valuable information. Another source of fire could come from the collection of data from people. This appears to have lagged and it is not clear that anything of value in a timely manner will be reported on the fire and damage effects observed directly by people and ascertained through interviews. In all of the fire predictions NIST has chosen to use its Fire Dynamics Simulator (FDS) as the sole computational tool. In order to evaluate its accuracy, experiments have been conducted on small features of the WTC office occupancies in order to calibrate and

assess the accuracy of the fire predictions. Hence, both the modeling and the experimental data offer information on the WTC fires. As with other aspects of the investigation, NIST appears to be weighting the computational approach as their primary result, especially since that result must be supplied to the structural modelers in order to make their prediction of the building's ability to carry its load.

NIST has approached the validation effort by conducting two series of tests. The first series consisted of a spray fuel fire in a compartment containing structural members. The second involved a larger compartment containing three workstations that NIST decided were representative of the WTC offices. That fuel load is roughly 4 lb/ft^2 (psf) (or about 20 kg/m^2 and 50 MJ/ m^2), June 2004 Vol. 1, p xxxvii, Vol. 5, J-37.

Series 1 consisted of the following (June 2004 Vol. 5, J-2):

> The test compartment consisted of a steel stud frame lined with calcium silicate board. The internal dimensions of the compartment were 3 m high, 7 m deep, and 4 m wide. There were four openings in the west wall through which air entered the room; they totaled 1.75 m 2 (10.8 ft^2) in area and were located 1 m (3.3 ft) above the floor. There were four openings in the east wall through which heat and combustion products were emitted; they also totaled 1.75 m^2 (10.8 ft^2) in area and were located 2 m above the floor. In each of the six tests, the four test subjects were a bar, two trusses, and a thin-walled tubular column. Depending on the test, these specimens were either left unprotected or were coated with spray-applied fire protective insulation material, Blaze Shield DC/F. The fibrous insulation was applied by an experienced applicator who took considerable care to apply an even coating of the specified thickness. As such, the insulated test subjects represent a best case in terms of thickness and uniformity. The fires consisted of liquid hydrocarbon fuels sprayed by a two-nozzle spray burner onto a 1 m × 2 m (3.3 ft × 6.6 ft) pan. The fuels were (a) heptanes and (b) a mixture of nominally 60 percent (by mass) heptanes with 40 percent toluene. The latter fuel produced a significantly sootier flame.

Six tests were done. The instrumentation for the tests comprised up to 352 channels of data.

Series 2 consisted of 3 workstations in a large room (June 2004, Vol. 5, J-27):

Six experiments were designed to assess the accuracy with which FDS predicts the fire spread, heat release rate, and thermal environment in a compartment burning multiple workstations in a configuration characteristic of that found in the WTC buildings. In each of these experiments, sets of three workstations were burned in a large compartment (about 11 m x 7 m x 3.4 m high). The challenges to the model included varying the location of the ignition burner (and thus the fire ventilation), adding jet fuel and/or noncombustible material occluding a fraction of the workstations' surfaces, and "rubblizing" the workstations.

It should be noted that the workstation fuel load was "suggested by personnel from a company that supplied office furnishings to the occupants of WTC 1. Information on the distribution of papers and other office items was provided by a frequent visitor to these offices". (p J-12)

NIST performed some additional computations based on FDS. They have early on reported on the smoke dynamics from the building (Rehm et al., IAFSS 2002), and recently on the fireball dynamics (Baum, Comb. Inst., 2004). These are considered somewhat ancillary to the prediction of the fire conditions on the floors that bear directly on the heating of the structure and the effect of the fire on the ultimate collapse. However, the work by Prasad and Baum (Comb. Inst. 2004) on linking the predictions of FDS for the fire with the heating of core columns under different core damage scenarios is very significant. It is the closure of the fire and the structure modeling that is critical to answering the issues pertaining to collapse. McGrattan has simulated the fires on a floor based on the workstation fuel load. That loading was indicated at about 4 pounds per square ft of office space (psf). McGrattan indicates the fire at this low fuel loading burn in an under-ventilated state as "oxygen consumed drives fires to the windows" (p. J-44). In addition, these full-scale WTC computer simulations are reported to for about 20 minutes in a region and then move on with an entire floor burning out in about 1 hour (Fact Sheet June 2004 pp. 2, 3).

Also it was indicated that these simulated fire burn at an average temperature over the floor at about 600 C.

Questions

It is well known that FDS results depend on the grid size and its scaling to the fire conditions. The experiments done by NIST may well serve the credibility and accuracy of using FDS with a grid size of 40 cm, but enough comparison has not been shown between the computations and the experiments. Only about 4 or 5 plots have been presented for comparison in the reports, and they show very good prediction for the fire gas temperatures and heat release rate. Some of NIST's own funded work (Ierardi and Barnett, 2003) have shown that the accuracy of predicting a single fire plume from a 30 cm burner give drastic variations in temperatures with the fire plume for grids of 1.5 to 15 cm. Temperatures within 20 per cent of the experiment results required grids of 1.5 to 5 cm. So it is incumbent on NIST to address this accuracy question completely. They have done 13 experiments with over 300 measuring stations in each test. In the least, NIST needs to demonstrate the ability of FDS to compute all aspects that FDS has in common with these measurements.

The issue of accuracy for computer models is a serious matter when they are to be used as general engineering tools. The literature is filled with data and correlations for fully develop fires. NIST should at least demonstrate how its approach using FDS compares to these other empirical approaches in the literature. Japan uses one of these empirical approaches as a design method in regulations, and the SFPE has just completed a guide on the prediction of fire conditions for structural considerations. It has been said that the full WTC floor simulation agree with the phenomenon observed by (I. Thomas et al.) in which the fire moves about the compartment seeking air. Can FDS predict the data of Thomas? These questions are broader that the effort that has gone into the WTC simulation, and therefore it would be important for NIST to examine FDS in light of its validation needs. Moreover, FDS is using a charring model to compute the burning rate and flame spread on the workstations, and NIST should state the accuracy of using FDS for the prediction of flame spread on charring materials. Boeing would not take the use of CFD models in its aircraft design lightly, and neither should those assessing fire behavior, especially from NIST.

The fuel load selected in the representative experiments and the modeling raises some questions. NIST is using roughly 4 psf, and a floor burns for an average of about 1 hour (Key Findings of NIST's June 2004 Progress Report...). This selection of loading is critical to establishing the burning time, crucial to predicting the impact of fire on the structure. The literature (Robertson and Gross, ASTM STP 464, 1970) suggests an average office load of 18.4 psf, ranging from 7 to 43 psf according to surveys. Why is the WTC representative office so low? This needs examining and supportive data.

The FDS simulations indicate a one-hour burning period for a floor at 600 C. This may be due to the light fuel, but appears inconsistent with the under-ventilated burning achieved in the simulation. Also the actual fires appear to have burned longer with WTC burning until collapse at 103 minutes. Finally, the average temperature of 600 C is about coincident with critical failure temperature associated with steel structures, and would never allow the steel to reach this temperature.

In an investigation where information comes in different forms, the final analysis must show that the information pieces are consistent. NIST has observational information, hopefully people information, experimental test information, and the FDS simulations. These must be shown to be consistent.

Ultimately FDS results must be linked to a structural model. Prasad and Baum (C.I. 2004) have attempted this for the heating of the core columns. They show that simplifications need to be made in representing the FDS temperature spatial distributions in order to better interface with the structural heating model. Their approach has demonstrated the needed closure of the fire and structural heating. However, they have not considered the vulnerable floor assembly in their calculations. This will need to be added to fully assess the role of the fire on the complete structure. NIST has not made clear how the fire and structural computations will come together, particularly since the structural modeling is being done under contract. We would like to see NIST speak to the accuracy and issues related to the modeling of the fire and structure together.

Since NIST has test data on the heating of insulated structural members in their fire tests, some comparisons, at least, need to be presented for these simpler fire scenarios.

Can NIST successfully modeling the 1975 WTC fire (June 2004, Vol. 4, G-1) that did extensive damage to a floor? This fire prompted the use of sprinklers, and local structural damage occurred. Since the damage and extent of the fire was known, it could be a useful benchmark for NIST to compare their simulations.

Comments

The fire computations are perhaps the most important determination since its heating impact and its duration determine the ultimate temperature of the protected steel. The heat transfer by conduction into the insulation and the steel is trivial by comparison. Also when it realized that failure in furnace testing of structures is often based on steel temperature, and temperature strongly affects the strength of steel, e.g. the modulus of elasticity is reduced by 50 % when steel attains about 600 C. Since the modulus is directly related to the critical load to cause buckling, the buckling of elements in compression can occur more easily at elevated temperatures. The ability of the fire modeling to relate to the structural heating model is very import step in this investigation. NIST should make this step as transparent as possible in order to judge its conclusions. FDS will yield a spatial and time varying temperature throughout a floor. Its accuracy needs to be supported at this level of sophistication. Alternative estimates on the level of temperature and its duration might need to be couched in simpler forms for the best structural analysis to be produced. It might serve just as well to specify uniform temperature in a range. The duration will depend on the fuel load, and it has been pointed out that the NIST selected load is very low compared to office load surveys. Some variation of uncertainty must be considered here.

Finally, it appears almost foolish to have received $16 million for the investigation and to not have conducted a test more representative of a WTC floor. A quarter of a floor could have been tested for fire and the heating of the structure. It would only involve a plan space at 100 x 100 feet. This could have settled many issues. Especially when it is realized that no experimental results exist for compartments with small ratios of height to their lateral dimension as 1/20 in the

WTC. The smallest has been ¼ in the well known CIB studies, and those results should be examined by NIST for their applicability. However, the interaction of air from the perimeter and fuel within the compartment need to be examined under these conditions by an experiment, to at least see if FDS is qualitatively correct. Moreover, it is known that in large fire plumes that smoke can trap radiation and drive the core fire temperatures to 1300 C and more. This can happen at fires of 30 ft in diameter, so the question must be raised if this might apply to the WTC with lateral floor dimensions of 200 ft.

<u>6. Structural Fire Response and Collapse Analysis</u>

<u>Objective:</u> Analyze the response of the WTC towers to fires with and without aircraft damage, the response of WTC 7 in fires, the performance of open-web steel joists, and determine the most probable structural collapse sequence for WTC 1, 2, and 7.

<u>Issue</u>

The principal issue here is to examine the NIST working hypothesis in conjunction with its collection of findings and to assess their consistency. The working hypothesis is found in June 2004 Vol. 6, Q-3.

> The working hypothesis addresses the following chronological sequence of major events; specific load redistribution paths and damage scenarios are currently under analysis:
>
> 1. Aircraft impact damage to perimeter columns with redistribution of column loads to adjacent perimeter columns and to the core columns via the hat truss;
> 2. After breaching the building's exterior, the aircraft continued to penetrate into the buildings, damaging core columns with redistribution of column loads to other intact core and perimeter columns via the hat truss and floor systems;
> 3. The subsequent fires, influenced by post-impact condition of the fireproofing, further weakened columns and floor systems (including those that had been damaged by aircraft impact), triggering additional local failures that ultimately led to column instability;

4. Initiation and horizontal progression of column instability ensued when redistributing loads could not be accommodated any further. The collapses then ensued.

NIST Approach

NIST and its contractors are using computational analyses to compute the impact damage by the aircrafts, the performance of a single floor truss under temperature elevation, the evaluation of a portion of the floor assembly in the ASTM E 119 test, and the history of the insulation applied in the WTC, especially to the floor assembly.

2. Impact computations: These computations are portrayed in figures on pp 78-79 of June 2004, Vol. 1, and they show an engine impacting and shredding a floor and then buckling a core column.

NIST reports further (June 2004, Vol. 1, p 81):

• A 500 mph engine impact against an exterior wall panel results in a penetration of the exterior wall and failure of impacted exterior columns. If the engine does not impact a floor slab, the majority of the engine core will remain intact through the exterior wall penetration with a reduction in velocity of about 10 percent and 20 percent. The residual

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

velocity and mass of the engine after penetration of the exterior wall is sufficient to fail a core column in a direct impact condition. Interaction with additional interior building contents prior to impact or a misaligned impact against the core column could change this result.

Also an analysis of the stability of the towers, assuming no damage to the core, gives the number of floors that need to be removed to cause global failure (June 2004, Vol. 1, p.81):

The following presents some preliminary findings obtained from the preliminary stability analyses under service live loads and subject to the assumptions and the limitations of these models (see Appendix D): Linear stability analysis was used to examine the stability of the undamaged WTC 1 under service loads through increased un-braced column lengths (floor removal). The tower was stable when two floors were removed. Two core columns buckled when three floors were removed, but the tower maintained its overall stability. The tower also maintained its stability when four columns buckled with four floors removed. The analysis suggested that global instability of the tower occurred when five floors were removed from the model. Assuming that all columns at the region of the removed floors reached a temperature of 600 °C (reduced modulus of elasticity), the analysis indicates that removal of four floors would induce global instability.

3. Single truss analysis: A model of a single truss and its connection shows that the truss fails at the interior column seat connection, and 'walks off' the seat. This occurs at 650 C. The web diagonals begin to buckle at 340 C, and the exterior columns bow inward at 560 C because the truss begins to act as a catenary. (June 2004, Vol. 1 p. 120).

4. E 119 tests: Standard fire tests were conducted at UL. Two were done at a 35 ft span representing the short span in the WTC towers. These had ¾ in. thickness of insulation applied. A third test was conducted with public viewing with ½ in. insulation, and at a span of 17 ft. In that test the truss was scaled –down so that it was half its depth. The failure criterion used was primarily structural integrity for the most part. The third test was conducted *restrained* and obtained a 2 hour restrained rating meaning it did not structurally collapse, and it obtained a 1 hour unrestrained rating which results from exceeding a critical temperature of the steel.

5. Insulations history: NIST has traced documents and recommendations related to the thickness of insulation, particularly on the floor joist assembly. They have found and stated the following:
    a. The truss specified thickness was 0.5 in., but as applied was 0.6 +/- 0.3 inch.

b. The upgraded truss insulation was 1.5 inches (based on UL G805, May 2003, p. 78), but was later measured in application as 1.7 +/- 0.4 inches based on photographic analysis, but was reported in audit documents over 1997 to 1999 as 2.5 +/0.6 inches, with thickness as high as 4 inches (June 2004, Vol. 4, I 15-18).

c. A model code recommended 2 inches for 2 hours in a 2001 assessment of a similar truss (June 2004).

d. A report by Burro-Happold recommended in 2001 that the upgraded insulation could be dropped to 0.5 inches based on an ambient value of the conductivity used in a calculation, but settled on a recommendation of 1.3 inches. (May 2003, p. 82)

Questions

Column impact: It is very important to determine an accurate estimate of the core column damage. In view of the variability of the impact computer codes, what does NIST consider is their accuracy? It was reported by the NY Times that the Weidlinger computations indicated that the South tower would fall solely upon impact of the aircraft. It is know that calculations were made in 1966 that indicated only local damage would occur. Why is there so much variability in these computations? In addition, the NIST reported results indicate that an engine needs to directly strike a core without loss of momentum for the column to fail. This would suggest very limited core column damage is possible as might be inferred from the NIST computational graphic shown above. Can an engine possibly hit a core column without hitting anything on the floor occupancy and structure? That does not seem possible, so how can an engine damage a core column? Perhaps I am missing something. Why is NIST then considering in its "working hypothesis" that considerable core damage is likely? Moreover, it is known that landing gear and at least one engine was found in the surrounding streets suggesting a flight path through the building. Can NIST use information on the location of the engines to assess the likelihood of core column damage?

Temperature importance for floor failure: The single truss analysis done by NIST and the work done both Usmani et al, and Burgess et al., indicate that the truss deflections occur at temperatures ranging from roughly 400 to 600 C. During these deflections, the truss can cause failure to its connections, or to column instability. It would seem that temperature is a key feature

in causing failure. How does NIST relate its work to those cited above in the literature? If one floor falls on the floor below while both are heated by fire, can the impacted floor carry the load? Will this be a mode of global collapse? NIST considers the number of floors to be removed before the columns would become unstable, but would not the loss of 2 or 3-floors cause the failure before this instability? Is a critical temperature a good measure of structural failure as it might appear from the element computations, and the implication of the loss in strength at elevated temperatures?

Role of E119: Ratings have been achieved at UL for the E-119 test. Will NIST be analyzing these results to see how they would apply to the WTC? If the temperatures reached by the steel in these tests is sufficient to cause failures in the WTC computations, but the structure did not fall in the E 119 test, how will NIST reconcile these differences? NIST scaled the depth of the truss to ½ full-scale in its 17 ft E 119 test. This was done for stress purposes, but the heat transfer along the web into the concrete deck is now changed. Since temperature is a criterion for failure of the test in some modes of testing, the temperature of particularly the full-scale 35 ft. truss should be examined. Moreover, as UL G805 was used for justifying the 1.5-inch insulation thickness, why would the recent tests give such different results? Also UL N 826 might have been more appropriate, and gives 2 1/16 inches. So what is the meaning of the E 119 test and how should it be used in this WTC analysis?

Reconciliation of insulation thicknesses: As seen by the various E 119 results for the Cafco insulation, and the varied specifications and recommendations on the WTC truss insulation, it is incumbent on NIST give some rationality to these variations. Since the amount of insulation is so crucial to the outcome of finding the cause, NIST needs to be very sure about how much insulation was actually in place. The latest information from PANYNJ indicates that the upgrade in WTC 1 could have been as much as 4 inches over the 1.5 specification, when field workers were having difficulties in application, and that was the main reason for the Burro-Happold report. A 4-inch radius on a 1 inch steel rod would give a 9-inch diameter cylinder – a very big result. How much confidence does NIST have on these large amounts? Do they have photographic evidence as in the previous smaller amounts? Would not a hearing on the insulation thickness issues serve NIST well in documenting the facts and rationality of these

variations? If so much variation occurred for the WTC, how does this relate to the protection in other buildings?

Comments

It appears that NIST has to answer some very focused questions with clarity and accuracy.

1. How many core columns were removed and why?
2. How much insulation was in place during the fire?
3. What are the critical temperatures needed for failure?
4. Could the fire cause these temperatures?

The global collapse mechanism of the buildings must be made as clear as possible. A vague answer expressed by the current NIST working hypothesis is not sufficient. NIST has expended a lot of good individual effort, and it has done some very good fact finding and analyses. Now all of that has to be put together, and it seems contractors (who we have not heard from) play a significant role. NIST needs to harness those individual efforts and expertise in a balanced evaluation. Reliance solely on complex computer models should not be the sole basis of the answers. If the core of the answers are really revealed and understood, NIST should be able to explain them in simple fundamental physics, and not shroud them in computer graphics. This was the purpose of the investigation, and this project task is critical.

Appendix C:

Analysis of the Fuel Load Calculations for the 96th Floor of the WTC North Tower

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April 2005
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Abstract

An impartial examination into the combustible fuel load for the 96th floor of the North World Trade tower is described in this paper.

Introduction

The dimensions used for analysis of the WTC North tower are as follows, the overall building dimensions are 207.2' x 207.2' = 42,932 ft^2 (3988.5 m^2), building core dimensions are 87' x 137' =11,919 ft^2 (1107.3 m^2), and the area that office equipment sits on is therefore 31,013 ft^2 (2881.2 m^2), while FEMA reports that area for office furniture is 30,930 ft^2 (2,873.5 m^2) [1].

Typical structural live loads used in design or analysis for offices are 50 psf (pounds per square foot) (244.35 kg/m^2), and for lobbies, 100 psf (488.7 kg/m^2).

The paperweight found in the Marsh & Mc Lennan office is significant because it directly impacts the fire size/duration, which in turn, affects results obtained for performance of structural members.

UMCP considerations and examination:

- The cabinets used by NIST contained two reams of packed paper, which is not consistent with the files that I weighed. The significance is that the tighter the packed paper is, the less air can get in to feed the fire whereas, typical files are not uniform in size or spacing and leave room for air to supply the fire.
- The following are graphical representations of the difference between the paper weight not included (NIST) and the total weight inclusion (UMCP):

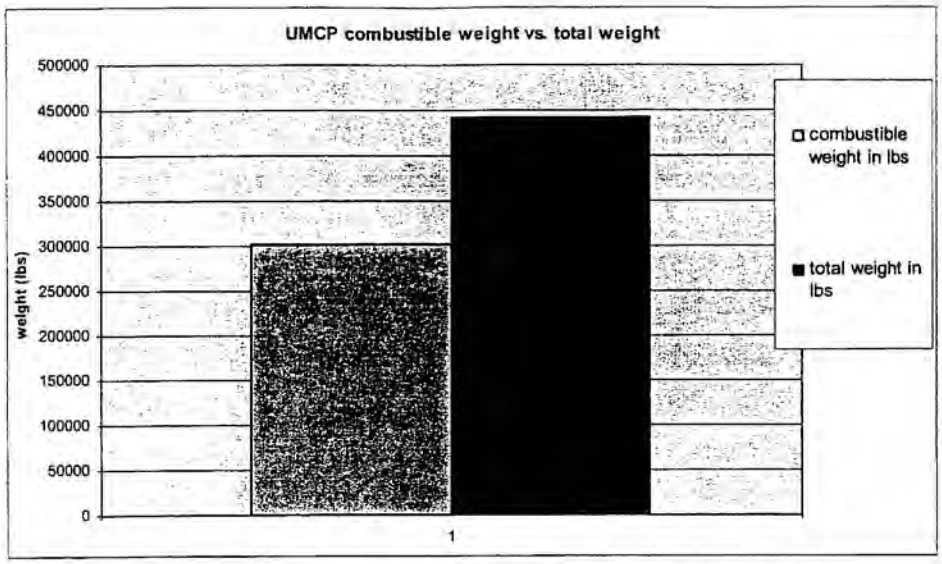

Figure 1. UMCP estimate of how the total workstation weight is distributed.

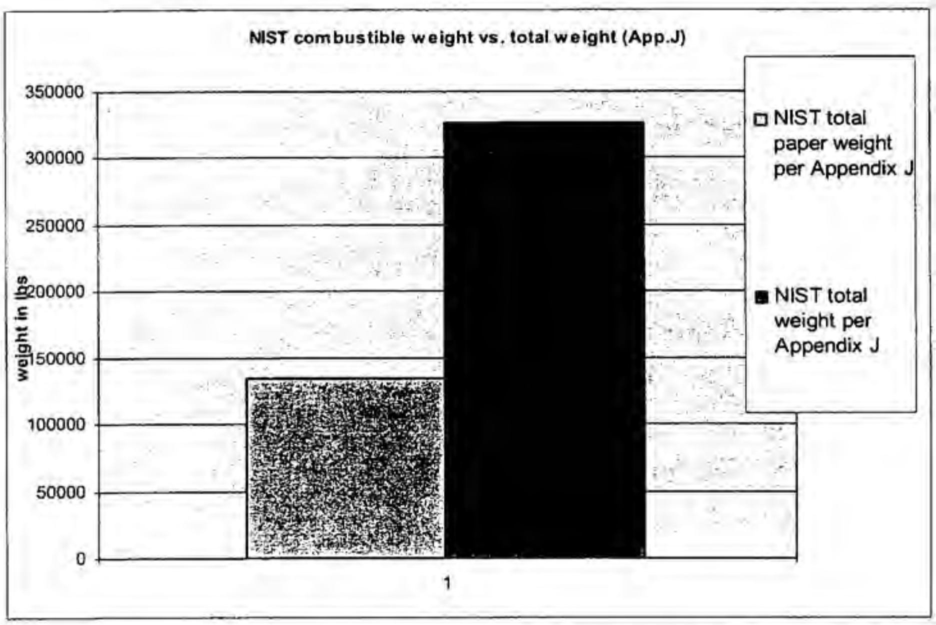

Figure 2. NIST estimate of how the total workstation weight is distributed.

Summary of results from NIST

- The book case, which was 48" high (1.22m), was stuffed with 10 boxes containing 13 reams of copier paper (260 lb ~ 118 kg).
- Total workstation weight considered to be 1600 pounds (726 kg) and the amount of combustible material contained in that workstation was estimated as 660 pounds (300 kg) by NIST. Based on the information obtained in these simulations, McGrattan then passed the FDS results onto others who analyzed the temperature of the steel and concrete [2].
- NIST used a per desk weight rather than obtaining combustibles for the entire floor and attributing that to their experiments. However, in the impact zone, there are two conference rooms (~1,590 lbs (721 kg) of combustible materials), 8 sets of four drawer lateral files (48 cabinets=192 drawers~13,824 lbs (6270.5 kg) (of paper that was likely dislodged by the impact) and the paper storage area (~28,000 lbs (12,701 kg) of paper & paper/office products) that directly contribute to the initial fire started by the jet fuel.

Information obtained from FEMA

- Estimated combustible fuel load as 8 psf.
- Additionally, the report acknowledges that typical office loading is 50 psf, per Load Resistance Factored Design published by American Society of Civil Engineers. (50*31013=1,550,650 lbs (7,577,988 kg) live load- i.e. combustible and non-combustible materials)

Methodology used for this examination

- The assumptions made for this project are as follows:
  1. That the symbols had not changed for the Knoll furniture between those used in 1997 and those used today.
  2. Veneer panels close in weight to panels used by NIST.
  3. Used FEMA building and core dimensions and assumed NIST did the same.
  4. Based on NIST drawing, I counted 204 workstations but according to plans from Dr. Quintiere, there were 210 workstations. I used 210 workstations.

5. Estimated that there were 20 units of five shelf storage files by the stairwell area. Each unit was determined to have dimensions 63" high x 36" wide (1.6 m x 0.9 m) and it was assumed that items were stored on top of the shelving units.
6. One Calibre cabinet held 15 lbs ~ 6.8 kg (of contents and one 3-drawer pedestal contained one paper file with 17" (0.4 m) of file storage (24 lbs ~ 10.9 kg of paper weight).
7. Southeast corner of building plan did not photocopy well therefore assumptions were made consistent with other corners of the 96th floor layout.

- The approximations made are as follows:
  1. The weights for chair models that were not found in the symbol library (perhaps not manufactured by Knoll), like "CH6", were estimated based on other known chair weights.
  2. Wall panels and workstation layout based on information provided by NIST [3]: (5) 4'panels-36"wide, (1) 5' panel-36"wide and (5) 4' panels-24"wide. In SI units: (5) 1.2 m panels- 0.91 m wide, (1) 1.5 m panel- 0.91 m wide, and (5) 1.2 m panels-0.61 m. The two foot panel weights were estimated using 10.55 lbs (4.8 kg) per foot of height.
  3. Based on files weighed in the ENFP office, an average file weight was obtained of 2 lbs/inch using standard paper size, type 20 wt.
  4. Only desks that could be positively identified as having a computer were given 'credit' for one (i.e. 165 computers for 210 workstations)
  5. Trapezoidal conference room table weight was estimated based on locating it once in AutoCAD, noting that there were several sizes, and then not being able to locate the table again.
  6. Knoll representative did not want to be quoted on specific amounts of combustible material in furniture.
  7. A request of the Manufacturer must be made in order for the privacy panels to be chemically treated to meet ASTM E-84 class "A" flame spread rating.

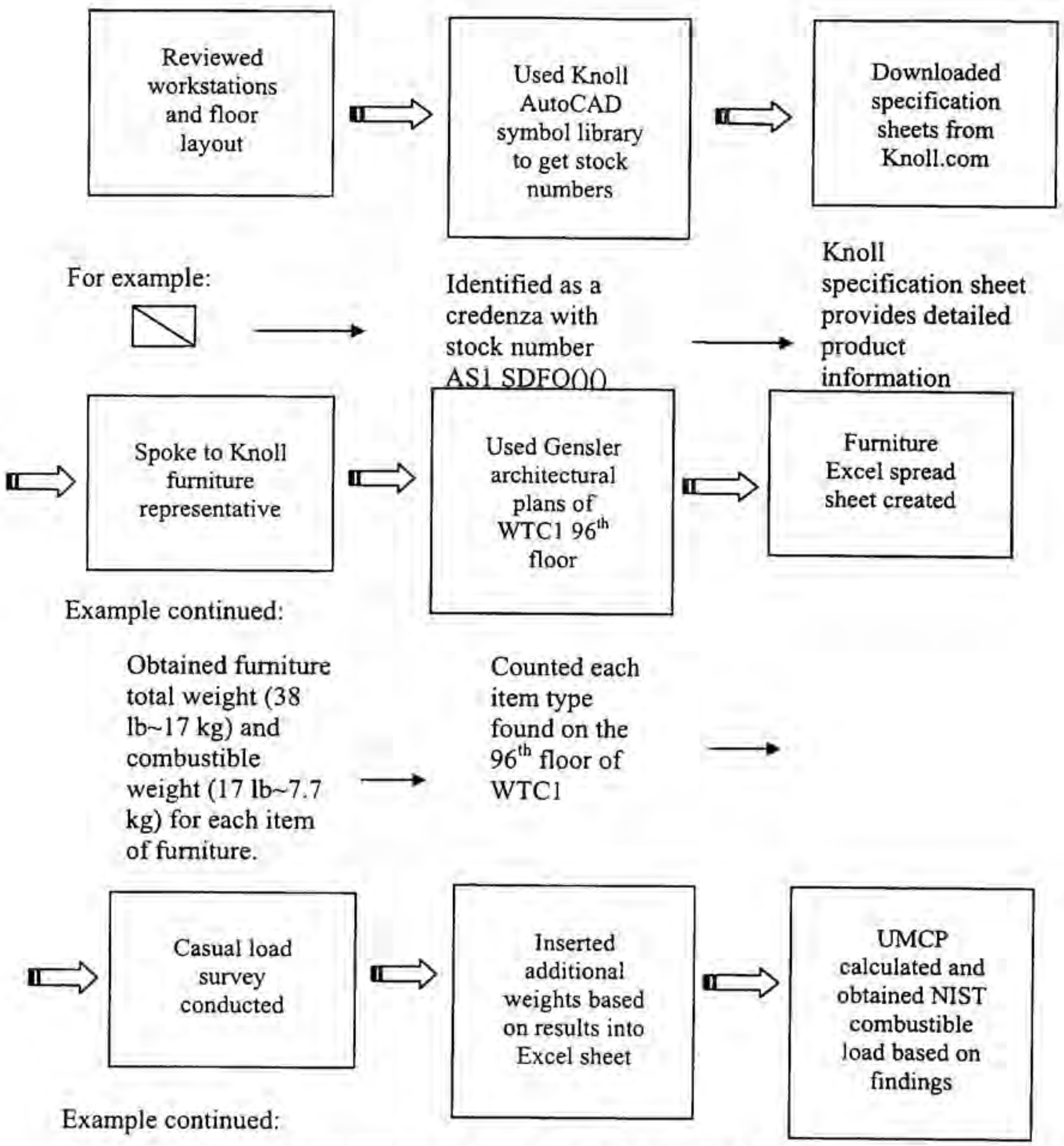

Figure 3. This flow chart demonstrates the methodology used to obtain furniture identifications.

Comparisons

The following comparison table is provided to sum-up the previously mentioned information and to clearly layout the three groups being compared.

Table 1.

	COMPARISON				
TOTAL WORKSTATION WT.	Average	High	Low		
description	UMCP			NIST	FEMA
Number of desks	211			204	
Total psf(*combined contents)	14.3				
Combustibles only desk wt	179441	1429	341		
Paper weight (lbs)	302062			134640	
Empty furniture weight (lb)	265162			191760	
Full furniture weight (lb)	441868			326400	248103
30% paper weight (lb)	90619				
Building area (ft^2)	42932				42932
Core area (ft^2)	11919			11745	11919
Area that furniture sits on	30930			31000	31013
Common file cabinets (lb):					
noncombustible	37626			0	
combustible	36,437			0	
combust. stored on top	255				
Total	74318				
Conf. rms/areas & pantries(lb)	7117			0	
***Combustible Material (psf)**	**10**			4 psf	8psf (39 kg/m^2)
SINGLE WORKSTATION WT.					
Combustible wrkstn weight	862	1443	341	660 lbs	
Total				1600lbs	
Wrkstn. weighted average (lb)	862				
Added Combustibles:					
workstation paper (lb)		370	6	160	
additional (lb)		30	0	0	
File cabinets:					
contents (lb)		424	124	40	
top (lb)		6	3	0	
workstation foot print	8'x8' (2.41 m * 2.41 m)			8'x8'	
paper NIST left out	71,844 lbs				

Comparison of fuel load between UMCP and NIST:

Table 2.

	NIST	UMCP
Total floor weight (combustible + noncombustible)	1600 lbs x 204 stations=326,400lb	210 stations x 1433 lb =301,012 lb
Total Combustibles Weight	134,640 lb/30930 ft^2= 4.3 lb/ft^2 combustibles only	301,012 lb/30930 ft^2 = 9.7 ~ 10 psf
*Paper weight for floor distributed per station	60,242 lb/204 wrkstns = 295 lbs.	176,706 lb /210wrkstns = 841 lbs.

*paper weights for NIST and UMCP are different because UMCP included common lateral files and paper storage whereas NIST did not.

**The reason for 1141.4 lbs of combustible per station is based on the accessible fuel per NIST. However, this is too low an estimate due to the fact that common files were not taken into account, nor conference rooms etc…

***This is the weighted average of the workstations.

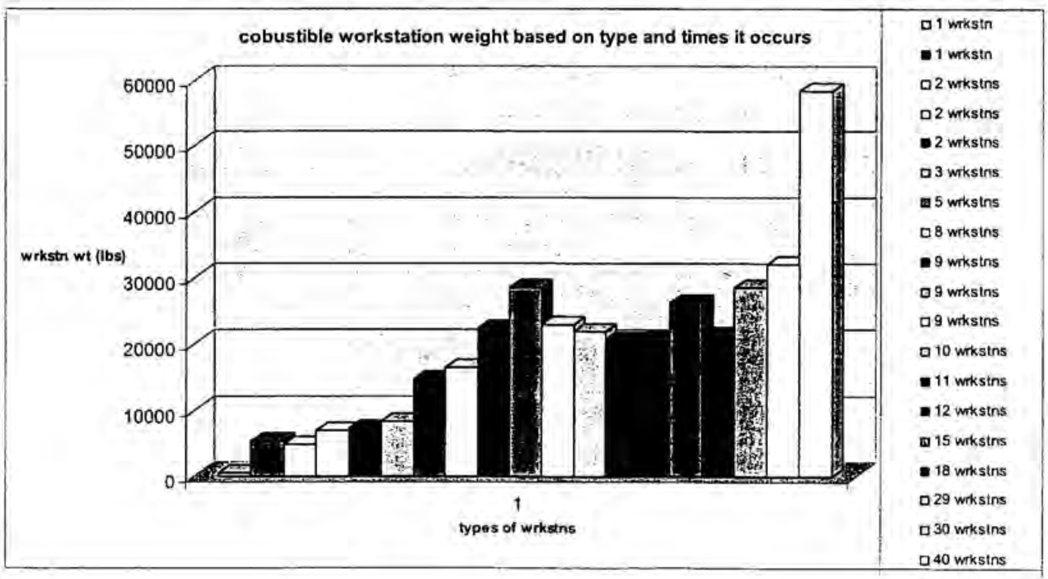

Figure 4. UMCP chart showing weight of workstation type plotted against the number of times the workstation type occurs on the 96th floor.

Recommendation

Use the NIST data for the temperature of steel then make a plot versus temperature of the outer steel insulation. The purpose of this plot is to help linearly estimate, based on corrected fuel load/fire size, the possible range of steel temperatures. Then, using something like SAFIR or lumped heat capacitance or maybe T. T. Lie's work, there would be a reference check as to the validity of the results.

From the above described course of action, a strong enough case can be made, which may prove to NIST that a re-examination of their original fuel load estimates is worthwhile.

References

1. McAllister, T., et al. FEMA WTC report "Chapter 2" page 2-1
2. McGrattan, K. "Simulation of the fires in WTC 1 and 2" BFRL, NIST, US Department of Commerce, October 19, 2004, slide 2.
3. NIST Preliminary WTC report 2004, Appendix J.

Other References not specifically cited:

4. NIST AND THE WORLD TRADE CENTER website "Status of Data Collection Efforts"
5. McGrattan, K. "Simulation of the fires in WTC 1 and 2" October 19, 2004. BFRL, NIST, US Department of Commerce.
6. McGrattan, K. "Simulation of the fires in WTC 1 and 2" October 19, 2004. BFRL, NIST, US Department of Commerce.
7. Knoll furniture catalog www.knoll.com/products

	wish to send confirmation of combustible weights via email).
H5 & I5	Combustible weight in lbs and kgs respectively
J3-J4	Weight of paper in one item is an estimate of the amount of paper to be found in/on a particular piece of furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
J5 & K5	Paper weight in lbs and kgs respectively
J9	Calibre cabinet was not given a paper weight of 15 lbs each but rather an estimate for clothing, note pads and other office items. The 15 lbs were put under weight of paper for ease of reference.
L2-L4	Total weight of paper for all items means that the weight of paper for one furniture item has been multiplied by the number of items on the floor.
L5 & M5	Total paper weight in lbs and kgs respectively
N2-N4	Combined weight for one full item means combustible and noncombustible weight of one full item. This column provides the total weight of one piece of a particular furniture type; self weight plus paper weight.
N5 & O5	Total furniture weight in lbs and kgs respectively
P2-P4	Total weight of combustible material for full item, this column provides the combustible weight of the furniture plus the added paper weight for one piece of a particular furniture type.
P5 & Q5	Combustible material weight in lbs and kgs respectively
R2-R4	Total combustible weight is the weight of combustible material times (x's) number of items. This means that the total combustible weight (P column) was multiplied by the number of times that piece of furniture was found on the 96th floor (G column).
R5 & S5	weight in lbs and kgs respectively
T2-T4	Total combustible and noncombustible weight provides the furniture self weight plus the added paper weight.
T5 & U5	Total weight (combustible + noncombustible) for 96th floor in lbs and kgs respectively

V3-V4	Total weight of the furniture only (both combustible and non-combustible furniture weight. Note, there is no added paper weight here)
V5 & W5	Furniture weight, only, for 96th floor in lbs and kgs respectively
B6-B25	Items that may be located in a workstation, there were different designs; these office items were found among the workstations on the 96th floor.
B27-B30	Common files refer to the lateral files that were either at the end of a workstation grouping or in a common area. (previously left out by NIST)
B32-B39	These are the different types of conference chairs found on the 96th floor.
B41-B45	These are the different types of conference tables found on the 96th floor.
B47-B51	These are the different types of common items found on the 96th floor.
B53-B61	These are the different common/shared rooms located on the 96th floor.
B63	Despite there being different sizes and weights of paper used, the estimate was based on Boise 20weight, 500 sheet 5 lb reams.
Notes:	
C7	The three file credenza was only included by NIST for the brand mane workstation. Appendix J shows that there was not a credenza for the generic workstation but rather a third two drawer file cabinet. If this was to account for the lack of a credenza then the combustible furniture weights were significantly different. (Credenza combustible weight of 17 lbs vs. all metal for the two drawer lateral file). If this was an attempt to account for the files at the end of workstation groupings then they should have been placed outside the workstation and the credenza would have been negated.
C9	The Calibre cabinet was not shown in any of the Appendix J photos but was present on the 96th floor, per Gensler, in the amount of 62 units with a **combustible** weight estimate of 175 lbs each!
Row 66	Provides 'sum' of columns
NIST	
A1	For ease of identification when printed I inserted column and row details.
A68	Row and designations for ease of reference.

B70	Heading to show that the following data is from NIST, Appendix J of preliminary report.
B71	Classification for the description of where the furniture item may typically found on the 96th floor from Appendix J.
C70	Item type refers to the physical description of an individual item found on the 96th floor as obtained from Gensler Architectural plans and Appendix J of the NIST preliminary WTC report.
D70	Stock identification numbers were obtained from comparing the Gensler Architectural plans to the AutoCAD symbol library obtained from www.Knoll.com
E69	Total weight of each item refers to the weight of one piece of furniture as it is, complete and unpacked. These weights were obtained from a Knoll Sales person.
E70	Weight of furniture in pounds (lbs)
F70	Weight of furniture in kilograms (kgs)
G68-G69	Number of items refers to the number of items found on the 96th floor of WTC 1. This information was obtained from Gensler Architectural plans except that the number of desks came from the FDS office graphic in Appendix J.
H68-H69	The weight of combustible material for empty furniture item refers to the amount of material for a single, unused piece of furniture (obtained from Knoll sales person who was referring to either a binder or computer when we spoke but did not wish to send confirmation of combustible weights via email).
H70 & I70	Combustible weight in lbs and kgs respectively
J68-J69	Weight of paper in one item is an estimate of the amount of paper to be found in/on a particular piece of furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
J70 & K70	Paper weight in lbs and kgs respectively
L68-L69	Total weight of paper for all items means that the weight of paper for one furniture item has been multiplied by the number of items on the floor.
L70 & M70	Total paper weight in lbs and kgs respectively

N68-N69	Combustible and noncombustible weight of one full item, this column provides the total weight on one piece of a particular furniture type, self weight plus paper weight.
N70 & O70	Total furniture weight in lbs and kgs respectively
P68-P69	Total weight of combustible material for full item, this column provides the combustible weight of the furniture plus the added paper weight for one piece of a particular furniture type.
P70 & Q70	Combustible material weight in lbs and kgs respectively
R68-R69	Weight of combustible material times (x's) number of items means that the total combustible weight (P column) was multiplied by the number of times that piece of furniture was found on the 96th floor (G column).
R70 & S70	weight in lbs and kgs respectively
T68-T69	Total combustible and noncombustible weight provides the furniture self weight plus the added paper weight.
T70 & U70	Total furniture weight for 96th floor in lbs and kgs respectively
B71-B84	Items that may be located in a workstation, there were different designs; these office items were found among the workstations on the 96th floor.
Notes:	
C73	The three file credenza was only included by NIST for the brand mane workstation. Appendix J shows that there was not a credenza for the generic workstation but rather a third two drawer file cabinet. If this was to account for the lack of a credenza then the combustible furniture weights were significantly different. (Credenza combustible weight of 17 lbs vs. all metal for the two drawer lateral file). If this was an attempt to account for the files at the end of workstation groupings then they should have been placed outside the workstation and the credenza would have been negated.
C72	The Calibre cabinet was not shown in any of the Appendix J photos but was present on the 96th floor, per Gensler, in the amount of 62 units with a **combustible** weight estimate of 175 lbs each!

Row 86	Provides 'sum' of columns
R86	Is the amount of combustible weight calculated by UMCP using NIST data however, it does not include carpet tiles and ceiling tiles. That contributes to the discrepancy UMCP(106,705 lbs) vs. NIST (660 lbs * 204 desks-134,640 lbs)
T86	Is the amount of total weight calculated by UMCP using NIST data however, it does not include carpet tiles and ceiling tiles. That contributes to the discrepancy UMCP(247,098 lbs) vs. NIST (1600 lbs * 204 desks-326,400 lbs)

Table 2. For Excel sheet 'wrkstn wts'

Column designation	Description of how the value was obtained and/or what it means/relevance
A1	Row and column designations for ease of reference.
B2	Heading to show that the following data is calculated from information obtained by Quintiere & Stewart of UMCP.
C2	WTC1 96^{th} floor ('wrkstn wts') to let reader know which printed sheet they are viewing.
E3, H3, P2, Z2 & AM2	These are sub category designations.
G2	All weights on this sheet are in pounds.
B4	Description refers to designation of the employee who was originally assigned to that desk location on the 96^{th} floor.
C4	Station identification is the number assigned on the architectural plans for a particular desk location.
D4	Telephone extension for a particular workstation
E4	Staff refers to the COMBUSTIBLE weight of one staff chair.
F4	Visitor refers to the combustible weight on staff chairs that can be attributed to that workstation.
G4	Conference refers to the conference area/room chairs that correspond to the

	designated location.
H4	J-shape refers to the style of knoll table that can be found at that workstation location; combustible weight is provided and does not include mounting or legs.
I4	Is the paper weight most likely to be found on the J-shape table and is an estimate of the amount of paper to be found on furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
J4	½ round table refers to the style of knoll table that can be found at that workstation location; combustible weight is provided and does not include mounting or legs.
K4	Is the paper weight most likely to be found on the ½ round table and is an estimate of the amount of paper to be found on furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
L3-L4	Teardrop or circular table refers to the style of knoll table that can be found at that workstation location; only combustible weight is provided and does not include mounting or legs.
M2-M4	Is the paper weight most likely to be found on the teardrop or circular tables and is an estimate of the amount of paper to be found on furniture. These two tables were grouped together because they have nearly identical weight as provided by Knoll customer service representative. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
N4	This is the boat shaped conference table that is located in the following conference rooms: NE, NW, SE, & SW
O3-O4	Is the paper weight most likely to be found on the boat shaped table and is an estimate of the amount of paper to be found on this furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
P2-P4	Wall Panels: 4 foot high and two feet wide privacy panels used at each desk. The weight of 3 panels*14 lbs = 42 lbs.
Q3-Q4	Is the paper weight most likely to be found on the three privacy panels and is an

	estimate of the amount of paper to be found on these pieces of furniture. One privacy panel was observed to have 0.15 lbs of paper attached to it which is ~ 15 sheets of standard paper. This information was obtained by casual load observations and calculations of privacy panel decorations, calendars and other items.
R3-R4	Wall Panels: 4 foot high and three feet wide privacy panels used at each desk. The weight of 3 panels*24 lbs = 72 lbs.
S3-S4	Is the paper weight most likely to be found on the three privacy panels and is an estimate of the amount of paper to be found on these pieces of furniture. One privacy panel was observed to have 0.15 lbs of paper attached to it which is ~ 15 sheets of standard paper. This information was obtained by casual load observations and calculations of privacy panel decorations, calendars and other items.
T3-T4	Wall Panels: 5 foot high and three feet wide privacy panels used at each desk. The weight of 1 panel*35 lbs = 35 lbs.
U3-U4	Is the paper weight most likely to be found on the three privacy panels and is an estimate of the amount of paper to be found on these pieces of furniture. One privacy panel was observed to have 0.15 lbs of paper attached to it which is ~ 15 sheets of standard paper. This information was obtained by casual load observations and calculations of privacy panel decorations, calendars and other items.
V3-V4	Overhead cabinet refers to the double door cabinet that attaches to the five foot high privacy panel. The estimated combustible weight provided.
W2-W4	Paper weight for the overhead cabinet obtained from NIST Appendix J
X3-X4	Combustible weight of the Calibre cabinet (not included by NIST at all)
Y3-Y4	Additional weight is the added combustible weight for this furniture item.
Z2-Z4	Credenza 3-drawer is another furniture item that NIST did not include but rather per appendix J, equated cabinet fronts, presumably to justify negation
AA2-AA4	Paper weight for the one horizontal file drawer, one slender drawer and another miscellaneous storage drawer. Again, this information was obtained by weighing the file contents of two different ENFP horizontal drawers and adding additional

	weight for note pads etc…
AB2-AB4	Lateral file two-drawers refer to the all metal personal lateral files found at each workstation.
AC2-AC4	This is the paper weight contained in the lateral files, capacity is 150 lbs per drawer but I used 100 lbs per drawer based on the file contents of the horizontal drawer survey mentioned previously.
AD3-AD4	Common files used a wood counter-top
AE2-AE4	Paper weight likely to be found on wood counter-tops
AF3-AF4	This is the standard desk, Morrison, as obtained the Gensler architectural drawings and AutoCAD symbol library. This is the combustible weight of the desk only and does not include the mounting or table legs.
AG3-AG4	Paper weight that is likely to be found on this desk, it is a conservative estimate, and the information was obtained from a casual load survey.
AH2-AH4	Supplementary worktable (square or one rounded edge), these are added to the Morrison desk set-up based upon the workstation design, as obtained from Gensler architectural drawings. This is the combustible weight of the desk only and does not include the mounting or table legs
AI3-AI4	Paper weight that is likely to be found on this desk, it is a conservative estimate, and the information was obtained from a casual load survey.
AJ3-AJ	Computer monitor at workstation. Not all workstations appear to have a computer and there is '?' for any location that I was unsure about.
AK2-AK4	Computer hard drive at workstation.
AL3-AL4	Additional – unable to id means that there was something at that workstation that unidentifiable from Gensler architectural drawings.
AM2-AM4	Some workstations have additional chairs attributed to them; that is all this column is referencing.
AN2-AN4	Lateral files: 3 drawer metal file cabinets that is part of the common files.
AO2-AO4	Lateral files: 4 drawer metal file cabinets that is part of the common files.
AP2-AP4	Common files used a wood counter-top
AQ2-AQ4	Paper weight likely to be found on wood counter-tops

AR2-AR4	Corresponding panels refer to the panels that line some parts of the file cabinet groups.
AS2-AS4	Comment on which workstation design repeats; designated by employee.
AT2-AT4	Total times it occurs refers to the number of times that workstation design can be found on the 96th floor.
AU2-AU4	Combustible weight for an individual workstation type
AV2-AV4	Combustible sum of workstation weight per type
AW2-AW4	Combustible weight of file cabinets that NIST left out from their experimental burns.
AX2-AX4	Noncombustible weight of file cabinets that NIST left out from their experimental burns, 3 drawer cabinet.
AY2-AY4	Noncombustible weight of file cabinets that NIST left out from their experimental burns, 4 drawer cabinet.
AZ2-AZ4	Noncombustible weight of open metal shelving units that NIST left out from their experimental burns, 6 metal shelves.
BA	Sum of the combustible weight of other rooms on the 96th floors.

A.8 Excel Sheets

(attached)

Comments on NIST NCSTAR 1 Draft

July 27, 2005

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General Comments

These comments pertain to the NIST summary chapter of the NCSTAR 1 Draft report, and are based on statements also from the June 2005 progress report. My comments will be annotated (Appendix A) to indicate their source and to provide additional information.

My comments address the fire analysis, the heating of the steel and issues pertaining to such. In summary, I list the issues and concerns that I have with the NIST presentation and findings:

1. I do not believe that NIST has presented a convincing argument for their collapse hypotheses for WTC 1 and 2. NIST had repeatedly stated that they would list all likely collapse scenarios in terms of their probabilities based on uncertainties in the analyses. That seems to have been abandoned in the final report. Their collapse hypothesis is based on damage done by the aircraft impacts, particularly in removing insulation from the core columns is key, together with brief local fire heating of above 1000 oC for about 15 minutes. NIST has not made a sufficient case for the removal of the steel insulation, and the fire analysis is based on a light fuel

load that is shown to be in error. I suggest an alternative hypothesis based on longer fire duration, and on the insulation staying primarily in place.

2. NIST claims that if the insulation had stayed in place, the computed fire was not able to cause building collapse. Therefore, they conclude that the insulation applied in design was adequate: "The WTC towers would likely not have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact." [p172] I have not seen sufficient evidence to indicate that the insulation was removed, nor that the insulation applied, had it remained in place, was adequate.

3. NIST was not able to document the WTC design process with respect to the selection of the steel insulation or its basis: "NIST was not able to find any evidence that there was a technical basis to relate SFRM thickness to a fire resistance rating, nor was there sufficient prior experience to establish such thickness requirements by analogy." [p 55] the lack of findings is a tragedy of this investigation as it goes to the core of fire protection design and its dependence on regulations. If we do not know how the process worked for these buildings, how do we know it is being done satisfactorily now.

4. The report represents more of a scientific analysis rather than an investigation to find all of the relevant facts. NIST held no hearings to ascertain testimony, used no subpoenas, and enlisted no investigative team to gather information. NIST was very late in acquiring witness accounts due to the federal government bureaucracy requirements on public surveys. Steel remnants were collected as they were available, and reports from the PA or others involved were taken as fact without corroboration. An example is the acceptance of insulation applied to the trusses in renovation to the north tower, WTC1, impact area as 2.5 inches compared to the

specification of 1.5 inches over the original 0.5 inches. This is an incredible difference, realizing that they reported up to 4 inches applied to a 1- inch diameter rod. ("The Port Authority provided NIST with the records of measurements of SFRM thickness on upgraded floors in both towers. The average thickness and standard deviation on the main trusses was 2.5 in. ± 0.6 in. NIST analysis of several Port Authority photographs from the 1990s of the upgraded 31 st floor of WTC 1 indicated an average thickness and standard deviation on the main trusses of 1.7 in. ± 0.4 in.") [p 70] Had more steel been examined from the fire floors, NIST may have been able to establish proof for its hypothesis that key core columns were denuded of insulation and therefore significantly heated to cause their reduction in strength. NIST found no evidence to corroborate that finding. "None of the recovered steel samples showed evidence of exposure to temperatures above 600 C for as long as 15 min. This was based on NIST annealing studies that established the set of time and temperature conditions necessary to alter the steel microstructure. These results provide some confirmation of the thermal modeling of the structures, since none of the samples were from zones where such heating was predicted." [p 176] Had NIST recovered steel from the areas where steel was predicted to have been heated, could have given them key evidence to support their claim. As the steel was expeditiously sold to Asia, before the fire floor steel could be identified from its markings and saved, was a significantly blunder in the investigation. Since NIST has jurisdiction over future investigations, a protocol for protecting evidence and securing the site must be established. Moreover, the rationale for the speedy elimination of the steel in this incident, NIST fails to document. Spoliation of fire scene evidence can border on a crime.

5. The NIST report is difficult to read due to its length and tedious style. It does not clearly show cause and effect. Standard analyses of fires attempt to give a time line. While the actual

timeline is clearly known in this case, the predicted timeline and its cause and effect listing is not presented. There are vague references that the predicted fire looked right. Dr. Sunder indicated that a timeline was not predicted, as difficulties exist with the nonlinear creep structural model. Only a mechanistic analysis was presented [NFPA meeting at NIST, July 12, 2005]. The report needs to clearly indicate the scientific reasons for the NIST description of the collapse scenarios and tie them to the results of their computations and assumptions. This needs to be done with footnoted annotations so a reader can find the details. This 10,000- page report will only serve as a smoke screen unless it is fully documented for easy reference.

6. NIST has never acknowledged of answered comments in the past, so it is doubtful that these comments will have any impact. I urge them to be more responsive. I am attaching my unanswered November 22, 2004 comments for background. (Appendix B)

Specific comments:

1. Collapse Hypothesis

Structural Failure

NIST contends that the collapse is due the floors pulling in the external columns that in turn lose stability [p 171,2]. This occurs on the south of WTC 1 and the east of WTC 2. They say WTC 2 collapses earlier because it received more damage from the aircraft.

I find an alternative hypothesis that can be supported by relatively simple computations on the heating of the steel trusses with their specified insulations in place [Quintiere et al, Fire Safety J. 2002, and Quintiere, Interflam 2004]. This analysis does not include the heating of the core columns, as they would never get hot enough to fail if their insulation remained intact. Table 1 summarizes the results, and shows computations for a fire of 800 °C, and indicates the time for the steel to reach 600 °C where it falls to 20 % of its original strength. The truss at this temperature would fail due to the deflection pulling in the external columns as indicated by Usmani [FSJ 2003], and by NIST [June 2004 Progress report, Vol 1, p 81, 120] by either this column buckling or by failure of the connections. Buckling can occur at steel temperatures as low as 400 °C while the seat failure occurs at 650 °C.

It is noted that the predicted times to reach the critical failure temperature of the truss steel of 55 -73 minutes for WTC 2 and 111 minutes for WTC 1 in Table 1 is consistent with the building collapse times of 56 and 102 minutes, respectively. These predicted heating times are also consistent with the NIST measured heating times (to 66 to 86 minutes, although the reduced scale 17 ft span tests compromised heat transfer) in the UL furnace tests at fire temperatures comparable to 800 °C shown in Table 2 taken from NIST. Indeed, the UL time to reach 1100 °F (593 °C) for the 35 ft span ranges from 66 to t6 minutes which is consistent with 73 minutes in Table 1 and an extrapolated time of 50 minutes for the UL temperature conditions. (See Figure 1.)

Table 1. Time for steel elements to reach 600 °C in an 800 °C fire (Interflam 2004).

Element	Insulation Thickness mm	Time to Reach 600 °C with insulation, min.	Time to Reach 600 °C with no insulation, min	E119 Rating Requirement min.
27.7 mm rod, 54 kg/m^2 WTC 2	12.7	55	8	120
N WTC 2	19.1	73	8	120
N WTC 1	38.1	111	8	120
14WF43, 43 kg/m^2 core	44.5	213	6	180
55.8 cm box column , 7.6 cm thick, 513 kg/m ^{2} core	28.6	1640	75	180

Table 2. UL test results form NIST

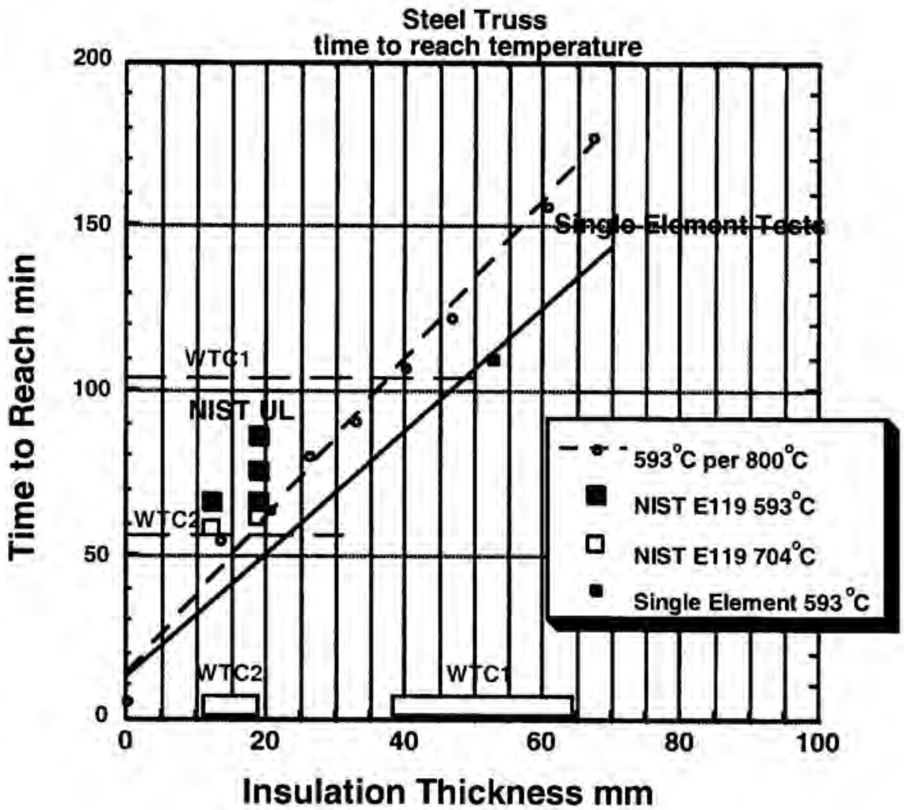

Figure 1. UL and Isolatek results.

Consequently, if the truss elements with specified insulation levels of ½- ¾ in. for WTC 2 and 1 ½ in. for WTC 1 can be heated to about 600 °C in an 800 °C fire at computed times of 55-73 minutes and 111 minutes, respectively, and NIST and others determined that the truss would cause either column buckling or connection failure at 600 °C or below, then this mode of collapse cannot be discounted. This is especially compelling since the collapse times are consistent at 56 and 102 minutes. Moreover, it is commonly known that floor sections were collapsing up to 20 minutes before the full collapse of each of the buildings. NIST has not addressed those early failures.

Fire Simulation

The results of the NIST fire predictions are based on a fuel loading of 4-5 psf. These levels are based on data from the impacted floors of Marsh & McLennan in WTC 1. NIST says this has "high" accuracy [p 119]. They find for WTC 1 that a given floor did not have uniform temperatures. "At any given location, the duration of temperatures near 1,000 °C was about 15 min to 20 min." [p 127] Upper layer temperatures are shown in Figure 2 for WTC 1 97th floor [NIST]. Temperatures generally exceeded 600°C for about 30 minutes, and for about 60 minutes in the core. In contrast, a scale model test conducted at the University of Maryland, representative of the 96th floor with a simulated fuel load of 11.5 psf, shown in Figure 3 indicates temperatures are generally over 6000C for 100 minutes, by are much cooler in the core. These results are distinctly different from the NIST simulation. One may be dubious of scale modeling, but it is a tried and true technique.

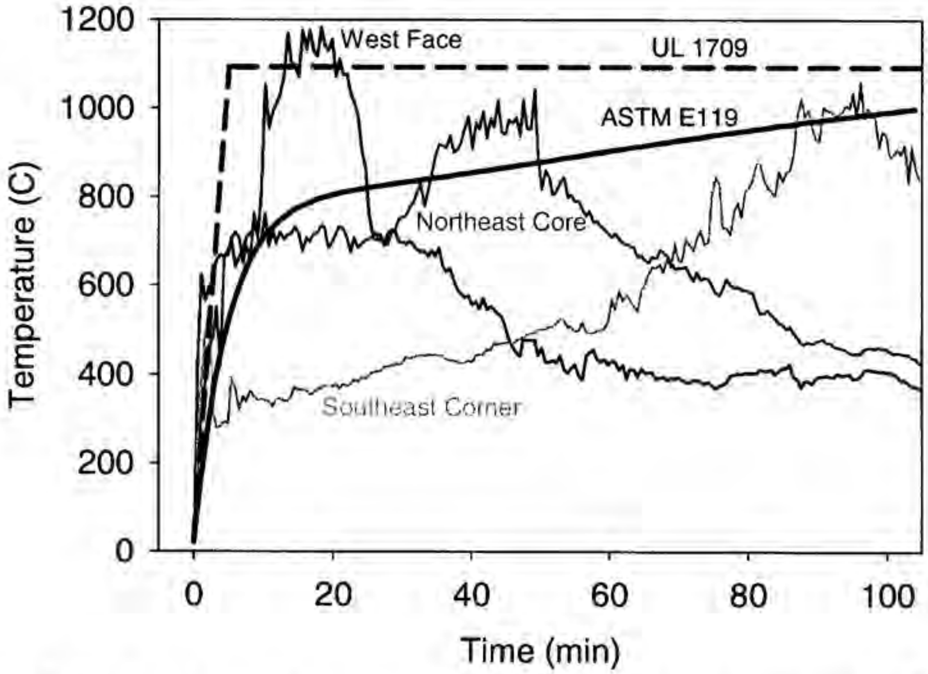

Figure 2. Predicted upper layer temperatures at various locations on the 97th Floor.

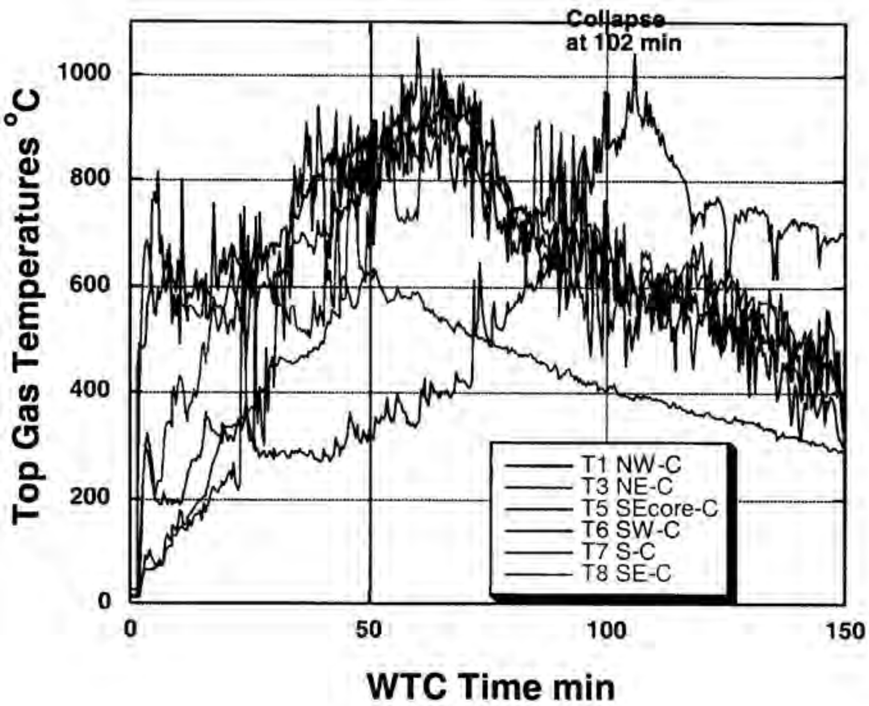

Figure 3. Temperatures in a scale model of WTC 1 96th floor

The heavier fuel load in the scale model was based on traditional office loadings and on anecdotal interviews of people familiar with the floors. Subsequently, we conducted a fuel load survey of the 96th floor based on architectural plans obtained from the furniture installer. This led to a conclusion that a loading of 10 psf or greater was the case. Appendix C contains the details in a report. Figure 4 shows a section of the architectural plans used for the 96th floor. A handwritten notation indicates a section of common files that ringed the core of the office space. There were 170 of these 4-drawer lateral files. NIST completely ignored this fuel load (and others) in their assessment. We assigned 100 lbs of paper per draw (a sub-capacity level) giving 68,000 lbs for this contribution. In addition, there were other common files and a storage room that gave a grand total of 95,400 lbs not included by NIST. In the survey conducted by Kate Stewart, estimates of paper and personal items were included in the workstation loads based on typical office conditions. Our total floor combustible loading was estimated at 302,062 lbs compared to 134,640 lbs determined by NIST. Taken over the office floor space area (31,013 ft^2), this computes to 9.7 psf and 4.3 psf for NIST. Our paper extimat per file draw is well below

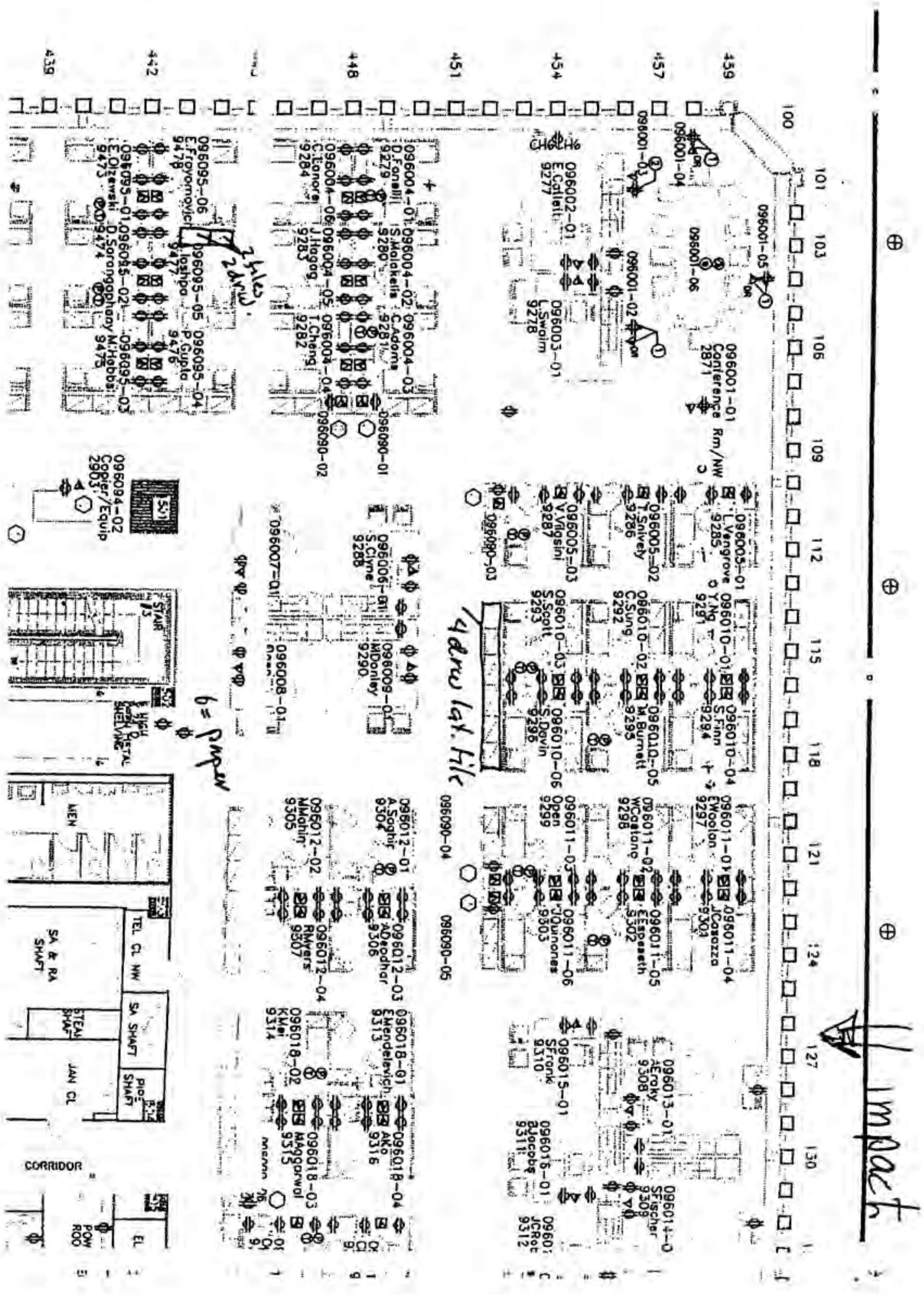

Figure 4. Section of furniture layout WTC 1 96th floor

capacity, so the loading we determine is likely too low. Indeed, it was told to us that Marsh was a "paper hog" and "kept everything". Paper fuel in closed files is de-rated in fire design considerations, but the aircraft impact could have opened the file draws.

It is generally expected that fully developed fires achieve nearly uniform temperature of over 800°C, and are expect to persist for hours. Hence, we have the standard rating of structures at 2 to 3 hours of endurance. Had NIST used higher fuel loadings, they would have had longer hot fire conditions and this would impact their input into the structural modeling. The discrepancy in the fuel load raises some questions. Moreover, the large differences in the fuel loading found by us and NIST on the Marsh floors raises more questions. Incidently, our independent check of the workstations exclusively counted by NIST gave us a combustible load of 133,694 lbs compared to their count of 134,640 lbs. In addition, while NIST claims high accuracy for the loading in WTC 1, they do not for WTC 2. Moreover, it appears that the fire simulation in WTC 2 is only about half the size of WTC 1. More needs to clarified here.

2. Insulation Lost on Impact

NIST has not presented clear and sufficient evidence that the aircraft impacts caused the elimination of insulation, especially from the core columns. According to NIST [Sunder, July 12, 2005 NFPA committee meeting], the planes disintegrated on impacting the exterior columns. This debris and its momentum is alleged to have removed the insulation. Heavy item, such as an engine or landing gear, could cause structural damage to a column in the core: "If the engine missed the floor slab, the majority of the engine core remained intact and had enough residual momentum to sever a core column upon direct impact. " [p 105] This suggest that hitting a floor slab, which is very likely due to the diameter of the engine, then less damage would be done. Moreover, the accuracy of the impact calculation is not high as other compute different damage results. Specifically on the insulation loss, NIST says it could be shook off due to vibrations, or eroded off due to pulverized debris impact. On the former NIST concludes: "The analyses were not sufficient to establish justifiable, general criteria for a coherent pattern of vibration-induced dislodging." [p 117] ON the erosion, NIST did static tests on the insulation adhesive strenth, but never coupled these results to a computational model. Instead, "NIST assumed that the debris impact dislodged insulation if the debris force was strong enough to break a gypsum board partition immediately in front of the structural component. Experiments at NIST confirmed that an array of 0.3 in. diameter pellets traveling at 350 mph stripped the insulation from steel bars like those used in the WTC trusses." [p 117] These pellet tests need more amplification, as they are the only test simulation of the erosion effect. Moreover, the test speed of 350 mph is not consistent with the average speed of debris traversing the buildings. The debris took about 0.7 s [sunder, July 12, 2005] to exit, giving an average speed of 205 ft/0.7s or 200 mph. As momentum depends on the square of the velocity, NIST has overestimated the momentum in these pellet tests by a factor of 3.

It is crucial to the NIST collapse hypothesis that the insulation is removed on impact. It begs more support.

3. WTC Fire Resistance Design

From the outset of its construction, fire safety was a concern for the WTC. From the records, clearly cost, time and safety were involved. For NIST not to have probed these facets, and to assess, in the least, the disparate range of insulation thickness assigned to the floor assembly truss system a dereliction of the intent of this investigation. NIST cites historical facts [p 69 +], but not the underlying rationale for decisions. Although an extensive civil suit on the insulation deficiencies occurred in the 1990's, NIST appears to have not examined those records.

How can on justify a specification of ½ in., a change to 1 ½ in. in the 90's, an ICBØ recommendation of 2 in. [p 192], and an actual upgrade to 2.5 +/- 0.6 in. on the impact floors of the WTC 1? The extensive over-application up to 3 in. on a round 1 in. diameter bar-joist is difficult to accept based solely on a report from the PA when photographic evidence for other upgraded floors shows only 1.7 +/- 0.4 in. according to NIST [p 71].

Whether this insulation on the truss was key as I believe, or not, is not the issue here. The process of fire resistance regulations and their interpretation is the issue. This needs to be scrutinized. It should have been at the heart of the investigation, and that is why NIST has proceeded as a scientific body rather than an investigative agent. Civil lawyers would have pushed this, whereas the Commerce lawyers seemed more concerned to restrict the scientists, and block information from the public.

4. Lack of In Depth Investigation

The NIST report reads like a scientific enterprise using computer simulations that have never been used (or validated) in this way before. [119] Other government agencies that have investigative authority operate differently. The NTSB has time scene presence, press briefings, and formal hearings with testimony. The ATF has a National Response Team that is on the scene within hours of the event. They secure the scene, question witnesses, and gather evidence. NIST has operated in near secrecy, has had a low public profile, and has gathered facts as in a library search. Although they have held public forums, these have been very controlled, under publicized, and dominated by NIST. They have not appeared to aggressively, or with corroboration in mind, pursued evidence. The Commerce lawyers could have helped here. With the amount of funding that they received they could have conducted a full-scale test of a floor. They could have given more support to their purely mathematically modeling results. As scientists are sometime stereotyped as being out of touch with reality, NIST cannot afford that stigma as an investigative body as NCSTAR.

5. On the Recommendations

Thirty recommendations are listed. They all are general and imply more research is needed. One cannot fault NIST fro trying to expand its research base, as they have not been properly funded in the fire and building areas since the 1970's. The fire funding with NSF and industry support ran as high as $ 10 million in the mid- 70's. Its comparable level in today's dollars is much lower. But the funding issues should not cloud the work of the NCSTAR. Yet the NCSTAR is only authorized to proceed and funding for its continuation is doubtful. So perhaps funding is the real issue.

The recommendation areas cover:

1. Increased structural integrity, including methods for preventing conditions that could result in progressive collapse (when a building or a significant portion of a building collapses due to disproportionate spread of an initial local failure), standardizing the estimation of wind loads that frequently govern the design of tall buildings, and enhancing the stability of tall buildings.
2. Enhanced fire resistance of structures, including the technical basis for determining construction classification and fire resistance ratings, improvements to the technical basis for standard fire resistance testing methods, adoption of the "structural frame" approach to fire resistance ratings, and in-service performance requirements and conformance assessment criteria for spray-applied fire resistive materials.
3. New methods for designing structures to resist fires, including the objective of burnout without collapse, the development of performance-based methods as an alternative to current prescriptive design methods, the development and evaluation of new fire resistive coating materials and technologies, evaluation of the fire performance of conventional and high performance structural materials, and elimination of technical and standards barriers to the introduction of new materials and technologies.
4. Improved active fire protection, including the design, performance, reliability, and redundancy of sprinklers, standpipes/hoses, fire alarms, and smoke management systems.
5. Improved building evacuation, including system designs that facilitate safe and rapid egress, methods for ensuring clear and timely emergency communications to occupants, better occupant preparedness for evacuation during emergencies, and incorporation of appropriate egress technologies.
6. Improved emergency response, including better access to the buildings and better operations, emergency communications, and command and control in large-scale emergencies.
7. Improved procedures and practices, including encouraging code compliance by nongovernmental and quasi-governmental entities, adoption and application of egress requirements in available code provisions for existing buildings, and retention and availability of building documents over the life of a building.

8. Education and training programs for fire protection engineers, structural engineers, and architects.

I generally support NIST in all of these areas, as they are important areas to pursue for research. Recommendation that can lead to immediate code changes need to go more slowly, as they require consensus and checks and balances. NIST as part of its name suggests can play an important role in "Standards" for fire safety, but they must be enabled to do that successfully. The fire and building programs at NIST have atrophied, and must be brought back to full competence. These and other programs at NIST must rely on outside funding to support their staffs. That effort, in particular, takes away form the fire program, as industry does not wish to fund safety regulations. For other programs in NIST where standards benefit industry and grease the market place, those programs find fertile support in industry. Fire safety is different, and the congress needs to appreciate that, and direct its funding accordingly.

I would like to offer some more specific comments to the NIST recommendations # 29 and 30 that pertain to education. They advocate "continuing education curricula" for structural and fire engineers and architects on modern principles and on the use of computational methods. While this is good, it is not enough; and it could produce people who think they have expertise, but do not. The education in fire protection engineering is sorely lacking in the US. Only about 50 engineers are produced a year at institutions granting a recognized engineering degree (U of MD, WPI) and technology degrees (OSU, U of Akron, etc.). The US likely needs 500 engineers a year. While a careful study of the need has not been done, the training received in continuing education courses currently indicates the lack of fire protection engineer in the field of fire investigation and in the protection of nuclear plants as stark examples. In addition, the population that makes up the regulators and participate in the code and standards making process generally lack degrees. The estimate I cite comes from the fact the University of Lund program in Sweden place all of their graduates at a rate of 2 in million of population per year in the private sector and 2 more in the fire service profession. This gives a benchmark of 2 to 4 per million of population. If the fire service in the US began to hire fire protection engineers, the estimate for the US would be 1000 per year.

The Congress needs to bring the education level of fire protection engineering up to a level that fill the infrastructure needs for the country. This can be fulfilled with NSF providing funds to this field. The Congress needs to further recognize that NIST is under funded in these areas, and the country needs a better way of getting the proper technical input into the regulatory process for fire safety. It cannot be dependent on voluntary efforts and special interest actions. After the tragedy of 9/11, a better process of fire safety needs to be created. Unfortunately, the NIST NCSTAR draft report does not dramatically demonstrate the deficiencies in the fire process for the design and collapse of the WTC buildings.

Appendix A: NIST NCSTAR 1 Draft Source Material

Collapse Cause

Why the collapse, p171,2

Objective 1: Determine why and how WTC 1 and WTC 2 collapsed following the initial impacts of the aircraft. • The two aircraft hit the towers at high speed and did considerable damage to principal structural components: core columns, perimeter columns, and floors. However, the towers withstood the impacts and would have remained standing were it not for the dislodged insulation and the subsequent multifloor fires. The robustness of the perimeter frame-tube system and the large size of the buildings helped the towers withstand the impact. The structural system redistributed loads without collapsing in places of aircraft impact, avoiding larger scale damage upon impact. The hat truss, which was intended to support a television antenna atop each tower, prevented earlier collapse of the building core. In each tower, a different combination of impact damage and heat-weakened structural components contributed to the abrupt structural collapse. • In WTC 1, the fires weakened the core columns and caused the floors on the south side of the building to sag. The floors pulled the heated south perimeter columns inward, reducing their capacity to support the building above. Their neighboring columns quickly became overloaded as the south wall buckled. The top section of the building tilted to the south and began its descent. The time from aircraft impact to collapse initiation was largely determined by how long it took for the fires to weaken the building core and to reach the south side of the building and weaken the perimeter columns and floors. • In WTC 2, the core was damaged severely at the southeast corner and was restrained by the east and south walls via the hat truss and the floors. The steady burning fires on the east side of the building caused the floors there to sag. The floors pulled the heated east perimeter columns inward, reducing their capacity to support the building above. Their neighboring columns quickly became overloaded as the east wall buckled. The top section of the building tilted to the east and to the south and began its descent. The time from aircraft impact to collapse initiation was largely determined by the time for the fires to weaken the perimeter columns and floor assemblies on the east and south sides of the building. WTC 2 collapsed more quickly than WTC 1 because there was more aircraft damage to the building core and there were early and persistent fires on the east side of the building, where the aircraft had extensively dislodged insulation from the structural steel. • The WTC towers would likely not have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact.

On WTC 1: p xliii-xliv

The two aircraft hit the towers at high speed and did considerable damage to principal structural components: core columns, floors, and perimeter columns. However, the towers withstood the impacts and would have remained standing were it not for the dislodged insulation (fireproofing) and the subsequent multifloor fires.

The time from aircraft impact to collapse initiation was largely determined by how long it took for the fires to weaken the building core and to reach the south side of the building and weaken the perimeter columns and floors.

On WTC 2

n WTC 2, the core was damaged severely at the southeast corner and was restrained by the east and south walls via the hat truss and the floors. The steady burning fires on the east side of the building caused the floors there to sag. The floors pulled the heated east perimeter columns inward, reducing their capacity to support the building above. Their neighboring columns quickly became overloaded as columns on the east wall buckled. The top section of the building tilted to the east and to the south and began its descent. The time from aircraft impact to collapse initiation was largely determined by the time for the fires to weaken the perimeter columns and floor assemblies on the east and the south sides of the building. WTC 2 collapsed more quickly than WTC 1 because there was more aircraft damage to the building core and there were early and persistent fires on the east side of the building, where the aircraft had extensively dislodged insulation from the structural steel.

Also an analysis of the stability of the towers, assuming no damage to the core, gives the number of floors that need to be removed to cause global failure (June 2004, Vol. 1, p.81):

The following presents some preliminary findings obtained from the preliminary stability analyses under service live loads and subject to the assumptions and the limitations of these models (see Appendix D): Linear stability analysis was used to examine the stability of the undamaged WTC 1 under service loads through increased un-braced column lengths (floor removal). The tower was stable when two floors were removed. Two core columns buckled when three floors were removed, but the tower maintained its overall stability. The tower also maintained its stability when four columns buckled with four floors removed. The analysis suggested that global instability of the tower occurred when five floors were removed from the model. Assuming that all columns at the region of the removed floors reached a temperature of 600 °C (reduced modulus of elasticity), the analysis indicates that removal of four floors would induce global instability.

1. Single truss analysis: A model of a single truss and its connection shows that the truss fails at the interior column seat connection, and 'walks off' the seat. This occurs at 650 C. The web diagonals begin to buckle at 340 C, and the exterior columns bow inward at 560 C causing the truss to act as a catenary. (June 2004, Vol. 1 p. 120).

On steel inspected p 88,89

Examination of photographs showed that 16 of the exterior panels recovered from WTC 1 were exposed to fire prior to the building collapse. None of the nine recovered panels from within the fire floors of WTC 2 were directly exposed to fire. NIST used two methods to estimate the maximum temperatures that the steel members had reached: • Observations of paint cracking due to thermal expansion. Of the more than 170 areas examined on 16 perimeter column panels, only three columns had evidence that the steel reached temperatures above 250 °C: east face, floor 98, inner web; east face, floor 92, inner web; and north face, floor 98, floor truss connector. Only two core column specimens had sufficient paint remaining to make such an analysis, and their temperatures did not reach 250 °C. NIST did not generalize these results, since the examined columns represented only 3 percent of the perimeter columns and 1 percent of the core columns from the fire floors. • Observations of the microstructure of the steel. High temperature excursions, such as due to a fire, can alter the basic structure of the steel and its mechanical properties. Using metallographic analysis, NIST determined that there was no evidence that any of the samples had reached temperatures above 600 oC. These results were for a very small fraction of the steel in the impact and fire zones. Nonetheless, these analyses indicated some zones within WTC 1 where the computer simulations should not, and did not, predict highly elevated steel temperatures. 6.5

On the steel p 176

None of the recovered steel samples showed evidence of exposure to temperatures above 600 oC for as long as 15 min. This was based on NIST annealing studies that established the set of time and temperature conditions necessary to alter the steel microstructure. These results provide some confirmation of the thermal modeling of the structures, since none of the samples were from zones where such heating was predicted.

On single truss analysis p 96

Single composite truss and concrete slab section. A floor section was modeled to investigate failure modes and sequences of failures under combined gravity and thermal loads. The floor section was heated to 700 °C (300 °C at the top surface of the slab) over a period of 30 min. Initially the thermal expansion of the floor pushed the columns outward, but with increased temperatures, the floor sagged and the columns were pulled inward. Knuckle failure was found to occur mainly at the ends of the trusses and had little effect on the deflection of the floor system. Figure 6–11 shows that the diagonals at the core (right) end of the truss buckled and caused an increase in the floor system deflection, ultimately reaching approximately 42 in. Two possible failure modes were identified for the floor-truss section: sagging of the floor and loss of truss seat support.

Impact Damage

On damage to WTC1 pp20- 21

The 94 th floor was more severely damaged. The midsection of the left wing, laden with jet fuel, and the left engine cut through the building façade, severing 17 of the perimeter columns and heavily damaging four more. The pieces of the aircraft continued inward, severing and heavily damaging core columns . The insulation applied to the floor trusses above and the columns was scraped off by shrapnel-like aircraft debris and building wall fragments over a wedge almost 100 ft wide at the north face of the tower and 50 ft wide at the south end of the building core.

A 40 ft width of the 96 floor slab was broken 80 ft into the building. The insulation was knocked off nearly all the core columns and over a 40 ft width of floor trusses from the south end of the core to the south face of the tower.

On WTC1 p34

Dislodging of SFRM from structural members due to the aircraft impact, that enabled rapid heating of the unprotected structural steel;

On WTC2 78 flr p 40

Dislodging of SFRM from structural members due to the aircraft impact, that enabled rapid heating of the unprotected structural steel;

On WTC2 81 flr p 41
On the 81 st floor, the fuselage pulverized a section of the floor 40 ft wide that extended into the southeast corner of the core. The SFRM and gypsum fire protection on the full depth of the east side of the core and in the entire east side of the tenant space was stripped.

On impact p 105

The Investigation Team gained valuable knowledge from these component impact analyses, for example: • Moving at 500 mph, an engine broke any exterior column it hit. If the engine missed the floor slab, the majority of the engine core remained intact and had enough residual momentum to sever a core column upon direct impact. • The impact of the inner half of an empty wing significantly damaged exterior columns but did not result in their complete failure. Impact of the same wing section, but filled with fuel, did result in failure of the exterior columns.

On the accuracy of the impact model p 114

Two pieces of landing gear penetrated WTC 1 and landed to the south of the tower. The Case B prediction showed landing gear penetrating the building core, but stopping before reaching the south exterior wall. For WTC 2, a landing gear fragment and the starboard engine penetrated the building and landed to the south. The Case D prediction correctly showed the main landing gear emerging from the northeast corner of WTC 2. However, Case D showed that engine not quite penetrating the building. Minor modifications to the model (all within the uncertainty of the input data) would have resulted in the engine passing through the north exterior wall of the tower.

On damage to insulation, p 117

An intact ceiling tile system could have provided the floor trusses with approximately 10 min to 15 min of thermal 6.9.3 Damage to Thermal Insulation The dislodgement of thermal insulation from structural members could have occurred as a result of direct impact by debris and could have occurred by inertial forces due to vibration of structural members as a result of the aircraft impact. In interpreting the output of the aircraft impact simulations, NIST assumed that the debris impact dislodged insulation if the debris force was strong enough to break a gypsum board partition immediately in front of the structural component. Experiments at NIST confirmed that an array of 0.3 in. diameter pellets traveling at 350 mph stripped the insulation from steel bars like those used in the WTC trusses. Determining the adherence of SFRM outside the debris zones was more difficult. There was photographic evidence that some fraction of the SFRM was dislodged from perimeter columns not directly impacted by debris. NIST developed a simple model to estimate the range of accelerations that might dislodge the SFRM from the structural steel components. As the SFRM in the towers was being upgraded with BLAZESHIELD II (CAFCO II) in the 1990s, The Port Authority had measured the force required to pull the insulation from the steel. The model used these data as input to some basic physics equations. The resulting ranges of accelerations depended on the geometry of the coated steel component and the SFRM thickness, density and bond strength. For a flat surface (as on the surface of a column), the range was from 20g to 530g, where g is the gravitational acceleration. For an encased bar (such as used in the WTC trusses), the range was from 40g to 730g. NIST estimated accelerations from the aircraft impacts of approximately 100g. The analyses were not sufficient to establish justifiable, general criteria for a coherent pattern of vibration-induced dislodging. Thus, NIST made the conservative assumption that all other insulation remained adhered to the structural components.

Fire Modeling

Active Fire Protection: Active fire protection systems (i.e., sprinklers, standpipes/ hoses, fire alarms, and smoke management systems) should be enhanced through improvements to design, performance, reliability, and redundancy of such systems.

On Fireballs WTC1 p 24

Less than 15 percent of the jet fuel burned in the spray cloud inside the building. A roughly comparable amount was consumed in the fireballs outside the building. Thus, well over half of the jet fuel remained in the building, unburned in the initial fires.

On loading p 76

NIST estimated the fuel loading on these floors to have been about 4 lb/ft 2 (20 kg/m2), or about 60 tons per floor. This was somewhat lower than found in prior surveys of office spaces. The small number of interior walls, and thus the minimal amount of combustible interior finish, and the limited bookshelf space account for much of the differences.

On WTC fire in 1975 p 89

INFORMATION GAINED FROM OTHER WTC FIRES There had been numerous fires in the towers prior to September 11, 2001. From these, the Investigation Team learned what size fire WTC 1 and WTC 2 had withstood and how the tower occupants and the responders functioned in emergencies. While The Port Authority's records of prior fires were lost in the collapses, FDNY provided reports on 342 fires that had occurred between 1970 and 2001. Most of these fires were small, and occupants extinguished many of them before FDNY arrival. Fortyseven of these fires activated one to three sprinklers and/or required a standpipe hose for suppression. Only two of the fires required the evacuation of hundreds of people. There were no injuries or loss of life in any of these fires, and the interruptions to operations within the towers were local. A major fire occurred in WTC 1 on February 13, 1975, before the installation of the sprinkler system. A furniture fire started in an executive office in the north end of an 11 th floor office suite in the southeast corner of the building. The fire spread south and west along corridors and entered a file room. The fire flashed over, broke seven windows, and spread to adjacent offices north and south. The air conditioning system turned on, pulling air into the return air ducts. Telephone cables in the vertical shafts were ignited, destroying the fire-retarded wood paneling on the closet doors. The fire emerged on the 12 th and 13 th floors, but there was little nearby that was combustible. The fire also extended vertically from the 9th to the 19 th floors within the telephone closet. Eventually the fire was confined to 9,000 ft2 of one floor, about one-fourth of the total floor area. The trusses and columns in this area had been sprayed with CAFCO D insulation to a specified 1/2 in. thickness. Four trusses were slightly distorted, but the structure was not threatened.

On modeling floor fires, p 119

6.10.2 Modeling Approach The time frame of the Investigation and the above requirements led to the use of the Fire Dynamics Simulator (FDS). Under development at NIST since 1978, FDS was first publicly released in February 2000 and had been used worldwide on a wide variety of applications, ranging from sprinkler activation to residential and industrial fire reconstructions. However, it had never before been applied to spreading fires in a building with such large floor areas. Figure 6–30 shows how FDS represented the eight modeled floors (92 through 99) of the undamaged WTC 1. A similar rendition was prepared for floors 78 through 83 of WTC 2. The layout of each floor was developed from architectural drawings and from the information described in Section 5.8. There was a wide range of confidence in the accuracy of these floor plans, varying from high (for the floors occupied by Marsh & McLennan in WTC 1, for which recent and detailed plans were obtained) to low (for most of the space in WTC 2 occupied by Fuji Bank, for which floor plans were not available).

On the fuel load effect p 124

6.10.3 The Four Cases Four fire scenarios (Case A and Case B for WTC 1 and Case C and Case D for WTC 2) were superimposed on the four cases of aircraft-driven damage of the same names (Section 6.9). A number of preliminary simulations had been performed to gain insight into the factors having the most influence on the severity of the fires. The most influential was the mass of combustibles per unit of floor area (fuel load); second was the extent of core wall damage, which affected the air supply for the fires. The aforementioned workstation fire tests had also indicated that the damage condition of the furnishings also played a key role. The scenario variables and their values are shown in Table 6–6. Table 6–6. Values of WTC fire simulation variables. WTC 1 WTC 2 Variable Case A Case B Case C Case D Tenant fuel load a 20 kg/m2 (4 lb/ft2) 25 kg/m2 (5 lb/ft2) 20 kg/m2 (4 lb/ft2) 20 kg/m2 (5 lb/ft2) Distribution of disturbed combustibles Even Weighted toward the core Heavily concentrated in the northeast corner Moderately concentrated in the northeast corner Condition of combustibles Undamaged except in impact zone Displaced furniture rubblized All rubblized Undamaged except in impact zone Representation of impacted core walls b Fully removed Soffit remained Fully removed Soffit remained a. In addition, approximately 12,000 kg (27,000 lb) of solid combustibles from the aircraft were distributed along the debris path. b. In Cases A and C, the walls impacted by the debris field were fully removed. This enabled rapid venting of the upper layer into the core shafts and reduced the burning rate of combustibles in the tenant spaces. In Cases B and D, a more severe representation of the damage was to leave a 1.2 m soffit that would maintain a hot upper layer on each fire floor. This produced a fire of longer duration near the core columns and the attached floor membranes. FDS contained no algorithm for breaking windows from the heat of the fires. Thus, during each simulation, windows were removed at times when photographs indicated they were first missing. Damage to the ventilation shafts was derived from the aircraft impact simulations. For undamaged floors, all the openings to the core area were assumed to total 5 m 2 in area. 6.10.4 Characterization of the Fires

On the accuracy of spread p 126

The fire simulation results for Case A and Case B were similar, indicating only a modest sensitivity to the fuel load and the degree of aircraft-generated damage. This was because, in general, the size and movement of the fires in WTC 1 were limited by the supply of air from the exterior windows. Since the window breakage pattern was not changed in Case B, the additional and re-distributed combustibles within the building did not contribute to a larger fire. The added fuel did slow the spread slightly because the fires were sustained longer in any given location. Although there was generally reasonable agreement between the simulated and observed fire spread rates, there were instances where the fires burned too quickly and too near the windows. This resulted from an artifact of the model: the combustible vapors burned immediately upon mixing with the incoming oxygen. Simulations performed with doubled fuel loads slowed the fire spread well below the observed rates. Combined with the above results, this suggested that the estimated overall combustible load of 4 lb/ft 2 was reasonable.

On the predicted fires in WTC1, p 127

The predictions of maximum temperatures (e.g., red zones in Figure 6–37) were consistent with those in the three-workstation fire tests. The use of an "average" gas temperature was not a satisfactory means of assessing the thermal environment on floors this large and would also have led to large errors in the subsequent thermal and structural analyses. The heat transferred to the structural components was largely by means of thermal radiation, whose intensity is proportional to the fourth power of the gas temperature. At any given location, the duration of temperatures near 1,000 °C was about 15 min to 20 min. The rest of the time, the calculated temperatures were near 500 °C or below. To put this in perspective, the radiative intensity onto a truss surrounded by smoke-laden gases at 1,000 °C was approximately 7 times the value for gases at 500 °C.

On the modeling of WTC2, p 127

WTC 2 Simulating the fires in WTC 2 posed challenges in addition to those encountered in simulating the fires in WTC 1. The aircraft, hitting the tower to the east of center, splintered much of the furnishings on the east side of the building and plowed them toward the northeast corner. Neither the impact study nor the validation experiments performed at NIST could be completely relied upon to predict the final distribution, condition, and burning behavior of the demolished furnishings. In addition, only the layouts of the 78th and 80th floors were available to the Investigation; the other floors were only roughly described by former occupants. As a result of these unknowns, the uncertainty in these calculations was distinctly greater than in those for WTC 1. To help mitigate gross differences between the simulations and the observables, NIST made floor-specific adjustments, based on the results of preliminary computations. In particular, the fuel load and volatility on the 80 th floor were reduced, and the fuel load on the 81st and 82 nd floors was increased. In contrast with WTC 1, in WTC 2 there was less movement of the fires. The major burning occurred along the east side, with some spread to the north. There was no significant burning on the west side of the tower. Also unlike WTC 1, changing the combustible load in WTC 2 had a noticeable effect on the outcome of the simulations. Because so many windows on the impact floors in WTC 2 were broken out by the aircraft debris and the ensuing fireballs, there was an adequate supply of air for the fires. Thus, the burning rate of the fires was determined by the fuel supply. In the Case D simulation, the office furnishings and aircraft debris were spread out over a wider area, and the furnishings away from the impact area were undamaged. Both of these factors enabled a higher burning rate for the combustibles.

ON the heating of the structure by the FDS fire, p 139

Tables 6–8 and 6–9 summarize the regions of the floors in which the structural steel reached temperatures at which their yield strengths would have been significantly diminished. Instances of brief heating of one or two columns early in the fires were not included. Even in the vicinity of the fires, the columns and trusses for which the insulation was intact did not heat to temperatures where significant loss of strength occurred. Unlike the simulations of the aircraft impact and the fires, there was no evidence, photographic or other, for direct comparison with the FSI results. Table 6–8. Regions in WTC 1 in which temperatures of structural steel exceeded 600 °C. Trusses Perimeter Columns Core Columns Floor Number Case A Case B Case A Case B Case A Case B 93 – – – – – – 94 – – – – N, S NE, S 95 N N, S – – S NW, S 96 N N, S – S S W, S 97 N, S N, S – S N W, S 98 N N, S – – – – 99 – – – – – – Key: N, north; S, south; W, west; NE, northeast; NW, northwest. Table 6–9. Regions in WTC 2 in which temperatures of structural steel exceeded 600 °C. Trusses Perimeter Columns Core Columns Floor Number Case C Case D Case C Case D Case C Case D 79 – – – – – – 80 – – – – – – 81 NE NE NE NE – NE 82 E E E E E E 83 E E – E – E

On the fire duration predicted, p 144

Both the results of the multiple workstation experiments and the simulations of the WTC fires showed that the combustibles in a given location, if undisturbed by the aircraft impact, would have been almost fully burned out in about 20 min.

Insulation Saga

On insulation: p xlvi

NIST found no technical basis or test data on which the thermal protection of the steel was based. On September 11, 2001, the minimum specified thickness of the insulation was adequate to delay heating of the trusses; the amount of insulation dislodged by the aircraft impact, however, was sufficient to cause the structural steel to be heated to critical levels. • Based on four standard fire resistance tests that were conducted under a range of insulation and test conditions, NIST found the fire rating of the floor system to vary between 3/4 hour and 2 hours; in all cases, the floors continued to support the full design load without collapse for over 2 hours.

P55 on insulation

NIST was not able to find any evidence that there was a technical basis to relate SFRM thickness to a fire resistance rating, nor was there sufficient prior experience to establish such thickness requirements by analogy.

On insulation p 69

Floor Systems At the time the WTC was designed, the ASTM E 119 test method had been used for nearly 50 years to determine the fire resistance of structural members and assemblies. However, The Port Authority confirmed to the Investigation Team that there was no record of fire endurance testing of the innovative assemblies representing the thermally protected floor system used in the towers. The floor assembly was not tested despite the fact that the Architect of Record and the Structural Engineer of Record stated that the fire rating of this novel floor system could not be determined without testing. Prior to construction, the Architect of Record had used information from (unidentified) manufacturers to recommend a 1 in. thickness of SFRM around the top and bottom chords of the trusses and a 2 in. thickness for the web members of the trusses. This was to achieve the fire endurance requirements for Class 1A construction (Section 5.3.3). In 1969, The Port Authority directed that a 1/2 in. thick coating of CAFCO BLAZE-SHIELD Type D (CAFCO D), a mixture of cement and asbestos fibers, be used to insulate the floor trusses. This was to achieve a Class 1A rating, even though the preponderance of evidence suggests that the towers were chosen to be Class 1B, the minimum required by the NYC Building Code. NIST found no evidence of a technical basis for selection of the 1/2 in. thickness. This coating had been installed as high as the 38 th floor of WTC 1 when its use was discontinued due to recognition of adverse health effects from inhalation of asbestos fibers. The spraying then proceeded with CAFCO DC/F, a similar product in which the asbestos was replaced by a glassy mineral fiber and whose insulating value was reported by Underwriters Laboratories, Inc., to be slightly better than that of CAFCO D. On the lower floors, the CAFCO D was encapsulated with a sprayed material that provided a hard coat to mitigate the dispersion of asbestos fibers into the air. In 1994, The Port Authority measured the SFRM thickness on trusses on floors 23 and 24 of WTC 1. In all, average thicknesses were reported for 32 locations, and the overall average thickness was found to be 0.74 in. NIST performed a further evaluation of the SFRM thickness using photographs taken in the 1990s of floor trusses on (non-upgraded) floors 22, 23, and 27 of WTC 1 (Figure 5–5). By measuring dimensions on the photographs, NIST estimated the insulation thicknesses on the diagonal web members of trusses. (The thickness of chord member insulation could not be measured.) The average thickness and standard deviation of web members was 0.6 in. ± 0.3 in. on the main trusses, 0.4 in. ± 0.25 in. on the bridging trusses, and 0.4 in. ± 0.2 in. on the diagonal struts. These numbers indicated that there were areas where the coating thickness was less than the specified 0.5 in.

P 70

Chapter 5 Draft for Public Comment 70 NIST NCSTAR 1, WTC Investigation Note: Enhancement by NIST. Figure 5–5. Irregularity of coating thickness and gaps in coverage on SFRM–coated bridging trusses. In 1995, The Port Authority performed a study to establish requirements for retrofit of sprayed insulation to the floor trusses during major alterations when tenants vacated spaces in the towers. Based on design information for fire ratings of a similar, but not identical, composite floor truss system contained in the Fire Resistance Directory published by Underwriters Laboratories, Inc., the study concluded that a 1 1⁄2 in. thickness of sprayed mineral fiber material would provide a 2 hour fire rating, consistent with the Class 1B requirements. In 1999, the removal of existing SFRM and the application of new material to this thickness became Port Authority policy for full floors undergoing new construction and renovation. For tenant spaces in which only part of a floor was being modified, the SFRM needed only to be patched to 3⁄4 in. thickness or to match the 1 1⁄2 in. thickness, if it had previously been upgraded. In the years between 1995 and 2001, thermal protection was upgraded on 18 floors of WTC 1, including those on which the major fires occurred on September 11, 2001, and 13 floors of WTC 2 that did not include the fire floors. The Port Authority reported that the insulation used in the renovations was CAFCO BLAZE-SHIELD II. In July 2000, an engineering consultant to The Port Authority issued a report on the requirements of the fire resistance of the floor system of the towers. Based on calculations and risk assessment, the consultant concluded that the structural design had sufficient inherent fire performance to ensure that the fire condition was never the critical condition with respect to loading allowances. The report recommended that a 1.3 in. thickness be used for the floor trusses. In December 2000, another condition assessment concluded that the structural insulation in the towers had an adequate 1 hour rating, considering that all floors were now fitted with sprinklers. The report also noted the ongoing Port Authority program to upgrade the fire resistive material thickness to 1 1/2 in. in order to achieve a 2 hour fire rating. The Port Authority provided NIST with the records of measurements of SFRM thickness on upgraded floors in both towers. The average thickness and standard deviation on the main trusses was 2.5 in. ± 0.6 in. NIST analysis of several Port Authority photographs from the 1990s of the upgraded 31 st floor of WTC 1 indicated an average thickness and standard deviation on the main trusses of 1.7 in. ± 0.4 in. NIST found no statistically significant difference in the average thickness of the upgraded insulation in the two towers.

Perimeter Columns In 1966, the contractor responsible for insulating the perimeter columns proposed applying a 1 3/16 in. thick coating of CAFCO D to the three external faces (Figure 5-6) to achieve a 4 hour rating, which is a Class 1A rating requirement (1 hour more than Class 1B). NIST found evidence of a technical basis for this decision. In the construction drawings prepared by the exterior cladding contractor, the following SFRM thicknesses were specified: • 7/8 in. of vermiculite plaster on the interior face and 1 3/16 in. of CAFCO D on the other three faces. • 1/2 in. of vermiculite plaster on the interior surfaces of the spandrels and 1/2 in. of CAFCO D on the exterior surfaces. Figure 5-6. Thermal insulation for perimeter columns. Vermiculite plaster had a higher thermal conductivity and thereby increased heat migration from the room air to the column steel and, thus, could keep the steel temperature at 70 °F when the temperature was 0 °F outside. In October 1969, The Port Authority provided the following instructions to the contractor applying the sprayed fire protection, in order to maintain the Class 1-A Fire Rating of the NYC Building Code: • 2 3/16 in. of CAFCO D for columns smaller than 14WF228 11 and 1 3/16 in. for columns equal to or greater than 14WF228. • 1/2 in. covering of CAFCO D for beams, spandrels and bar joists. NIST's review of available documents has not uncovered the reasons for selecting CAFCO fire resistive material or the technical basis for specifying 1/2 in. thickness of SFRM for the floor trusses. As with the trusses, CAFCO DC/F was applied to the perimeter columns above the 38 th floor of WTC 1 and all the perimeter columns in WTC 2. Core Columns and Beams Multiple approaches were used to insulate structural elements in the core: • Those core columns located in rentable and public spaces, closets, and mechanical shafts were enclosed in boxes of gypsum wallboard (and thus were inaccessible for inspection). The amount of the gypsum enclosure in contact with the column varied depending on the location of the column within the core. SFRM (CAFCO D and DC/F) was applied on those faces that were not protected by the gypsum enclosure. The thicknesses specified in the construction documents were 1 3/16 in. for the heavier columns and 2 3/16 in. for the lighter columns. • Columns located at the elevator shafts were protected using the same SFRM thicknesses. They were not enclosed and thus were accessible for routine inspections. Inspection of the columns within the elevator shaft spaces in 1993 indicated some loss of SFRM coverage. As a result, new insulation was applied to selected columns within the elevator shaft space. Information provided to NIST indicated that a different SFRM, Monokote Type 2-106, was used. Thickness measurements for columns and beams below the 45 th floor indicated average thicknesses of 0.82 in. and 0.97 in., respectively. Information from The Port Authority indicated that the minimum required thickness of the re-applied SFRM was 1⁄2 in. for the columns and 3⁄4 in. for the beams. NIST was unable to locate information from which to characterize the insulation of the core columns and beams that were not accessible. Except as noted above, once completed, the core was generally not inspected. NIST was not able to locate any post-collapse core beams or columns with sufficient insulation still attached to make pre-collapse thickness measurements.

On the selection of insulation, p 192

No technical basis was found for selecting the spray-applied fire resistive material (SFRM) used or its thickness for the large-span open-web floor trusses of the WTC towers. The assessment of the insulation thickness needed to meet the 2 hour fire rating requirement for the untested WTC floor system evolved over time: – In October 1969, The Port Authority directed the insulation contractor to apply 1/2 in. of insulation to the floor trusses. – In 1999, The Port Authority issued guidelines requiring that insulation be upgraded to 1 1/2 in. for full floors undergoing alterations. – Unrelated to the WTC buildings, an International Conference of Building Officials (ICBO) Evaluation Service report (ER-1244), re-issued June 1, 2001, using the same SFRM recommends a minimum thickness of 2 in. for "unrestrained steel joists" with "lightweight concrete" slab.

Recommendations

On major rec's p xlvii

The eight major groups of recommendations are: • Increased Structural Integrity: The standards for estimating the load effects of potential hazards (e.g., progressive collapse, wind) and the design of structural systems to mitigate the effects of those hazards should be improved to enhance structural integrity. • Enhanced Fire Resistance of Structures: The procedures and practices used to ensure the fire resistance of structures should be enhanced by improving the technical basis for construction classifications and fire resistance ratings, improving the technical basis for standard fire resistance testing methods, use of the "structural frame" approach to fire resistance ratings, and developing in-service performance requirements and conformance criteria for sprayapplied fire resistive materials. • New Methods for Fire Resistance Design of Structures: The procedures and practices used in the fire resistance design of structures should be enhanced by requiring an objective that uncontrolled fires result in burnout without local or global collapse. Performance-based methods are an alternative to prescriptive design methods. This effort should include the development and evaluation of new fire resistive coating materials and technologies and evaluation of the fire performance of conventional and high-performance structural materials. ethecal and standards barriers to the introduction of new materials and technologies should be eliminated. • Improved

Appendix B: November 2004 Comments

November 22, 2004

To: The National Construction Safety Team Advisory Committee
NCST Advisory Committee
100 Bureau Drive, Stop 8610
Gaithersburg, MD 20899-8610
NCSTAC@nist.gov

From: James G. Quintiere

RE: NIST conclusions on the WTC collapse mechanism reported on October 19, 2004

The October surprise in the NIST investigation was the assertion that all of the core column insulation was knocked off by the airplane impacts. To a lesser extent, reliance on NYNJPA audit insulation data solidified the NIST assertion that the failure of the core columns, and not the trusses, were to blame for the collapses of the South and North towers. That audit information was reported by NIST to have the fire floors of the north tower with truss insulation thicknesses as an average of 2.5 inches up to 4 inches instead of the prescribed 1.5 inches.
NIST needs to produce demonstrable and clear substantive information to support this rationale for its conclusions. The core-damage theory was put forth by the Weidlinger group in the Silverstein civil suit, and I heard it expressed at a local ASME meeting over a year ago by a NIST staffer. Therefore, I think it is incumbent on NIST to explain when and how they came to this conclusion. This collapse mechanism conclusion has profound influence on the recommendations brought from this investigation. The airplane-caused column collapse theory yields significantly, and almost diametrically, opposed recommendations than the fire induced truss collapse mechanism.

NIST needs to validate its conclusion by addressing the following:

1. The NYNJPA North tower insulation data needs to be authenticated. There is a long saga on the insulation coverage of the truss assemblies, and it should not end with an audit report that contains data that are extraordinary. The claim that up to 4 inches of insulation was sprayed onto 1-inch diameter truss elements needs testimony, photographic corroboration, or other tangible evidence to establish the accuracy of this information.
2. It needs to be clearly demonstrated how the core column insulation was removed. This cannot simply be based on an assumption or an extrapolation from impact calculations. It is too important to the conclusions to have modeling as the sole basis. Sandia has been experimenting with airplane crashes into buildings. Have they been consulted for supporting information or assistance? NIST needs to live up to the Daubert-rulling in civil case law, and demonstrate a clear methodology for their conclusion that the insulation was removed.

Finally, NIST needs to clarify inconsistencies that appear in their public information to date. These inconsistencies and apparent weakness lead me to question their collapse theory, and place the collapse cause more on the lack of sufficient truss insulation.

1. NIST metallurgical analyses show no core columns from the fire floors reached temperatures above 250 C. It is claimed that this information is consistent with computer modeling. Moreover, I was pleased to see that after many inquiries for microscopic analysis of the steel debris, it was done and reported in the October briefing. The importance of forensic evidence to document the temperatures reached of the steel cannot be overlooked. First, its consistency with the modeling has little significance since the modeling cannot have that level of detailed accuracy precise fire effects around the core columns. Secondly, the core column theory requires that the columns got sufficiently hot, say 500 C, and tangible evidence from metallurgical analysis is crucial in supporting the NIST conclusion. Unfortunately, that evidence has not been found by NIST. Thirdly, as a consequence, this crucial lack of evidence must indict the selling of the WTC steel debris before an investigation could be launched. Will NIST speak to this as they now have future investigative authority?

2. NIST computations show that floor truss assemblies can fail at temperature measured in the UL tests. UL fire tests showed for ½ and ¾-inch insulation that steel truss temperatures exceeded 1300 F (704 C) in roughly 58 minutes and 62-76 minutes, respectively. They reached average temperatures of 1110 F (593 C) in 66 and 66-86 minutes, respectively. My own data with Isolatek indicate that individual web elements can reach 593 C in about 35 to 50 minutes, respectively for ½ and ¾ inches. NIST's model for a single WTC truss (which is more accurate than the impact computations), predicts a truss would fail at the column connections at these temperatures. The NIST model for a single truss and its connection shows that the truss fails at the interior column seat connection, and 'walks off" the seat. This occurs at 650 C. The web diagonals begin to buckle at 340 C, and the exterior columns bow inward at 560 C causing the truss to act as a catenary. Other independent work done by Usmani et al, and Burgess et al., show similar results. If one floor falls on the floor below while both are heated by fire, can the impacted floor carry the load? Is this a plausible global collapse mechanism? To me, this means that truss failure is likely, at least in the South tower; and in the North if the PA audit data are wrong. Collapses of the floors were seen in both of the towers well up to 20 minutes before the buildings collapsed. This indicates the presence of the floor collapse mechanism.

   Incidently, the NIST scaling criterion used for the ½-scaling in the UL tests should be examined, as it is thermally not to scale. The shorter truss members will cause lower temperatures as the web transfers heat into the concrete floor.

3. NIST has relied on state-of-the-art computer models that are at the forefront of their technologies. However, these models have not been proven comprehensively for less complex incidents than the WTC. Will NIST continue to invest in these modeling technologies, or are they proven and ready for general use? If they are ready, will NIST advocate their use in design, or will NIST continue to perform research to improve them? If the latter is true, will NIST articulate the uncertain aspects of the modeling, and comment on how they bear on the investigation's conclusions?

4. NIST has used workstations fire experiments as a basis for their modeling. The stated fuel load is 4 lbs/ft^2 and this loading has been questioned, as it appears very low in the spectrum of office loadings. Because our students are conducting a scale model experiment of the 96th floor of the North tower, it forced us to examine this loading. While we could not pursue our information in depth, I can relate some major concerns. NIST experimental photographs of the office modules show little paper, and NIST has told me that the paper load was reported as light. I was told by a WTC inspector that the load was heavy, storage areas were overloaded and floors were continually cited for having paper stacked on the window sills; a furniture installer of the Marsh floors gave me information that showed extensive file cabinets surrounding the cubicles and these were not included in the NIST fire experiments – he, too, said that the Marsh office spaces were heavy in paper; an anonymous Marsh employee said that the Marsh company were paper "hogs", and a family member said it was heavy as well. The fuel loading is crucial to the duration and the temperatures of the fires. A light fuel load in the modeling will lead to low temperatures and this would affect the overall results.

It is imperative that NIST get the cause of the WTC tower collapses correct. The legacy of its victims bears on future fire safety. The protection of buildings in fire and terrorists attacks will be impacted by these conclusions, so they need to be right. The Advisory Panel plays a clear role to sign off on these conclusions. I know of others that feel the NIST conclusions need, in the least, clarity, and in the main, more support. However, we are few in number, and it falls on you to insure the public that they got it right.

<u>Recommendations</u> that should come from this study are submitted in no priority order as suggestions for your consideration:

1. Experimental studies to establish temperatures and fire duration characteristic of modern facilities including office large plan spaces, places assembly, and underground structures should be undertaken to validate models and establish design methods. The current correlations are incomplete in terms of fuel type and building type.

2. The standard time-temperature structural fire tests should be examined in light of computational methods. Data for the tests yielding temperature and deflection should be integrated with computations to extrapolate to actual assemblies used in practice.
3. Sensor technologies integrated with alarm monitoring for building performance should be integrated into the emergency response network for assessing the nature of the hazard.
4. Forensic techniques and standards should be established to assess failure information from structural debris. The elimination of the steel structure from the WTC site should be fully addressed, and its consequences fully stated.
5. Fire and disaster planning should include full and proper analyses for safe egress and effective response. Responders and building planners need to have the benefit of analyses that quantitatively address these facets. Real time modeling of the fire effects based on sensor information are possible and should be integrated into special building designs and response actions.
6. Novel techniques need to be investigated to rescue people and to fight high-rise fires.
7. Current codes weaknesses, in light the WTC collapses, need to be fully addressed. Issues of lightweight construction designs that are vulnerable to catastrophic collapse of a structure need particular attention.
8. A nationally supported infrastructure is needed to insure that objective scientific input is placed into the code consensus process to bring fire safety to a proper level of engineering analyses. The current code process is lacking in scientific underpinning, and the WTC disaster should stand for change in this direction, especially if the scientific community cannot render a clear and decisive verdict.

October Review:

Review of NIST WTC Investigation
Addressing Tasks 3, 5 and 6.

J. G. Quintiere
September 11, 2004

Modified October 17, 2004

The following constitutes the NIST projects designed to reach the objective of the investigation.

NIST Projects: Federal building and fire safety investigation of the WTC disaster

Project No./Technical Area /Project Purpose

1. Analysis of Building and Fire Codes and Practices
   a. Document and analyze the code provisions, procedures, and practices used in the design, construction, operation, and maintenance of the structural, passive fire protection, and emergency access and evacuation systems of the WTC 1, 2, and 7.
2. Baseline Structural Performance and Aircraft Impact Damage Analysis
   a. Analyze the baseline performance of WTC 1 and 2 under design, service, and abnormal loads, and aircraft impact damage on the structural, fire protection, and egress systems.
3. Mechanical and Metallurgical Analysis of Structural Steel
   a. Determine and analyze the mechanical and metallurgical properties
4. Investigation of Active Fire-Protection Systems
   a. Investigate the performance of the active fire protection systems in WTC 1, 2, and 7 and their role in fire control, emergency response, and fate of occupants and responders.
5. Reconstruction of Thermal and Tenability Environment
   a. Reconstruct the time-evolving temperature, thermal environment, and smoke movement in WTC 1, 2, and 7 for use in evaluating the structural performance of the buildings and behavior and fate of occupants and responders.
6. Structural Fire Response and Collapse Analysis
   a. Analyze the response of the WTC towers to fires with and without aircraft damage, the response of WTC 7 in fires, the performance of open-web steel joists,

and determine the most probable structural collapse sequence for WTC 1, 2, and 7.

7. Occupant Behavior, Egress, and Emergency Communications
   a. Analyze the behavior and fate of occupants and responders, both those who survived and those who did not, and the performance of the evacuation system.
8. Fire Service Technologies and Guidelines
   a. Building on work done by the Fire Department of New York and McKinsey & Company, document what happened during the response by the fire services to the WTC attacks until the collapse of WTC 7;
   b. identify issues that need to be addressed in changes to practice, standards, and codes;
   c. identify alternative practices and/or technologies that may address these issues; and
   d. identify research and development needs that advance the safety of the fire service in responding to massive fires in tall buildings.

The NIST investigation objectives are:

1. To determine (a) why and how the WTC 1 and WTC 2 collapsed following the initial impact of the aircraft, and (b) why and how the 47-story WTC 7 collapsed.

2. To determine why the loss of life and injuries were so low or so high depending on location, including technical aspects of fire protection, occupant behavior, evacuation, and emergency response.

3. To determine the procedures and practices which were used in the design, construction, operation, and maintenance of the WTC buildings.

4. To identify, as specifically as possible, areas in national building and fire codes, standards, and practices that warrant revision.

Among the **specific questions that NIST is investigating** within the above four objectives are the following:

- How and why did WTC 1 stand nearly twice as long as WTC 2 before collapsing (103 min versus 56 min), though they were hit by virtually identical aircraft?
- What factors related to normal building and fire safety considerations not unique to the terrorist attacks of September 11, 2001, if any, could have delayed or prevented the collapse of the WTC towers?
- Would the undamaged WTC towers have remained standing in a normal major building fire?
- What factors related to normal building and fire safety considerations, if any, could have saved additional WTC occupant lives or could have minimized the loss of life among the ranks of first responders on September 11, 2001?
- How well did the procedures and practices used in the design, construction, operation, and maintenance of the WTC buildings conform to accepted national practices, standards, and codes?

I will address Tasks 3, 5 and 6 in the format indicated below:

<u>Issue</u> for the project
<u>Approach</u> taken by NIST
<u>Questions</u> on the Approach
<u>Comments</u> on ability to address objectives

3. Mechanical and Metallurgical Analysis of Structural Steel

Objective: Determine and analyze the mechanical and metallurgical properties

Issue

NIST has established the mechanical and thermal properties of the steel used in the WTC, and generally has found no remarkable departures from the literature for steel. However, an important aspect of this fire and large fires in general is the temperature reached by the fire, and that achieved by the steel.

NIST approach

In the December 2003 Public Update it states that part of this task objective is "estimating the maximum temperature reached by available steel" (p.8). In the May 2003 (p. 33) and June 2004 Vol. 1, p. 87), it appears that this objective is being done by examining paint degradation at 250 and 750 C.

Questions

A common forensic technique for determining the temperature reached by steel in a fire is to microscopically examine the grain size. It has been said that very precise determinations can be made if compared to an unheated similar steel sample. Why has NIST not used this method?

Comments

The importance of knowing the temperature achieved by the steel on the fire floors is crucial to establishing the cause of the buildings collapse. This is like a thermometer in the building, so its significance cannot be overlooked. The temperature of the fire and the steel are important in determining the time and the nature of the collapse of the buildings. NIST is using computational methods to predict these temperatures. It is incumbent on NIST to use all methods for ascertaining the steel temperatures to achieve confirmation of its predictions.

Also, NIST has steel samples salvaged from the dumpsite, and has said those samples were adequate. NYC made a unilateral decision to remove and sell the steel before the NIST investigation began. What is the NIST recommendation on how to preserve evidence in future investigations in order to render complete structural and thermal analysis to the debris samples? Was the steel prematurely discarded in the WTC before adequate analysis could occur?

5. Reconstruction of Thermal and Tenability Environment

Objective: Reconstruct the time-evolving temperature, thermal environment, and smoke movement in WTC 1, 2, and 7 for use in evaluating the structural performance of the buildings and behavior and fate of occupants and responders.

Issue

The accuracy of the computer modeling predictions for the fire environment need to be assessed, and their consistency with literature data for fully developed fires and with the factual evidence of the WTC fires needs addressing. A computation of this magnitude is beyond the state of the art for fire modeling, and although NIST and the investigators should be commended for their efforts at pushing the state of the art, they must not solely rely on computer-driven computations for estimating the fire temperatures. They have other sources from which to also draw information on the state of the fire: They include: conducted fire tests, correlations for fully developed fires in the literature, data on window breakage and the fire progress, and people reaction to the fire heat and smoke from potential interviews. Consistency must be assessed between the various sources of information and from alternative, albeit, simpler computational methods.

NIST Approach

Information about the fire can come from several sources. NIST has extensively examined and compiled the fire behavior and its effect on the building through the correlation of various photographic evidence. This task has been done with excellence it appears, and should offer valuable information. Another source of fire could come from the collection of data from people. This appears to have lagged and it is not clear that anything of value in a timely manner will be reported on the fire and damage effects observed directly by people and ascertained through interviews. In all of the fire predictions NIST has chosen to use its Fire Dynamics Simulator (FDS) as the sole computational tool. In order to evaluate its accuracy, experiments have been conducted on small features of the WTC office occupancies in order to calibrate and

assess the accuracy of the fire predictions. Hence, both the modeling and the experimental data offer information on the WTC fires. As with other aspects of the investigation, NIST appears to be weighting the computational approach as their primary result, especially since that result must be supplied to the structural modelers in order to make their prediction of the building's ability to carry its load.

NIST has approached the validation effort by conducting two series of tests. The first series consisted of a spray fuel fire in a compartment containing structural members. The second involved a larger compartment containing three workstations that NIST decided were representative of the WTC offices. That fuel load is roughly 4 lb/ft^2 (psf) (or about 20 kg/m^2 and 50 MJ/ m^2), June 2004 Vol. 1, p xxxvii, Vol. 5, J-37.

<u>Series 1 consisted of the following (June 2004 Vol. 5, J-2):</u>

> The test compartment consisted of a steel stud frame lined with calcium silicate board. The internal dimensions of the compartment were 3 m high, 7 m deep, and 4 m wide. There were four openings in the west wall through which air entered the room; they totaled 1.75 m 2 (10.8 ft^2) in area and were located 1 m (3.3 ft) above the floor. There were four openings in the east wall through which heat and combustion products were emitted; they also totaled 1.75 m^2 (10.8 ft^2) in area and were located 2 m above the floor. In each of the six tests, the four test subjects were a bar, two trusses, and a thin-walled tubular column. Depending on the test, these specimens were either left unprotected or were coated with spray-applied fire protective insulation material, Blaze Shield DC/F. The fibrous insulation was applied by an experienced applicator who took considerable care to apply an even coating of the specified thickness. As such, the insulated test subjects represent a best case in terms of thickness and uniformity. The fires consisted of liquid hydrocarbon fuels sprayed by a two-nozzle spray burner onto a 1 m × 2 m (3.3 ft × 6.6 ft) pan. The fuels were (a) heptanes and (b) a mixture of nominally 60 percent (by mass) heptanes with 40 percent toluene. The latter fuel produced a significantly sootier flame.

Six tests were done. The instrumentation for the tests comprised up to 352 channels of data.

Series 2 consisted of 3 workstations in a large room (June 2004, Vol. 5, J-27):

Six experiments were designed to assess the accuracy with which FDS predicts the fire spread, heat release rate, and thermal environment in a compartment burning multiple workstations in a configuration characteristic of that found in the WTC buildings. In each of these experiments, sets of three workstations were burned in a large compartment (about 11 m x 7 m x 3.4 m high). The challenges to the model included varying the location of the ignition burner (and thus the fire ventilation), adding jet fuel and/or noncombustible material occluding a fraction of the workstations' surfaces, and "rubblizing" the workstations.

It should be noted that the workstation fuel load was "suggested by personnel from a company that supplied office furnishings to the occupants of WTC 1. Information on the distribution of papers and other office items was provided by a frequent visitor to these offices". (p J-12)

NIST performed some additional computations based on FDS. They have early on reported on the smoke dynamics from the building (Rehm et al., IAFSS 2002), and recently on the fireball dynamics (Baum, Comb. Inst., 2004). These are considered somewhat ancillary to the prediction of the fire conditions on the floors that bear directly on the heating of the structure and the effect of the fire on the ultimate collapse. However, the work by Prasad and Baum (Comb. Inst. 2004) on linking the predictions of FDS for the fire with the heating of core columns under different core damage scenarios is very significant. It is the closure of the fire and the structure modeling that is critical to answering the issues pertaining to collapse. McGrattan has simulated the fires on a floor based on the workstation fuel load. That loading was indicated at about 4 pounds per square ft of office space (psf). McGrattan indicates the fire at this low fuel loading burn in an under-ventilated state as "oxygen consumed drives fires to the windows" (p. J-44). In addition, these full-scale WTC computer simulations are reported to for about 20 minutes in a region and then move on with an entire floor burning out in about 1 hour (Fact Sheet June 2004 pp. 2, 3).

Also it was indicated that these simulated fire burn at an average temperature over the floor at about 600 C.

Questions

It is well known that FDS results depend on the grid size and its scaling to the fire conditions. The experiments done by NIST may well serve the credibility and accuracy of using FDS with a grid size of 40 cm, but enough comparison has not been shown between the computations and the experiments. Only about 4 or 5 plots have been presented for comparison in the reports, and they show very good prediction for the fire gas temperatures and heat release rate. Some of NIST's own funded work (Ierardi and Barnett, 2003) have shown that the accuracy of predicting a single fire plume from a 30 cm burner give drastic variations in temperatures with the fire plume for grids of 1.5 to 15 cm. Temperatures within 20 per cent of the experiment results required grids of 1.5 to 5 cm. So it is incumbent on NIST to address this accuracy question completely. They have done 13 experiments with over 300 measuring stations in each test. In the least, NIST needs to demonstrate the ability of FDS to compute all aspects that FDS has in common with these measurements.

The issue of accuracy for computer models is a serious matter when they are to be used as general engineering tools. The literature is filled with data and correlations for fully develop fires. NIST should at least demonstrate how its approach using FDS compares to these other empirical approaches in the literature. Japan uses one of these empirical approaches as a design method in regulations, and the SFPE has just completed a guide on the prediction of fire conditions for structural considerations. It has been said that the full WTC floor simulation agree with the phenomenon observed by (I. Thomas et al.) in which the fire moves about the compartment seeking air. Can FDS predict the data of Thomas? These questions are broader that the effort that has gone into the WTC simulation, and therefore it would be important for NIST to examine FDS in light of its validation needs. Moreover, FDS is using a charring model to compute the burning rate and flame spread on the workstations, and NIST should state the accuracy of using FDS for the prediction of flame spread on charring materials. Boeing would not take the use of CFD models in its aircraft design lightly, and neither should those assessing fire behavior, especially from NIST.

The fuel load selected in the representative experiments and the modeling raises some questions. NIST is using roughly 4 psf, and a floor burns for an average of about 1 hour (Key Findings of NIST's June 2004 Progress Report…). This selection of loading is critical to establishing the burning time, crucial to predicting the impact of fire on the structure. The literature (Robertson and Gross, ASTM STP 464, 1970) suggests an average office load of 18.4 psf, ranging from 7 to 43 psf according to surveys. Why is the WTC representative office so low? This needs examining and supportive data.

The FDS simulations indicate a one-hour burning period for a floor at 600 C. This may be due to the light fuel, but appears inconsistent with the under-ventilated burning achieved in the simulation. Also the actual fires appear to have burned longer with WTC burning until collapse at 103 minutes. Finally, the average temperature of 600 C is about coincident with critical failure temperature associated with steel structures, and would never allow the steel to reach this temperature.

In an investigation where information comes in different forms, the final analysis must show that the information pieces are consistent. NIST has observational information, hopefully people information, experimental test information, and the FDS simulations. These must be shown to be consistent.

Ultimately FDS results must be linked to a structural model. Prasad and Baum (C.I. 2004) have attempted this for the heating of the core columns. They show that simplifications need to be made in representing the FDS temperature spatial distributions in order to better interface with the structural heating model. Their approach has demonstrated the needed closure of the fire and structural heating. However, they have not considered the vulnerable floor assembly in their calculations. This will need to be added to fully assess the role of the fire on the complete structure. NIST has not made clear how the fire and structural computations will come together, particularly since the structural modeling is being done under contract. We would like to see NIST speak to the accuracy and issues related to the modeling of the fire and structure together.

Since NIST has test data on the heating of insulated structural members in their fire tests, some comparisons, at least, need to be presented for these simpler fire scenarios.

Can NIST successfully modeling the 1975 WTC fire (June 2004, Vol. 4, G-1) that did extensive damage to a floor? This fire prompted the use of sprinklers, and local structural damage occurred. Since the damage and extent of the fire was known, it could be a useful benchmark for NIST to compare their simulations.

Comments

The fire computations are perhaps the most important determination since its heating impact and its duration determine the ultimate temperature of the protected steel. The heat transfer by conduction into the insulation and the steel is trivial by comparison. Also when it realized that failure in furnace testing of structures is often based on steel temperature, and temperature strongly affects the strength of steel, e.g. the modulus of elasticity is reduced by 50 % when steel attains about 600 C. Since the modulus is directly related to the critical load to cause buckling, the buckling of elements in compression can occur more easily at elevated temperatures. The ability of the fire modeling to relate to the structural heating model is very import step in this investigation. NIST should make this step as transparent as possible in order to judge its conclusions. FDS will yield a spatial and time varying temperature throughout a floor. Its accuracy needs to be supported at this level of sophistication. Alternative estimates on the level of temperature and its duration might need to be couched in simpler forms for the best structural analysis to be produced. It might serve just as well to specify uniform temperature in a range. The duration will depend on the fuel load, and it has been pointed out that the NIST selected load is very low compared to office load surveys. Some variation of uncertainty must be considered here.

Finally, it appears almost foolish to have received $16 million for the investigation and to not have conducted a test more representative of a WTC floor. A quarter of a floor could have been tested for fire and the heating of the structure. It would only involve a plan space at 100 x 100 feet. This could have settled many issues. Especially when it is realized that no experimental results exist for compartments with small ratios of height to their lateral dimension as 1/20 in the

WTC. The smallest has been ¼ in the well known CIB studies, and those results should be examined by NIST for their applicability. However, the interaction of air from the perimeter and fuel within the compartment need to be examined under these conditions by an experiment, to at least see if FDS is qualitatively correct. Moreover, it is known that in large fire plumes that smoke can trap radiation and drive the core fire temperatures to 1300 C and more. This can happen at fires of 30 ft in diameter, so the question must be raised if this might apply to the WTC with lateral floor dimensions of 200 ft.

6. Structural Fire Response and Collapse Analysis

Objective: Analyze the response of the WTC towers to fires with and without aircraft damage, the response of WTC 7 in fires, the performance of open-web steel joists, and determine the most probable structural collapse sequence for WTC 1, 2, and 7.

Issue

The principal issue here is to examine the NIST working hypothesis in conjunction with its collection of findings and to assess their consistency. The working hypothesis is found in June 2004 Vol. 6, Q-3.

> The working hypothesis addresses the following chronological sequence of major events; specific load redistribution paths and damage scenarios are currently under analysis:
>
> 1. Aircraft impact damage to perimeter columns with redistribution of column loads to adjacent perimeter columns and to the core columns via the hat truss;
> 2. After breaching the building's exterior, the aircraft continued to penetrate into the buildings, damaging core columns with redistribution of column loads to other intact core and perimeter columns via the hat truss and floor systems;
> 3. The subsequent fires, influenced by post-impact condition of the fireproofing, further weakened columns and floor systems (including those that had been damaged by aircraft impact), triggering additional local failures that ultimately led to column instability;

4. Initiation and horizontal progression of column instability ensued when redistributing loads could not be accommodated any further. The collapses then ensued.

NIST Approach

NIST and its contractors are using computational analyses to compute the impact damage by the aircrafts, the performance of a single floor truss under temperature elevation, the evaluation of a portion of the floor assembly in the ASTM E 119 test, and the history of the insulation applied in the WTC, especially to the floor assembly.

2. Impact computations: These computations are portrayed in figures on pp 78-79 of June 2004, Vol. 1, and they show an engine impacting and shredding a floor and then buckling a core column.

NIST reports further (June 2004, Vol. 1, p 81):

• A 500 mph engine impact against an exterior wall panel results in a penetration of the exterior wall and failure of impacted exterior columns. If the engine does not impact a floor slab, the majority of the engine core will remain intact through the exterior wall penetration with a reduction in velocity of about 10 percent and 20 percent. The residual

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

velocity and mass of the engine after penetration of the exterior wall is sufficient to fail a core column in a direct impact condition. Interaction with additional interior building contents prior to impact or a misaligned impact against the core column could change this result.

Also an analysis of the stability of the towers, assuming no damage to the core, gives the number of floors that need to be removed to cause global failure (June 2004, Vol. 1, p.81):

The following presents some preliminary findings obtained from the preliminary stability analyses under service live loads and subject to the assumptions and the limitations of these models (see Appendix D): Linear stability analysis was used to examine the stability of the undamaged WTC 1 under service loads through increased un-braced column lengths (floor removal). The tower was stable when two floors were removed. Two core columns buckled when three floors were removed, but the tower maintained its overall stability. The tower also maintained its stability when four columns buckled with four floors removed. The analysis suggested that global instability of the tower occurred when five floors were removed from the model. Assuming that all columns at the region of the removed floors reached a temperature of 600 °C (reduced modulus of elasticity), the analysis indicates that removal of four floors would induce global instability.

3. Single truss analysis: A model of a single truss and its connection shows that the truss fails at the interior column seat connection, and 'walks off' the seat. This occurs at 650 C. The web diagonals begin to buckle at 340 C, and the exterior columns bow inward at 560 C causing the truss to act as a catenary. (June 2004, Vol. 1 p. 120).

4. E 119 tests: Standard fire tests were conducted at UL. Two were done at a 35 ft span representing the short span in the WTC towers. These had ¾ in. thickness of insulation applied. A third test was conducted with public viewing with ½ in. insulation, and at a span of 17 ft. In that test the truss was scaled –down so that it was half its depth. The failure criterion used was primarily structural integrity for the most part. The third test was conducted *restrained* and obtained a 2 hour restrained rating meaning it did not structurally collapse, and it obtained a 1 hour unrestrained rating which results from exceeding a critical temperature of the steel.

5. Insulations history: NIST has traced documents and recommendations related to the thickness of insulation, particularly on the floor joist assembly. They have found and stated the following:
    a. The truss specified thickness was 0.5 in., but as applied was 0.6 +/- 0.3 inch.

b. The upgraded truss insulation was 1.5 inches (based on UL G805, May 2003, p. 78), but was later measured in application as 1.7 +/- 0.4 inches based on photographic analysis, but was reported in audit documents over 1997 to 1999 as 2.5 +/0.6 inches, with thickness as high as 4 inches (June 2004, Vol. 4, I 15-18).
c. A model code recommended 2 inches for 2 hours in a 2001 assessment of a similar truss (June 2004).
d. A report by Burro-Happold recommended in 2001 that the upgraded insulation could be dropped to 0.5 inches based on an ambient value of the conductivity used in a calculation, but settled on a recommendation of 1.3 inches. (May 2003, p. 82)

Questions

Column impact: It is very important to determine an accurate estimate of the core column damage. In view of the variability of the impact computer codes, what does NIST consider is their accuracy? It was reported by the NY Times that the Weidlinger computations indicated that the South tower would fall solely upon impact of the aircraft. It is know that calculations were made in 1966 that indicated only local damage would occur. Why is there so much variability in these computations? In addition, the NIST reported results indicate that an engine needs to directly strike a core without loss of momentum for the column to fail. This would suggest very limited core column damage is possible as might be inferred from the NIST computational graphic shown above. Can an engine possibly hit a core column without hitting anything on the floor occupancy and structure? That does not seem possible, so how can an engine damage a core column? Perhaps I am missing something. Why is NIST then considering in its "working hypothesis" that considerable core damage is likely? Moreover, it is known that landing gear and at least one engine was found in the surrounding streets suggesting a flight path through the building. Can NIST use information on the location of the engines to assess the likelihood of core column damage?

Temperature importance for floor failure: The single truss analysis done by NIST and the work done both Usmani et al, and Burgess et al., indicate that the truss deflections occur at temperatures ranging from roughly 400 to 600 C. During these deflections, the truss can cause failure to its connections, or to column instability. It would seem that temperature is a key feature

in causing failure. How does NIST relate its work to those cited above in the literature? If one floor falls on the floor below while both are heated by fire, can the impacted floor carry the load? Will this be a mode of global collapse? NIST considers the number of floors to be removed before the columns would become unstable, but would not the loss of 2 or 3-floors cause the failure before this instability? Is a critical temperature a good measure of structural failure as it might appear from the element computations, and the implication of the loss in strength at elevated temperatures?

Role of E119: Ratings have been achieved at UL for the E-119 test. Will NIST be analyzing these results to see how they would apply to the WTC? If the temperatures reached by the steel in these tests is sufficient to cause failures in the WTC computations, but the structure did not fall in the E 119 test, how will NIST reconcile these differences? NIST scaled the depth of the truss to ½ full-scale in its 17 ft E 119 test. This was done for stress purposes, but the heat transfer along the web into the concrete deck is now changed. Since temperature is a criterion for failure of the test in some modes of testing, the temperature of particularly the full-scale 35 ft. truss should be examined. Moreover, as UL G805 was used for justifying the 1.5-inch insulation thickness, why would the recent tests give such different results? Also UL N 826 might have been more appropriate, and gives 2 1/16 inches. So what is the meaning of the E 119 test and how should it be used in this WTC analysis?

Reconciliation of insulation thicknesses: As seen by the various E 119 results for the Cafco insulation, and the varied specifications and recommendations on the WTC truss insulation, it is incumbent on NIST give some rationality to these variations. Since the amount of insulation is so crucial to the outcome of finding the cause, NIST needs to be very sure about how much insulation was actually in place. The latest information from PANYNJ indicates that the upgrade in WTC 1 could have been as much as 4 inches over the 1.5 specification, when field workers were having difficulties in application, and that was the main reason for the Burro-Happold report. A 4-inch radius on a 1 inch steel rod would give a 9-inch diameter cylinder – a very big result. How much confidence does NIST have on these large amounts? Do they have photographic evidence as in the previous smaller amounts? Would not a hearing on the insulation thickness issues serve NIST well in documenting the facts and rationality of these

variations? If so much variation occurred for the WTC, how does this relate to the protection in other buildings?

Comments

It appears that NIST has to answer some very focused questions with clarity and accuracy.

1. How many core columns were removed and why?
2. How much insulation was in place during the fire?
3. What are the critical temperatures needed for failure?
4. Could the fire cause these temperatures?

The global collapse mechanism of the buildings must be made as clear as possible. A vague answer expressed by the current NIST working hypothesis is not sufficient. NIST has expended a lot of good individual effort, and it has done some very good fact finding and analyses. Now all of that has to be put together, and it seems contractors (who we have not heard from) play a significant role. NIST needs to harness those individual efforts and expertise in a balanced evaluation. Reliance solely on complex computer models should not be the sole basis of the answers. If the core of the answers are really revealed and understood, NIST should be able to explain them in simple fundamental physics, and not shroud them in computer graphics. This was the purpose of the investigation, and this project task is critical.

Appendix C:

Analysis of the Fuel Load Calculations for the 96^{th} Floor of the WTC North Tower

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April 2005

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Abstract

An impartial examination into the combustible fuel load for the 96th floor of the North World Trade tower is described in this paper.

Introduction

The dimensions used for analysis of the WTC North tower are as follows, the overall building dimensions are 207.2' x 207.2' = 42,932 ft^2 (3988.5 m^2), building core dimensions are 87' x 137' =11,919 ft^2 (1107.3 m^2), and the area that office equipment sits on is therefore 31,013 ft^2 (2881.2 m^2), while FEMA reports that area for office furniture is 30,930 ft^2 (2,873.5 m^2) [1].

Typical structural live loads used in design or analysis for offices are 50 psf (pounds per square foot) (244.35 kg/m^2), and for lobbies, 100 psf (488.7 kg/m^2).

The paperweight found in the Marsh & Mc Lennan office is significant because it directly impacts the fire size/duration, which in turn, affects results obtained for performance of structural members.

UMCP considerations and examination:

- The cabinets used by NIST contained two reams of packed paper, which is not consistent with the files that I weighed. The significance is that the tighter the packed paper is, the less air can get in to feed the fire whereas, typical files are not uniform in size or spacing and leave room for air to supply the fire.
- The following are graphical representations of the difference between the paper weight not included (NIST) and the total weight inclusion (UMCP):

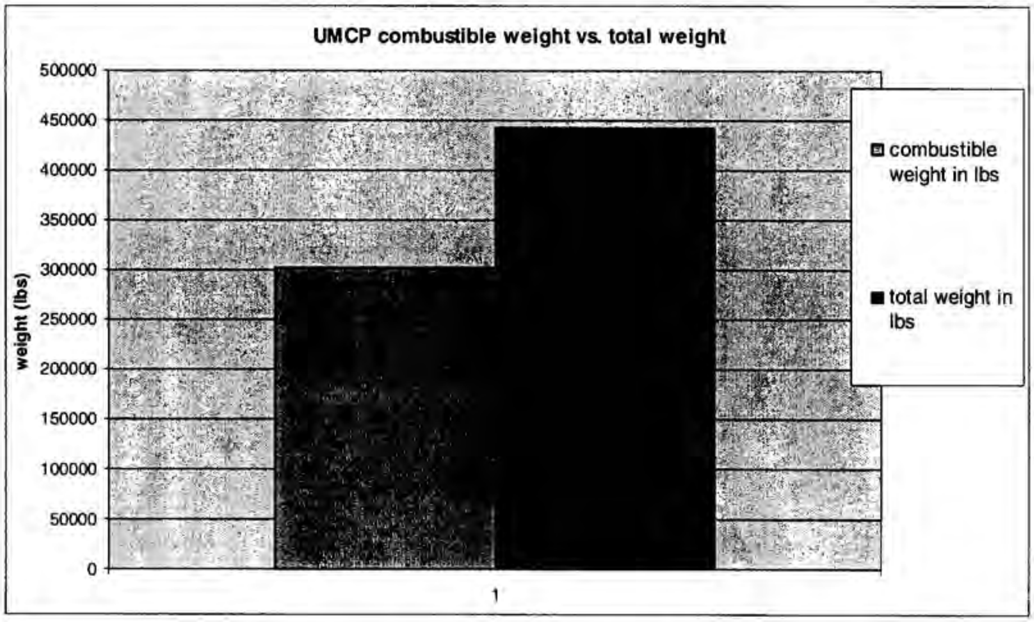

Figure 1. UMCP estimate of how the total workstation weight is distributed.

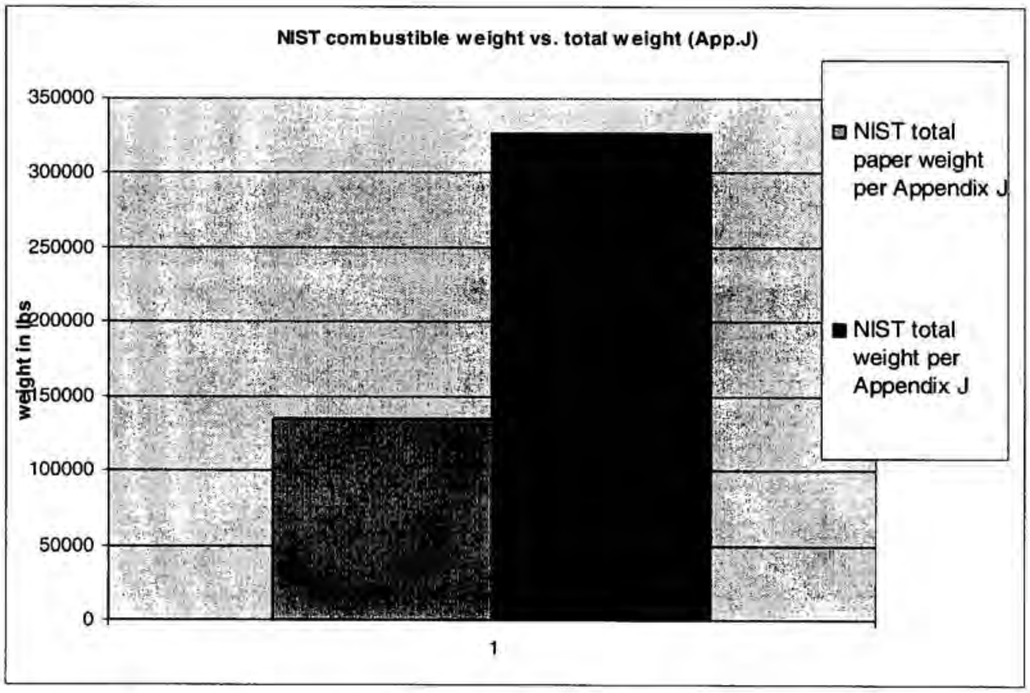

Figure 2. NIST estimate of how the total workstation weight is distributed.

Summary of results from NIST

- The book case, which was 48" high (1.22m), was stuffed with 10 boxes containing 13 reams of copier paper (260 lb ~ 118 kg).
- Total workstation weight considered to be 1600 pounds (726 kg) and the amount of combustible material contained in that workstation was estimated as 660 pounds (300 kg) by NIST. Based on the information obtained in these simulations, McGrattan then passed the FDS results onto others who analyzed the temperature of the steel and concrete [2].
- NIST used a per desk weight rather than obtaining combustibles for the entire floor and attributing that to their experiments. However, in the impact zone, there are two conference rooms (~1,590 lbs (721 kg) of combustible materials), 8 sets of four drawer lateral files (48 cabinets=192 drawers~13,824 lbs (6270.5 kg) (of paper that was likely dislodged by the impact) and the paper storage area (~28,000 lbs (12,701 kg) of paper & paper/office products) that directly contribute to the initial fire started by the jet fuel.

Information obtained from FEMA

- Estimated combustible fuel load as 8 psf.
- Additionally, the report acknowledges that typical office loading is 50 psf, per Load Resistance Factored Design published by American Society of Civil Engineers. (50*31013=1,550,650 lbs (7,577,988 kg) live load- i.e. combustible and non-combustible materials)

Methodology used for this examination

- The assumptions made for this project are as follows:
  1. That the symbols had not changed for the Knoll furniture between those used in 1997 and those used today.
  2. Veneer panels close in weight to panels used by NIST.
  3. Used FEMA building and core dimensions and assumed NIST did the same.
  4. Based on NIST drawing, I counted 204 workstations but according to plans from Dr. Quintiere, there were 210 workstations. I used 210 workstations.

5. Estimated that there were 20 units of five shelf storage files by the stairwell area. Each unit was determined to have dimensions 63" high x 36" wide (1.6 m x 0.9 m) and it was assumed that items were stored on top of the shelving units.
6. One Calibre cabinet held 15 lbs ~ 6.8 kg (of contents and one 3-drawer pedestal contained one paper file with 17" (0.4 m) of file storage (24 lbs ~ 10.9 kg of paper weight).
7. Southeast corner of building plan did not photocopy well therefore assumptions were made consistent with other corners of the 96th floor layout.

- The approximations made are as follows:
  1. The weights for chair models that were not found in the symbol library (perhaps not manufactured by Knoll), like "CH6", were estimated based on other known chair weights.
  2. Wall panels and workstation layout based on information provided by NIST [3]: (5) 4'panels-36"wide, (1) 5' panel-36"wide and (5) 4' panels-24"wide. In SI units: (5) 1.2 m panels- 0.91 m wide, (1) 1.5 m panel- 0.91 m wide, and (5) 1.2 m panels-0.61 m. The two foot panel weights were estimated using 10.55 lbs (4.8 kg) per foot of height.
  3. Based on files weighed in the ENFP office, an average file weight was obtained of 2 lbs/inch using standard paper size, type 20 wt.
  4. Only desks that could be positively identified as having a computer were given 'credit' for one (i.e. 165 computers for 210 workstations)
  5. Trapezoidal conference room table weight was estimated based on locating it once in AutoCAD, noting that there were several sizes, and then not being able to locate the table again.
  6. Knoll representative did not want to be quoted on specific amounts of combustible material in furniture.
  7. A request of the Manufacturer must be made in order for the privacy panels to be chemically treated to meet ASTM E-84 class "A" flame spread rating.

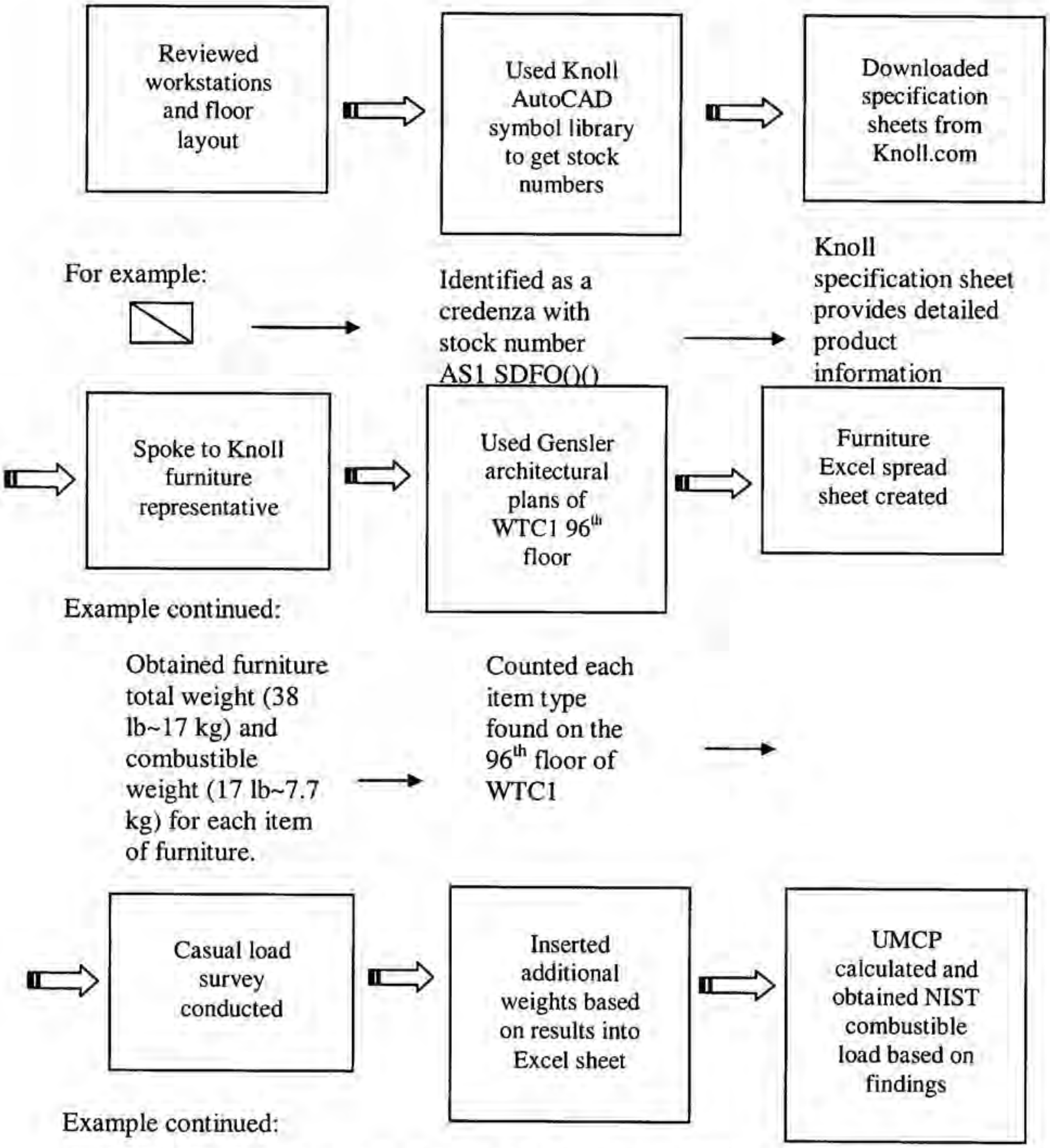

Figure 3. This flow chart demonstrates the methodology used to obtain furniture identifications.

Comparisons

The following comparison table is provided to sum-up the previously mentioned information and to clearly layout the three groups being compared.

Table 1.

	COMPARISON				
TOTAL WORKSTATION WT.	Average	High	Low		
description	UMCP			NIST	FEMA
Number of desks	211			204	
Total psf(*combined contents)	14.3				
Combustibles only desk wt	179441	1429	341		
Paper weight (lbs)	302062			134640	
Empty furniture weight (lb)	265162			191760	
Full furniture weight (lb)	441868			326400	248103
30% paper weight (lb)	90619				
Building area (ft^2)	42932				42932
Core area (ft^2)	11919			11745	11919
Area that furniture sits on	30930			31000	31013
Common file cabinets (lb):					
noncombustible	37626			0	
combustible	36,437			0	
combust. stored on top	255				
Total	74318				
Conf. rms/areas & pantries(lb)	7117			0	
***Combustible Material (psf)**	**10**			**4** psf	**8**psf (39 kg/m^2)
SINGLE WORKSTATION WT.					
Combustible wrkstn weight	862	1443	341	660 lbs	
Total				1600lbs	
Wrkstn. weighted average (lb)	862				
Added Combustibles:					
workstation paper (lb)		370	6	160	
additional (lb)		30	0	0	
File cabinets:					
contents (lb)		424	124	40	
top (lb)		6	3	0	
workstation foot print	8'x8' (2.41 m * 2.41 m)			8'x8'	
paper NIST left out	71,844 lbs				

Comparison of fuel load between UMCP and NIST:

Table 2.

	NIST	UMCP
Total floor weight (combustible + noncombustible)	1600 lbs x 204 stations=326,400lb	210 stations x 1433 lb =301,012 lb
Total Combustibles Weight	134,640 lb/30930 ft^2= 4.3 lb/ft^2 combustibles only	301,012 lb/30930 ft^2 = 9.7 ~ 10 psf
*Paper weight for floor distributed per station	60,242 lb/204 wrkstns = 295 lbs.	176,706 lb /210wrkstns = 841 lbs.

*paper weights for NIST and UMCP are different because UMCP included common lateral files and paper storage whereas NIST did not.

**The reason for 1141.4 lbs of combustible per station is based on the accessible fuel per NIST. However, this is too low an estimate due to the fact that common files were not taken into account, nor conference rooms etc…

***This is the weighted average of the workstations.

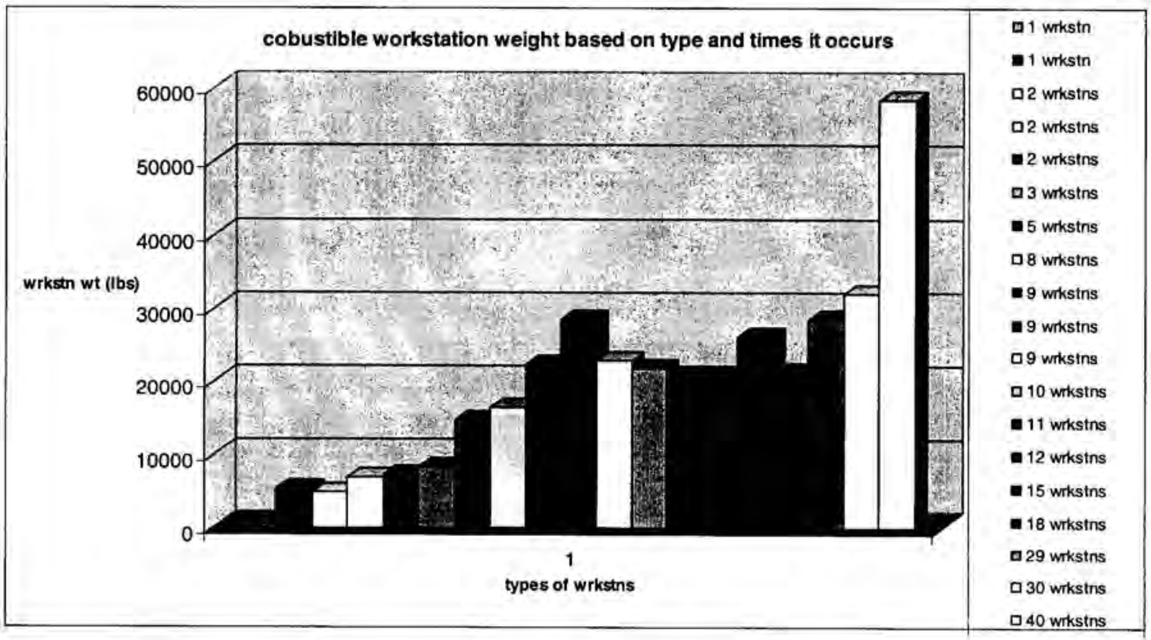

Figure 4. UMCP chart showing weight of workstation type plotted against the number of times the workstation type occurs on the 96th floor.

Recommendation

Use the NIST data for the temperature of steel then make a plot versus temperature of the outer steel insulation. The purpose of this plot is to help linearly estimate, based on corrected fuel load/fire size, the possible range of steel temperatures. Then, using something like SAFIR or lumped heat capacitance or maybe T. T. Lie's work, there would be a reference check as to the validity of the results.

From the above described course of action, a strong enough case can be made, which may prove to NIST that a re-examination of their original fuel load estimates is worthwhile.

References

1. McAllister, T., et al. FEMA WTC report "Chapter 2" page 2-1
2. McGrattan, K. "Simulation of the fires in WTC 1 and 2" BFRL, NIST, US Department of Commerce, October 19, 2004, slide 2.
3. NIST Preliminary WTC report 2004, Appendix J.

Other References not specifically cited:

4. NIST AND THE WORLD TRADE CENTER website "Status of Data Collection Efforts"
5. McGrattan, K. "Simulation of the fires in WTC 1 and 2" October 19, 2004. BFRL, NIST, US Department of Commerce.
6. McGrattan, K. "Simulation of the fires in WTC 1 and 2" October 19, 2004. BFRL, NIST, US Department of Commerce.
7. Knoll furniture catalog www.knoll.com/products

8. Knoll furniture symbols library www.knoll.com/furniture symb dnld.htm
9. Sunder, S.S. "World Trade Center Investigation Status" October 19, 2004, BFRL-NIST.
10. Sadek, F., Riley, M.A., Simiu, E., Fritz, W. and Lew, H.S."Baseline Structural Performance and Aircraft Impact Damage Analysis" June 22, 2004.
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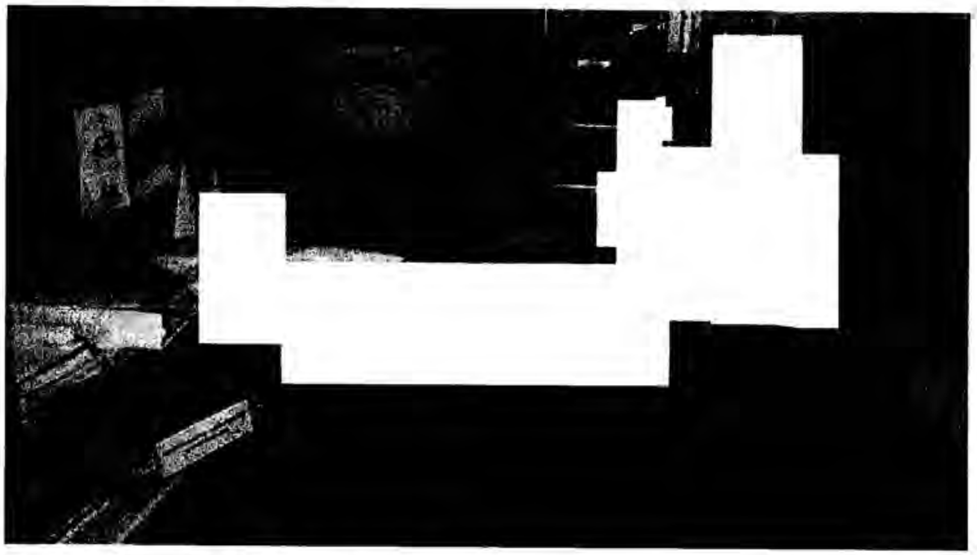
12. Sadek, F., Riley, M.A., Simiu, E., Fritz, W. and Lew, H.S."Baseline Structural Performance and Aircraft Impact Damage Analysis" October 10, 2004, BFRL-NIST.
13. NIST Special publication 1000-4 "December 2003 public update on the Federal Building and Fire Safety investigation of the WTC Disaster" 12/20/2003, NIST.
14. McAllister, T., et al. FEMA WTC report "Chapter1-Introduction"

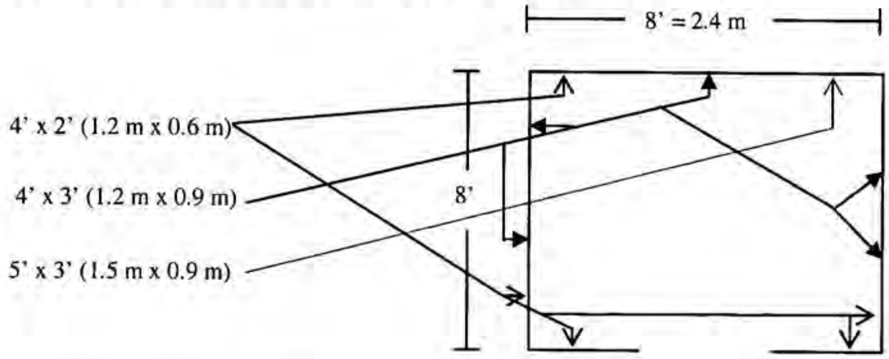
Appendices

A.1 Photo of typical workstation



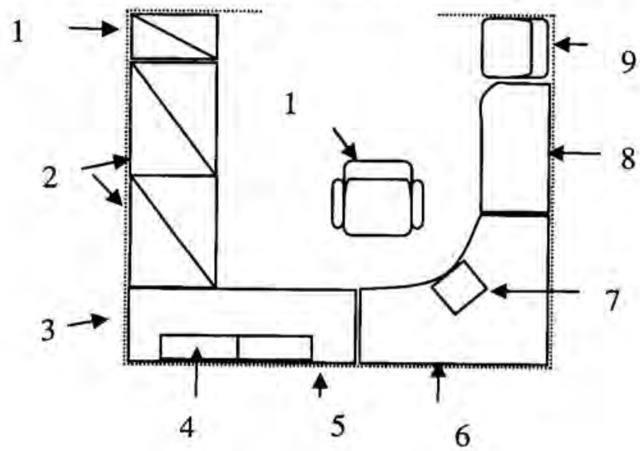
A.2 Panel layout of NIST workstation

Workstation layout using the NIST 8'x8' (2.44 m x 2.44 m) printout:



A.3 Workstation symbol example

Workstation number: 096075-05



1. Credenza

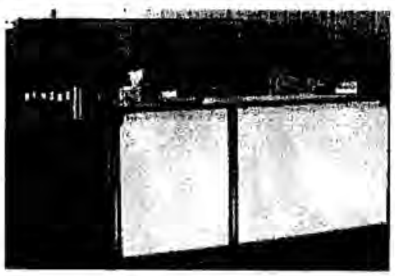
2. Lateral file cabinets-two drawers

3. Supplemental work surface

4. Overhead storage

5. Privacy panel

6. Morrison desk



7. Computer

8. Rounded edge supplemental work surface

9. Visitor chair

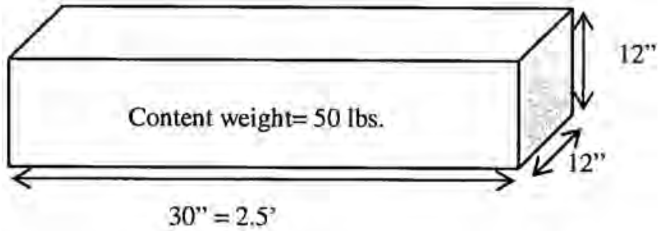
10. Staff chair

A.4 Sample calculations

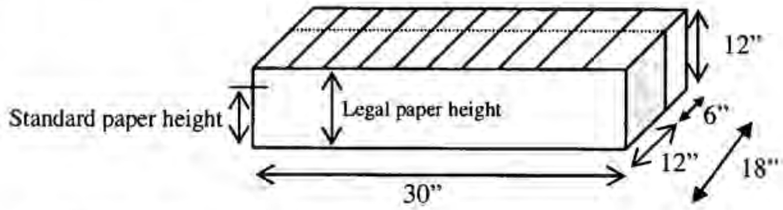
1. For load survey of panels, I determined that one sheet of paper weighs 0.01 lbs (0.0045 kg), therefore 0.25 lbs (0.11 kg) = 25 sheets of paper and 1 ream of paper = 500 sheets = 5 lbs (2.27 kg).
2. Load survey of pantry was done by estimation of the ENFP department pantry. The area of contents in the room considered were the storage racks, three file cabinet drawers, microwave, refrigerator, and few boxes of stored party supplies.
3. Load survey for the desk tops was done by weighing contents of one desk then observing other desks in the engineering building, physician offices and the desk of an MRI technician. Work desk was apportioned three pounds of combustible material in the form of paper weight. The supplemental desk was estimated to have six pounds of additional paper weight on desk surface.
4. File cabinet weight for the credenza was based on the following horizontal file weights from the ENFP department: the first file drawer contained 294 files, weighed 37 lbs (16.8 kg), and measured 18.75 inches (0.48 m) long. The second file cabinet contained 138 files and was 16 inches (0.41 m) long. Therefore, the credenza file drawer which holds horizontal files is about 23.43 lbs (10.63 kg) which was then rounded to 24 lbs (10.9 kg) of paper weight contained in the credenza to account for note pads, other files and additional combustible office supplies. My findings are consistent with the check done by Dr.Quintiere in Appendix A.5.
5. Storage file cabinet drawer in ENFP photocopy room held 10 reams of paper at about 2.5" (0.064 m) thick and five pounds per ream. One drawer held ~ 50 lbs (22.68 kg) of photocopy paper.

A.5 Dr. Quintiere check of file cabinet content and comparison

Horizontal File Cabinet:



Lateral File Cabinet:



Legal paper ~ 50(3/2)=75 lbs (34.02 kg)
Standard paper ~ 50 lbs (22.68 kg)
Drawer capacity = 150 lbs (68.04 kg)
30 inches = 0.762 m
18 inches = 0.457 m
12 inches = 0.305 m
6 inches = 0.15 m

A.7 NIST Presentation Explanatory Page for the Excel Document 'NIST prsntn'

The following information is meant to clearly explain the Excel documents used to analyze the combustible load on the 96th floor of the WTC North tower.

Table 1. For Excel sheet 'item wts."

Column designation	Description of how the value was obtained and/or what it means/relevance
A1	For ease of identification when printed I inserted column and row details.
A2	Row and column designations for ease of reference.
B2	Heading to show that the following data is calculated from information obtained by Quintiere & Stewart of UMCP.
C2	WTC1 96th floor ('item wts.') to let reader know which printed sheet they are viewing.
B4	Classification refers to the description of where the furniture item may typically found on the 96th floor.
C4	Item type refers to the physical description of an individual item found on the 96th floor as obtained from Gensler Architectural plans and Appendix J of the NIST preliminary WTC report.
D2-D4	Stock identification numbers were obtained from comparing the Gensler Architectural plans to the AutoCAD symbol library obtained from www.Knoll.com
E3-E4	Weight of furniture per item refers to the weight of one piece of furniture as it is, complete and unpacked. These weights were obtained from a Knoll Sales person.
E5	Weight of furniture in pounds (lbs)
F5.	Weight of furniture in kilograms (kgs)
G3-G4	Number of items refers to the number of items found on the 96th floor of WTC 1. This information was obtained from Gensler Architectural plans.
H2-H4	The weight of combustible material for empty furniture item refers to the amount of material for a single, unused piece of furniture (obtained from Knoll sales person who was referring to either a binder or computer when we spoke but did not

	wish to send confirmation of combustible weights via email).
H5 & I5	Combustible weight in lbs and kgs respectively
J3-J4	Weight of paper in one item is an estimate of the amount of paper to be found in/on a particular piece of furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
J5 & K5	Paper weight in lbs and kgs respectively
J9	Calibre cabinet was not given a paper weight of 15 lbs each but rather an estimate for clothing, note pads and other office items. The 15 lbs were put under weight of paper for ease of reference.
L2-L4	Total weight of paper for all items means that the weight of paper for one furniture item has been multiplied by the number of items on the floor.
L5 & M5	Total paper weight in lbs and kgs respectively
N2-N4	Combined weight for one full item means combustible and noncombustible weight of one full item. This column provides the total weight of one piece of a particular furniture type; self weight plus paper weight.
N5 & O5	Total furniture weight in lbs and kgs respectively
P2-P4	Total weight of combustible material for full item, this column provides the combustible weight of the furniture plus the added paper weight for one piece of a particular furniture type.
P5 & Q5	Combustible material weight in lbs and kgs respectively
R2-R4	Total combustible weight is the weight of combustible material times (x's) number of items. This means that the total combustible weight (P column) was multiplied by the number of times that piece of furniture was found on the 96th floor (G column).
R5 & S5	weight in lbs and kgs respectively
T2-T4	Total combustible and noncombustible weight provides the furniture self weight plus the added paper weight.
T5 & U5	Total weight (combustible + noncombustible) for 96th floor in lbs and kgs respectively

V3-V4	Total weight of the furniture only (both combustible and non-combustible furniture weight. Note, there is no added paper weight here)
V5 & W5	Furniture weight, only, for 96th floor in lbs and kgs respectively
B6-B25	Items that may be located in a workstation, there were different designs; these office items were found among the workstations on the 96th floor.
B27-B30	Common files refer to the lateral files that were either at the end of a workstation grouping or in a common area. (previously left out by NIST)
B32-B39	These are the different types of conference chairs found on the 96th floor.
B41-B45	These are the different types of conference tables found on the 96th floor.
B47-B51	These are the different types of common items found on the 96th floor.
B53-B61	These are the different common/shared rooms located on the 96th floor.
B63	Despite there being different sizes and weights of paper used, the estimate was based on Boise 20weight, 500 sheet 5 lb reams.
Notes:	
C7	The three file credenza was only included by NIST for the brand mane workstation. Appendix J shows that there was not a credenza for the generic workstation but rather a third two drawer file cabinet. If this was to account for the lack of a credenza then the combustible furniture weights were significantly different. (Credenza combustible weight of 17 lbs vs. all metal for the two drawer lateral file). If this was an attempt to account for the files at the end of workstation groupings then they should have been placed outside the workstation and the credenza would have been negated.
C9	The Calibre cabinet was not shown in any of the Appendix J photos but was present on the 96th floor, per Gensler, in the amount of 62 units with a **combustible** weight estimate of 175 lbs each!
Row 66	Provides 'sum' of columns
NIST	
A1	For ease of identification when printed I inserted column and row details.
A68	Row and designations for ease of reference.

B70	Heading to show that the following data is from NIST, Appendix J of preliminary report.
B71	Classification for the description of where the furniture item may typically found on the 96th floor from Appendix J.
C70	Item type refers to the physical description of an individual item found on the 96th floor as obtained from Gensler Architectural plans and Appendix J of the NIST preliminary WTC report.
D70	Stock identification numbers were obtained from comparing the Gensler Architectural plans to the AutoCAD symbol library obtained from www.Knoll.com
E69	Total weight of each item refers to the weight of one piece of furniture as it is, complete and unpacked. These weights were obtained from a Knoll Sales person.
E70	Weight of furniture in pounds (lbs)
F70	Weight of furniture in kilograms (kgs)
G68-G69	Number of items refers to the number of items found on the 96th floor of WTC 1. This information was obtained from Gensler Architectural plans except that the number of desks came from the FDS office graphic in Appendix J.
H68-H69	The weight of combustible material for empty furniture item refers to the amount of material for a single, unused piece of furniture (obtained from Knoll sales person who was referring to either a binder or computer when we spoke but did not wish to send confirmation of combustible weights via email).
H70 & I70	Combustible weight in lbs and kgs respectively
J68-J69	Weight of paper in one item is an estimate of the amount of paper to be found in/on a particular piece of furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
J70 & K70	Paper weight in lbs and kgs respectively
L68-L69	Total weight of paper for all items means that the weight of paper for one furniture item has been multiplied by the number of items on the floor.
L70 & M70	Total paper weight in lbs and kgs respectively

N68-N69	Combustible and noncombustible weight of one full item, this column provides the total weight on one piece of a particular furniture type, self weight plus paper weight.
N70 & O70	Total furniture weight in lbs and kgs respectively
P68-P69	Total weight of combustible material for full item, this column provides the combustible weight of the furniture plus the added paper weight for one piece of a particular furniture type.
P70 & Q70	Combustible material weight in lbs and kgs respectively
R68-R69	Weight of combustible material times (x's) number of items means that the total combustible weight (P column) was multiplied by the number of times that piece of furniture was found on the 96th floor (G column).
R70 & S70	weight in lbs and kgs respectively
T68-T69	Total combustible and noncombustible weight provides the furniture self weight plus the added paper weight.
T70 & U70	Total furniture weight for 96th floor in lbs and kgs respectively
B71-B84	Items that may be located in a workstation, there were different designs; these office items were found among the workstations on the 96th floor.
Notes:	
C73	The three file credenza was only included by NIST for the brand mane workstation. Appendix J shows that there was not a credenza for the generic workstation but rather a third two drawer file cabinet. If this was to account for the lack of a credenza then the combustible furniture weights were significantly different. (Credenza combustible weight of 17 lbs vs. all metal for the two drawer lateral file). If this was an attempt to account for the files at the end of workstation groupings then they should have been placed outside the workstation and the credenza would have been negated.
C72	The Calibre cabinet was not shown in any of the Appendix J photos but was present on the 96th floor, per Gensler, in the amount of 62 units with a **combustible** weight estimate of 175 lbs each!

Row 86	Provides 'sum' of columns
R86	Is the amount of combustible weight calculated by UMCP using NIST data however, it does not include carpet tiles and ceiling tiles. That contributes to the discrepancy UMCP(106,705 lbs) vs. NIST (660 lbs * 204 desks-134,640 lbs)
T86	Is the amount of total weight calculated by UMCP using NIST data however, it does not include carpet tiles and ceiling tiles. That contributes to the discrepancy UMCP(247,098 lbs) vs. NIST (1600 lbs * 204 desks-326,400 lbs)

Table 2. For Excel sheet 'wrkstn wts'

Column designation	Description of how the value was obtained and/or what it means/relevance
A1	Row and column designations for ease of reference.
B2	Heading to show that the following data is calculated from information obtained by Quintiere & Stewart of UMCP.
C2	WTC1 96th floor ('wrkstn wts') to let reader know which printed sheet they are viewing.
E3, H3, P2, Z2 & AM2	These are sub category designations.
G2	All weights on this sheet are in pounds.
B4	Description refers to designation of the employee who was originally assigned to that desk location on the 96th floor.
C4	Station identification is the number assigned on the architectural plans for a particular desk location.
D4	Telephone extension for a particular workstation
E4	Staff refers to the COMBUSTIBLE weight of one staff chair.
F4	Visitor refers to the combustible weight on staff chairs that can be attributed to that workstation.
G4	Conference refers to the conference area/room chairs that correspond to the

	designated location.
H4	J-shape refers to the style of knoll table that can be found at that workstation location; combustible weight is provided and does not include mounting or legs.
I4	Is the paper weight most likely to be found on the J-shape table and is an estimate of the amount of paper to be found on furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
J4	½ round table refers to the style of knoll table that can be found at that workstation location; combustible weight is provided and does not include mounting or legs.
K4	Is the paper weight most likely to be found on the ½ round table and is an estimate of the amount of paper to be found on furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
L3-L4	Teardrop or circular table refers to the style of knoll table that can be found at that workstation location; only combustible weight is provided and does not include mounting or legs.
M2-M4	Is the paper weight most likely to be found on the teardrop or circular tables and is an estimate of the amount of paper to be found on furniture. These two tables were grouped together because they have nearly identical weight as provided by Knoll customer service representative. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
N4	This is the boat shaped conference table that is located in the following conference rooms: NE, NW, SE, & SW
O3-O4	Is the paper weight most likely to be found on the boat shaped table and is an estimate of the amount of paper to be found on this furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
P2-P4	Wall Panels: 4 foot high and two feet wide privacy panels used at each desk. The weight of 3 panels*14 lbs = 42 lbs.
Q3-Q4	Is the paper weight most likely to be found on the three privacy panels and is an

	estimate of the amount of paper to be found on these pieces of furniture. One privacy panel was observed to have 0.15 lbs of paper attached to it which is ~ 15 sheets of standard paper. This information was obtained by casual load observations and calculations of privacy panel decorations, calendars and other items.
R3-R4	Wall Panels: 4 foot high and three feet wide privacy panels used at each desk. The weight of 3 panels*24 lbs = 72 lbs.
S3-S4	Is the paper weight most likely to be found on the three privacy panels and is an estimate of the amount of paper to be found on these pieces of furniture. One privacy panel was observed to have 0.15 lbs of paper attached to it which is ~ 15 sheets of standard paper. This information was obtained by casual load observations and calculations of privacy panel decorations, calendars and other items.
T3-T4	Wall Panels: 5 foot high and three feet wide privacy panels used at each desk. The weight of 1 panel*35 lbs = 35 lbs.
U3-U4	Is the paper weight most likely to be found on the three privacy panels and is an estimate of the amount of paper to be found on these pieces of furniture. One privacy panel was observed to have 0.15 lbs of paper attached to it which is ~ 15 sheets of standard paper. This information was obtained by casual load observations and calculations of privacy panel decorations, calendars and other items.
V3-V4	Overhead cabinet refers to the double door cabinet that attaches to the five foot high privacy panel. The estimated combustible weight provided.
W2-W4	Paper weight for the overhead cabinet obtained from NIST Appendix J
X3-X4	Combustible weight of the Calibre cabinet (not included by NIST at all)
Y3-Y4	Additional weight is the added combustible weight for this furniture item.
Z2-Z4	Credenza 3-drawer is another furniture item that NIST did not include but rather per appendix J, equated cabinet fronts, presumably to justify negation
AA2-AA4	Paper weight for the one horizontal file drawer, one slender drawer and another miscellaneous storage drawer. Again, this information was obtained by weighing the file contents of two different ENFP horizontal drawers and adding additional

	weight for note pads etc…
AB2-AB4	Lateral file two-drawers refer to the all metal personal lateral files found at each workstation.
AC2-AC4	This is the paper weight contained in the lateral files, capacity is 150 lbs per drawer but I used 100 lbs per drawer based on the file contents of the horizontal drawer survey mentioned previously.
AD3-AD4	Common files used a wood counter-top
AE2-AE4	Paper weight likely to be found on wood counter-tops
AF3-AF4	This is the standard desk, Morrison, as obtained the Gensler architectural drawings and AutoCAD symbol library. This is the combustible weight of the desk only and does not include the mounting or table legs.
AG3-AG4	Paper weight that is likely to be found on this desk, it is a conservative estimate, and the information was obtained from a casual load survey.
AH2-AH4	Supplementary worktable (square or one rounded edge), these are added to the Morrison desk set-up based upon the workstation design, as obtained from Gensler architectural drawings. This is the combustible weight of the desk only and does not include the mounting or table legs
AI3-AI4	Paper weight that is likely to be found on this desk, it is a conservative estimate, and the information was obtained from a casual load survey.
AJ3-AJ	Computer monitor at workstation. Not all workstations appear to have a computer and there is '?' for any location that I was unsure about.
AK2-AK4	Computer hard drive at workstation.
AL3-AL4	Additional – unable to id means that there was something at that workstation that unidentifiable from Gensler architectural drawings.
AM2-AM4	Some workstations have additional chairs attributed to them; that is all this column is referencing.
AN2-AN4	Lateral files: 3 drawer metal file cabinets that is part of the common files.
AO2-AO4	Lateral files: 4 drawer metal file cabinets that is part of the common files.
AP2-AP4	Common files used a wood counter-top
AQ2-AQ4	Paper weight likely to be found on wood counter-tops

AR2-AR4	Corresponding panels refer to the panels that line some parts of the file cabinet groups.
AS2-AS4	Comment on which workstation design repeats; designated by employee.
AT2-AT4	Total times it occurs refers to the number of times that workstation design can be found on the 96th floor.
AU2-AU4	Combustible weight for an individual workstation type
AV2-AV4	Combustible sum of workstation weight per type
AW2-AW4	Combustible weight of file cabinets that NIST left out from their experimental burns.
AX2-AX4	Noncombustible weight of file cabinets that NIST left out from their experimental burns, 3 drawer cabinet.
AY2-AY4	Noncombustible weight of file cabinets that NIST left out from their experimental burns, 4 drawer cabinet.
AZ2-AZ4	Noncombustible weight of open metal shelving units that NIST left out from their experimental burns, 6 metal shelves.
BA	Sum of the combustible weight of other rooms on the 96th floors.

A.8 Excel Sheets

(attached)

Comments on NIST NCSTAR 1 Draft

July 27, 2005

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With suggested changes in red to NIST report by Arthur Scheuerman

General Comments

These comments pertain to the NIST summary chapter of the NCSTAR 1 Draft report, and are based on statements also from the June 2005 progress report. My comments will be annotated (Appendix A) to indicate their source and to provide additional information.

My comments address the fire analysis, the heating of the steel and issues pertaining to such. In summary, I list the issues and concerns that I have with the NIST presentation and findings:

1. I do not believe that NIST has presented a convincing argument for their collapse hypotheses for WTC 1 and 2. NIST had repeatedly stated that they would list all likely collapse scenarios in terms of their probabilities based on uncertainties in the analyses. That seems to have been abandoned in the final report. Their collapse hypothesis is based on damage done by the aircraft impacts, particularly in removing insulation from the core columns is key, together with brief local fire heating of above 1000 oC for about 15 minutes. NIST has not made a sufficient case for the removal of the steel insulation, and the fire analysis is based on a light fuel

load that is shown to be in error. I suggest an alternative hypothesis based on longer fire duration, and on the insulation staying primarily in place.

2. NIST claims that if the insulation had stayed in place, the computed fire was not able to cause building collapse. Therefore, they conclude that the insulation applied in design was adequate: "The WTC towers would likely not have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact." [p172] I have not seen sufficient evidence to indicate that the insulation was removed, nor that the insulation applied, had it remained in place, was adequate.

3. NIST was not able to document the WTC design process with respect to the selection of the steel insulation or its basis: "NIST was not able to find any evidence that there was a technical basis to relate SFRM thickness to a fire resistance rating, nor was there sufficient prior experience to establish such thickness requirements by analogy." [p 55] the lack of findings is a tragedy of this investigation as it goes to the core of fire protection design and its dependence on regulations. If we do not know how the process worked for these buildings, how do we know it is being done satisfactorily now.

4. The report represents more of a scientific analysis rather than an investigation to find all of the relevant facts. NIST held no hearings to ascertain testimony, used no subpoenas, and enlisted no investigative team to gather information. NIST was very late in acquiring witness accounts due to the federal government bureaucracy requirements on public surveys. Steel remnants were collected as they were available, and reports from the PA or others involved were taken as fact without corroboration. An example is the acceptance of insulation applied to the trusses in renovation to the north tower, WTC1, impact area as 2.5 inches compared to the

specification of 1.5 inches over the original 0.5 inches. This is an incredible difference, realizing that they reported up to 4 inches applied to a 1- inch diameter rod. ("The Port Authority provided NIST with the records of measurements of SFRM thickness on upgraded floors in both towers. The average thickness and standard deviation on the main trusses was 2.5 in. ± 0.6 in. NIST analysis of several Port Authority photographs from the 1990s of the upgraded 31 st floor of WTC 1 indicated an average thickness and standard deviation on the main trusses of 1.7 in. ± 0.4 in.") [p 70] Had more steel been examined from the fire floors, NIST may have been able to establish proof for its hypothesis that key core columns were denuded of insulation and therefore significantly heated to cause their reduction in strength. NIST found no evidence to corroborate that finding. "None of the recovered steel samples showed evidence of exposure to temperatures above 600 C for as long as 15 min. This was based on NIST annealing studies that established the set of time and temperature conditions necessary to alter the steel microstructure. These results provide some confirmation of the thermal modeling of the structures, since none of the samples were from zones where such heating was predicted." [p 176] Had NIST recovered steel from the areas where steel was predicted to have been heated, could have given them key evidence to support their claim. As the steel was expeditiously sold to Asia, before the fire floor steel could be identified from its markings and saved, was a significantly blunder in the investigation. Since NIST has jurisdiction over future investigations, a protocol for protecting evidence and securing the site must be established. Moreover, the rationale for the speedy elimination of the steel in this incident, NIST fails to document. Spoliation of fire scene evidence can border on a crime.

5. The NIST report is difficult to read due to its length and tedious style. It does not clearly show cause and effect. Standard analyses of fires attempt to give a time line. While the actual

timeline is clearly known in this case, the predicted timeline and its cause and effect listing is not presented. There are vague references that the predicted fire looked right. Dr. Sunder indicated that a timeline was not predicted, as difficulties exist with the nonlinear creep structural model. Only a mechanistic analysis was presented [NFPA meeting at NIST, July 12, 2005]. The report needs to clearly indicate the scientific reasons for the NIST description of the collapse scenarios and tie them to the results of their computations and assumptions. This needs to be done with footnoted annotations so a reader can find the details. This 10,000- page report will only serve as a smoke screen unless it is fully documented for easy reference.

6. NIST has never acknowledged of answered comments in the past, so it is doubtful that these comments will have any impact. I urge them to be more responsive. I am attaching my unanswered November 22, 2004 comments for background. (Appendix B)

Specific comments:

1. Collapse Hypothesis

Structural Failure

NIST contends that the collapse is due the floors pulling in the external columns that in turn lose stability [p 171,2]. This occurs on the south of WTC 1 and the east of WTC 2. They say WTC 2 collapses earlier because it received more damage from the aircraft.

I find an alternative hypothesis that can be supported by relatively simple computations on the heating of the steel trusses with their specified insulations in place [Quintiere et al, Fire Safety J. 2002, and Quintiere, Interflam 2004]. This analysis does not include the heating of the core columns, as they would never get hot enough to fail if their insulation remained intact. Table 1 summarizes the results, and shows computations for a fire of 800 °C, and indicates the time for the steel to reach 600 °C where it falls to 20 % of its original strength. The truss at this temperature would fail due to the deflection pulling in the external columns as indicated by Usmani [FSJ 2003], and by NIST [June 2004 Progress report, Vol 1, p 81, 120] by either this column buckling or by failure of the connections. Buckling can occur at steel temperatures as low as 400 °C while the seat failure occurs at 650 °C.

It is noted that the predicted times to reach the critical failure temperature of the truss steel of 55 -73 minutes for WTC 2 and 111 minutes for WTC 1 in Table 1 is consistent with the building collapse times of 56 and 102 minutes, respectively. These predicted heating times are also consistent with the NIST measured heating times (to 66 to 86 minutes, although the reduced scale 17 ft span tests compromised heat transfer) in the UL furnace tests at fire temperatures comparable to 800 °C shown in Table 2 taken from NIST. Indeed, the UL time to reach 1100 °F (593 °C) for the 35 ft span ranges from 66 to t6 minutes which is consistent with 73 minutes in Table 1 and an extrapolated time of 50 minutes for the UL temperature conditions. (See Figure 1.)

Table 1. Time for steel elements to reach 600 °C in an 800 °C fire (Interflam 2004).

Element	Insulation Thickness mm	Time to Reach 600 °C with insulation, min.	Time to Reach 600 °C with no insulation, min	E119 Rating Requirement min.
27.7 mm rod, 54 kg/m^2 WTC 2	12.7	55	8	120
N WTC 2	19.1	73	8	120
N WTC 1	38.1	111	8	120
14WF43, 43 kg/m^2 core	44.5	213	6	180
55.8 cm box column, 7.6 cm thick, 513 kg/m^2 core	28.6	1640	75	180

Table 2. UL test results form NIST

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

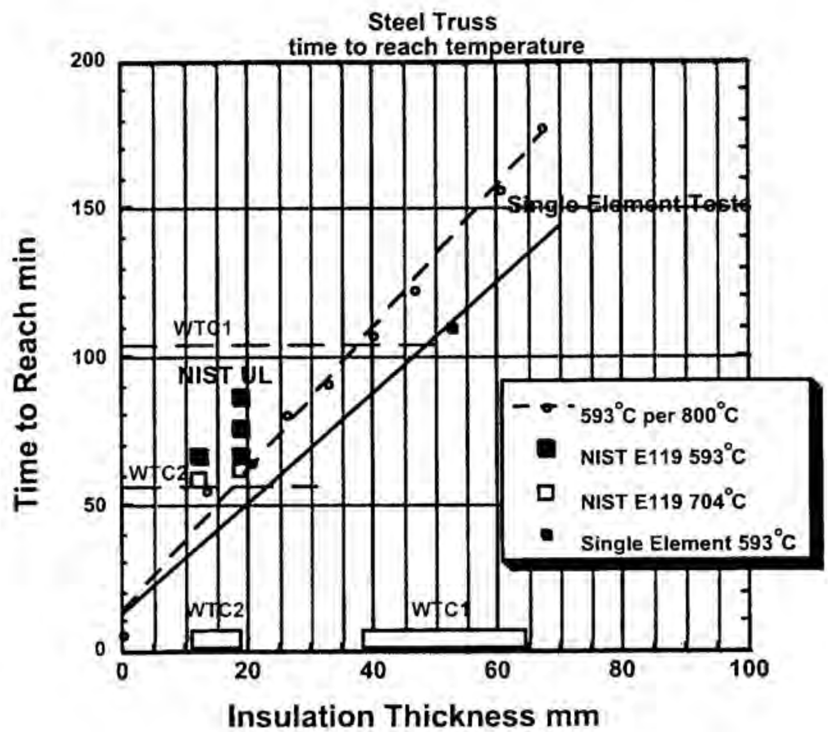

Figure 1. UL and Isolatek results.

Consequently, if the truss elements with specified insulation levels of ½- ¾ in. for WTC 2 and 1 ½ in. for WTC 1 can be heated to about 600 °C in an 800 °C fire at computed times of 55-73 minutes and 111 minutes, respectively, and NIST and others determined that the truss would cause either column buckling or connection failure at 600 °C or below, then this mode of collapse cannot be discounted. This is especially compelling since the collapse times are consistent at 56 and 102 minutes. Moreover, it is commonly known that floor sections were collapsing up to 20 minutes before the full collapse of each of the buildings. NIST has not addressed those early failures.

Fire Simulation

The results of the NIST fire predictions are based on a fuel loading of 4-5 psf. These levels are based on data from the impacted floors of Marsh & McLennan in WTC 1. NIST says this has "high" accuracy [p 119]. They find for WTC 1 that a given floor did not have uniform temperatures. "At any given location, the duration of temperatures near 1,000 °C was about 15 min to 20 min." [p 127] Upper layer temperatures are shown in Figure 2 for WTC 1 97th floor [NIST]. Temperatures generally exceeded 600°C for about 30 minutes, and for about 60 minutes in the core. In contrast, a scale model test conducted at the University of Maryland, representative of the 96th floor with a simulated fuel load of 11.5 psf, shown in Figure 3 indicates temperatures are generally over 6000C(typo?, 600C) for 100 minutes, by(typo?) are much cooler in the core. These results are distinctly different from the NIST simulation. One may be dubious of scale modeling, but it is a tried and true technique.

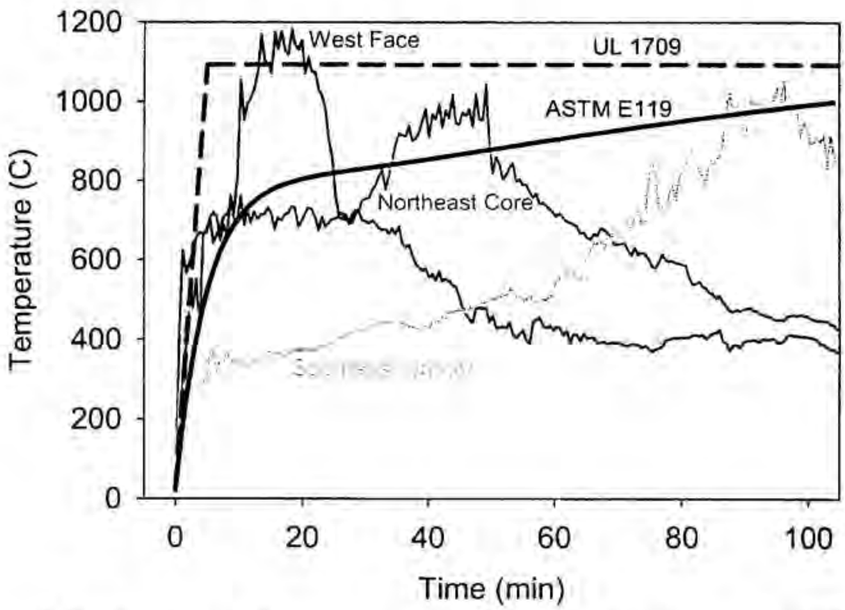

Figure 2. Predicted upper layer temperatures at various locations on the 97th Floor.

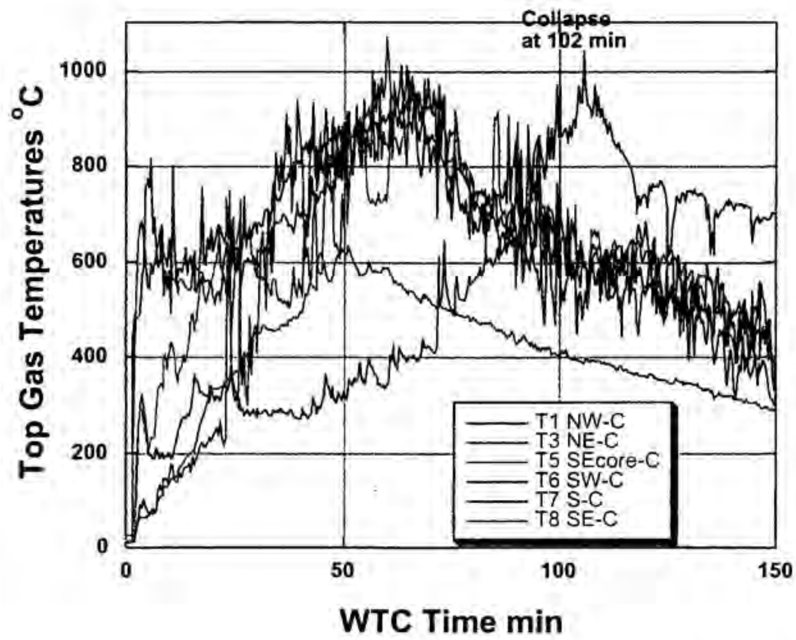

Figure 3. Temperatures in a scale model of WTC 1 96th floor

The heavier fuel load in the scale model was based on traditional office loadings and on anecdotal interviews of people familiar with the floors. Subsequently, we conducted a fuel load survey of the 96th floor based on architectural plans obtained from the furniture installer. This led to a conclusion that a loading of 10 psf or greater was the case. Appendix C contains the details in a report. Figure 4 shows a section of the architectural plans used for the 96th floor. A handwritten notation indicates a section of common files that ringed the core of the office space. There were 170 of these 4-drawer lateral files. NIST completely ignored this fuel load (and others) in their assessment. We assigned 100 lbs of paper per draw (a sub-capacity level) giving 68,000 lbs for this contribution. In addition, there were other common files and a storage room that gave a grand total of 95,400 lbs not included by NIST. In the survey conducted by Kate Stewart, estimates of paper and personal items were included in the workstation loads based on typical office conditions. Our total floor combustible loading was estimated at 302,062 lbs compared to 134,640 lbs determined by NIST. Taken over the office floor space area (31,013 ft^2), this computes to 9.7 psf and 4.3 psf for NIST. Our paper extimat per file draw is well below

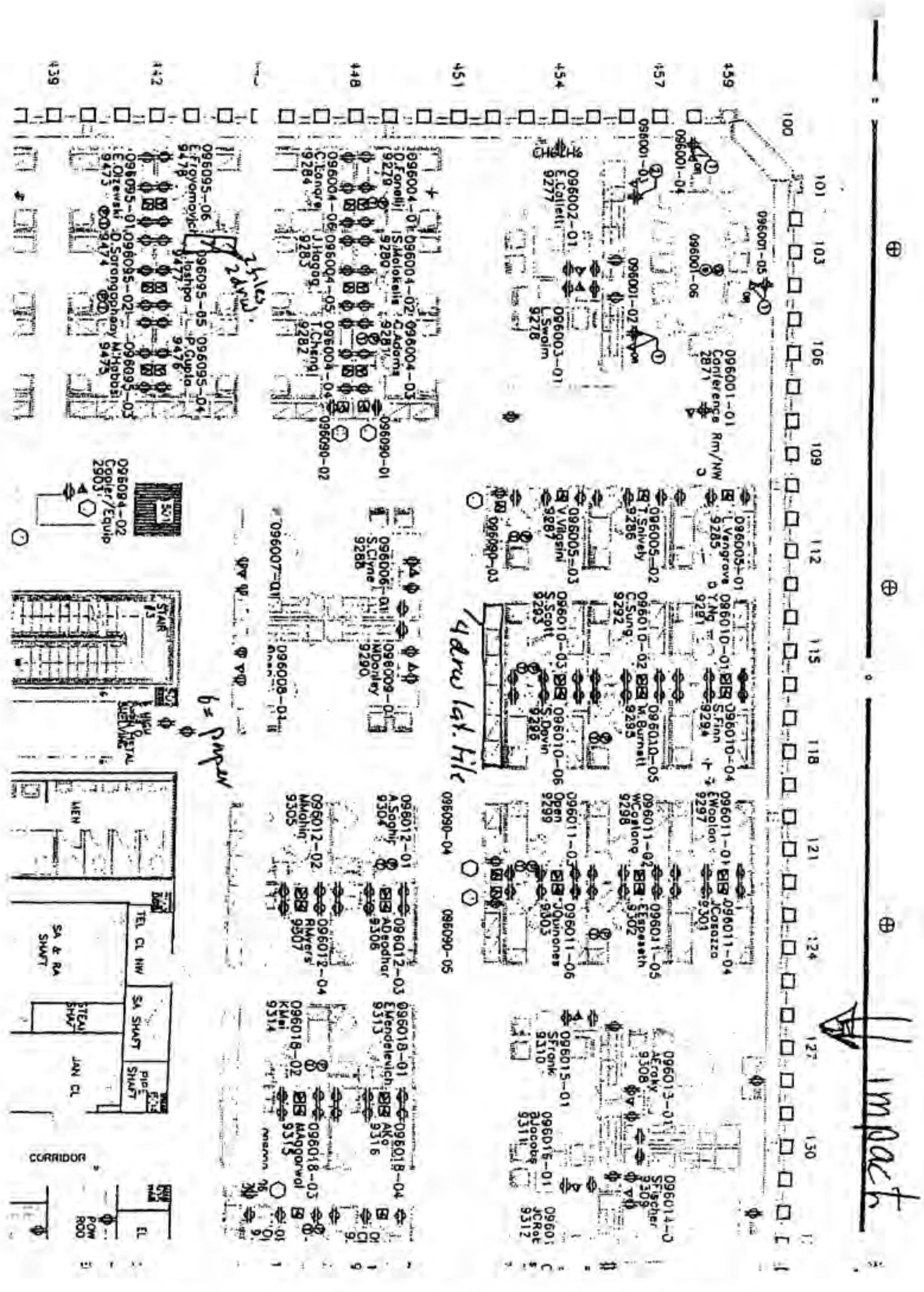

Figure 4. Section of furniture layout WTC 1 96th floor

capacity, so the loading we determine is likely too low. Indeed, it was told to us that Marsh was a "paper hog" and "kept everything". Paper fuel in closed files is de-rated in fire design considerations, but the aircraft impact could have opened the file draws.

It is generally expected that fully developed fires achieve nearly uniform temperature of over 800°C, and are expect to persist for hours. Hence, we have the standard rating of structures at 2 to 3 hours of endurance. Had NIST used higher fuel loadings, they would have had longer hot fire conditions and this would impact their input into the structural modeling. The discrepancy in the fuel load raises some questions. Moreover, the large differences in the fuel loading found by us and NIST on the Marsh floors raises more questions. Incidently, our independent check of the workstations exclusively counted by NIST gave us a combustible load of 133,694 lbs compared to their count of 134,640 lbs. In addition, while NIST claims high accuracy for the loading in WTC 1, they do not for WTC 2. Moreover, it appears that the fire simulation in WTC 2 is only about half the size of WTC 1. More needs to clarified here.

2. *Insulation Lost on Impact*

NIST has not presented clear and sufficient evidence that the aircraft impacts caused the elimination of insulation, especially from the core columns. According to NIST [Sunder, July 12, 2005 NFPA committee meeting], the planes disintegrated on impacting the exterior columns. This debris and its momentum is alleged to have removed the insulation. Heavy item, such as an engine or landing gear, could cause structural damage to a column in the core: "If the engine missed the floor slab, the majority of the engine core remained intact and had enough residual momentum to sever a core column upon direct impact. " [p 105] This suggest that hitting a floor slab, which is very likely due to the diameter of the engine, then less damage would be done. Moreover, the accuracy of the impact calculation is not high as other compute different damage results. Specifically on the insulation loss, NIST says it could be shook off due to vibrations, or eroded off due to pulverized debris impact. On the former NIST concludes: "The analyses were not sufficient to establish justifiable, general criteria for a coherent pattern of vibration-induced dislodging." [p 117] ON the erosion, NIST did static tests on the insulation adhesive strenth, but never coupled these results to a computational model. Instead, "NIST assumed that the debris impact dislodged insulation if the debris force was strong enough to break a gypsum board

partition immediately in front of the structural component. Experiments at NIST confirmed that an array of 0.3 in. diameter pellets traveling at 350 mph stripped the insulation from steel bars like those used in the WTC trusses." [p 117] These pellet tests need more amplification, as they are the only test simulation of the erosion effect. Moreover, the test speed of 350 mph is not consistent with the average speed of debris traversing the buildings. The debris took about 0.7 s [sunder, July 12, 2005] to exit, giving an average speed of 205 ft/0.7s or 200 mph. As momentum depends on the square of the velocity, NIST has overestimated the momentum in these pellet tests by a factor of 3.

It is crucial to the NIST collapse hypothesis that the insulation is removed on impact. It begs more support.

3. WTC Fire Resistance Design

From the outset of its construction, fire safety was a concern for the WTC. From the records, clearly cost, time and safety were involved. For NIST not to have probed these facets, and to assess, in the least, the disparate range of insulation thickness assigned to the floor assembly truss system a dereliction of the intent of this investigation. NIST cites historical facts [p 69 +], but not the underlying rationale for decisions. Although an extensive civil suit on the insulation deficiencies occurred in the 1990's, NIST appears to have not examined those records.

How can on justify a specification of ½ in., a change to 1 ½ in. in the 90's, an ICBØ recommendation of 2 in. [p 192], and an actual upgrade to 2.5 +/- 0.6 in. on the impact floors of the WTC 1? The extensive over-application up to 3 in. on a round 1 in. diameter bar-joist is difficult to accept based solely on a report from the PA when photographic evidence for other upgraded floors shows only 1.7 +/- 0.4 in. according to NIST [p 71].

Whether this insulation on the truss was key as I believe, or not, is not the issue here. The process of fire resistance regulations and their interpretation is the issue. This needs to be scrutinized. It should have been at the heart of the investigation, and that is why NIST has proceeded as a scientific body rather than an investigative agent. Civil lawyers would have

pushed this, whereas the Commerce lawyers seemed more concerned to restrict the scientists, and block information from the public.

4. Lack of In Depth Investigation

The NIST report reads like a scientific enterprise using computer simulations that have never been used (or validated) in this way before. [119] Other government agencies that have investigative authority operate differently. The NTSB has time scene presence, press briefings, and formal hearings with testimony. The ATF has a National Response Team that is on the scene within hours of the event. They secure the scene, question witnesses, and gather evidence. NIST has operated in near secrecy, has had a low public profile, and has gathered facts as in a library search. Although they have held public forums, these have been very controlled, under publicized, and dominated by NIST. They have not appeared to have aggressively, or with corroboration in mind, pursued evidence. The Commerce lawyers could have helped here. With the amount of funding that they received they could have conducted a full-scale test of a floor. They could have given more support to their purely mathematically modeling results. As scientists are sometime stereotyped as being out of touch with reality, NIST cannot afford that stigma as an investigative body as NCSTAR.

5. On the Recommendations

Thirty recommendations are listed. They all are general and imply more research is needed. One cannot fault NIST fro trying to expand its research base, as they have not been properly funded in the fire and building areas since the 1970's. The fire funding with NSF and industry support ran as high as $ 10 million in the mid- 70's. Its comparable level in today's dollars is much lower. But the funding issues should not cloud the work of the NCSTAR. Yet the NCSTAR is only authorized to proceed and funding for its continuation is doubtful. So perhaps funding is the real issue.

The recommendation areas cover:

1. Increased structural integrity, including methods for preventing conditions that could result in progressive collapse (when a building or a significant portion of a building collapses due to disproportionate spread of an initial local failure), standardizing the estimation of wind loads that frequently govern the design of tall buildings, and enhancing the stability of tall buildings.

2. Enhanced fire resistance of structures, including the technical basis for determining construction classification and fire resistance ratings, improvements to the technical basis for standard fire resistance testing methods, adoption of the "structural frame" approach to fire resistance ratings, and in-service performance requirements and conformance assessment criteria for spray-applied fire resistive materials.

3. New methods for designing structures to resist fires, including the objective of burnout without collapse, the development of performance-based methods as an alternative to current prescriptive design methods, the development and evaluation of new fire resistive coating materials and technologies, evaluation of the fire performance of conventional and high performance structural materials, and elimination of technical and standards barriers to the introduction of new materials and technologies.

4. Improved active fire protection, including the design, performance, reliability, and redundancy of sprinklers, standpipes/hoses, fire alarms, and smoke management systems.

5. Improved building evacuation, including system designs that facilitate safe and rapid egress, methods for ensuring clear and timely emergency communications to occupants, better occupant preparedness for evacuation during emergencies, and incorporation of appropriate egress technologies.

6. Improved emergency response, including better access to the buildings and better operations, emergency communications, and command and control in large-scale emergencies.

7. Improved procedures and practices, including encouraging (legislating?) code compliance by nongovernmental and quasi-governmental entities, adoption and application of egress requirements in available code provisions for existing buildings, and retention and availability of building documents over the life of a building.

8. Education and training programs for fire protection engineers, structural engineers, and architects.

I generally support NIST in all of these areas, as they are important areas to pursue for research. Recommendation that can lead to immediate code changes need to go more slowly, as they require consensus and checks and balances. NIST as part of its name suggests can play an important role in "Standards" for fire safety, but they must be enabled to do that successfully. The fire and building programs at NIST have atrophied, and must be brought back to full competence. These and other programs at NIST must rely on outside funding to support their staffs. That effort, in particular, takes away form the fire program, as industry does not wish to fund safety regulations. For other programs in NIST where standards benefit industry and grease the market place, those programs find fertile support in industry. Fire safety is different, and the congress needs to appreciate that, and direct its funding accordingly.

I would like to offer some more specific comments to the NIST recommendations # 29 and 30 that pertain to education. They advocate "continuing education curricula" for structural and fire engineers and architects on modern principles and on the use of computational methods. While this is good, it is not enough; and it could produce people who think they have expertise, but do not. The education in fire protection engineering is sorely lacking in the US. Only about 50 engineers are produced a year at institutions granting a recognized engineering degree (U of MD, WPI) and technology degrees (OSU, U of Akron, etc.). The US likely needs 500 engineers a year. While a careful study of the need has not been done, the training received in continuing education courses currently indicates the lack of fire protection engineer in the field of fire investigation and in the protection of nuclear plants as stark examples. In addition, the population that makes up the regulators and participate in the code and standards making process generally lack degrees. The estimate I cite comes from the fact the University of Lund program in Sweden place all of their graduates at a rate of 2 in million of population per year in the private sector and 2 more in the fire service profession. This gives a benchmark of 2 to 4 per million of population. If the fire service in the US began to hire fire protection engineers, the estimate for the US would be 1000 per year.

The Congress needs to bring the education level of fire protection engineering up to a level that fill the infrastructure needs for the country. This can be fulfilled with NSF providing funds to this field. The Congress needs to further recognize that NIST is under funded in these areas, and

the country needs a better way of getting the proper technical input into the regulatory process for fire safety. It cannot be dependent on voluntary efforts and special interest actions. After the tragedy of 9/11, a better process of fire safety needs to be created. Unfortunately, the NIST NCSTAR draft report does not dramatically demonstrate the deficiencies in the fire process for the design and collapse of the WTC buildings.

Appendix A: NIST NCSTAR 1 Draft Source Material

Collapse Cause

Why the collapse, p171,2

Objective 1: Determine why and how WTC 1 and WTC 2 collapsed following the initial impacts of the aircraft. • The two aircraft hit the towers at high speed and did considerable damage to principal structural components: core columns, perimeter columns, and floors. However, the towers withstood the impacts and would have remained standing were it not for the dislodged insulation and the subsequent multifloor fires. The robustness of the perimeter frame-tube system and the large size of the buildings helped the towers withstand the impact. The structural system redistributed loads without collapsing in places of aircraft impact, avoiding larger scale damage upon impact. The hat truss, which was intended to support a television antenna atop each tower, prevented earlier collapse of the building core. In each tower, a different combination of impact damage and heat-weakened structural components contributed to the abrupt structural collapse. • In WTC 1, the fires weakened the core columns and caused the floors on the south side of the building to sag. (this sentence should read "The fires caused the floors on the South side of the building to sag and weakened the core columns.") The floors pulled the heated south perimeter columns inward, reducing their capacity to support the building above. Their neighboring columns quickly became overloaded as the south wall buckled. The top section of the building tilted to the south and began its descent. The time from aircraft impact to collapse initiation was largely determined by how long it took for the fires to weaken the building core and to reach the south side of the building and weaken the perimeter columns and floors. (This sentence should read; "The time from aircraft impact to collapse initiation was largely determined by haw long it took for the fires to weaken the long span floors on the south side of the building. In WTC 1 the perimeter wall and the core were heavily damaged on the North side and if it were not for the South side floors sagging and failing, destabilizing the South perimeter wall and possibly the core, the building would have tilted to the North before collapsing.") • In WTC 2, the core was damaged severely at the southeast corner and was restrained by the east and south walls via the hat truss and the floors. The steady burning fires on

the east side of the building caused the floors there to sag. The floors pulled the heated east perimeter columns inward, reducing their capacity to support the building above. Their neighboring columns quickly became overloaded as the east wall buckled. The top section of the building tilted to the east and to the south and began its descent. The time from aircraft impact to collapse initiation was largely determined by the time for the fires to weaken the perimeter columns and floor assemblies (change to; "to waken the floor assemblies and possibly the perimeter columns") on the east and south (eliminate "east and") side of the building. WTC 2 collapsed more quickly than WTC 1 because there were early and persistent fires on the east side of the building, where the fireproofing was thinner and had not been upgraded and aircraft may have extensively dislodged insulation from the structural steel. Since the core columns on the lower floors in Tower 2 were much more robust than in Tower 1, it was unlikely there was more aircraft damage to the building core. • It is unknown whether the WTC towers would likely have collapsed under the combined effects of aircraft impact damage and the extensive, multifloor fires if the thermal insulation had not been widely dislodged or had been only minimally dislodged by aircraft impact. A full scale test of the 60 foot long span flooring assembly is needed to clarify thermal stability problems.

On WTC 1: p xliii-xliv

The two aircraft hit the towers at high speed and did considerable damage to principal structural components: core columns, floors, and perimeter columns. However, the towers withstood the impacts and would have remained standing were it not for the (add "deficient", "inadequate" or) dislodged insulation (fireproofing) and the subsequent multifloor fires.

The time from aircraft impact to collapse initiation was largely determined by how long it took for the fires to weaken the building core and to reach the south side of the building and weaken the perimeter columns and floors. (change to "... largely determined by how long it took to weaken the floors which sagged and possibly detached destabilizing the heat weakened perimeter columns and building core."

On WTC 2

n WTC 2, the core was damaged severely at the southeast corner and was restrained by the east and south walls via the hat truss and the floors. The steady burning fires on the east side of the building caused the floors there to sag. The floors pulled the heated east perimeter columns inward, reducing their capacity to support the building above. Their neighboring columns quickly became overloaded as columns on the east wall buckled. The top section of the building tilted to the east and to the south and began its descent. The time from aircraft impact to collapse initiation was largely determined by the time for the fires to weaken the floor assemblies and perimeter columns and on the east and the south sides of the building. WTC 2 collapsed more quickly than WTC 1 because there were early and persistent fires on the east side of the building, where there was less insulation on the structural steel. Whether there was more aircraft damage to the building core and aircraft had extensively dislodged the insulation is still questionable.

Also an analysis of the stability of the towers, assuming no damage to the core, gives the number of floors that need to be removed to cause global failure (June 2004, Vol. 1, p.81):

> The following presents some preliminary findings obtained from the preliminary stability analyses under service live loads and subject to the assumptions and the limitations of these models (see Appendix D): Linear stability analysis was used to examine the stability of the undamaged WTC 1 under service loads through increased un-braced column lengths (floor removal). The tower was stable when two complete floors including the core floors were removed. Two core columns buckled when three floors were removed, but the tower maintained its overall stability. The tower also maintained its stability when four columns buckled with four floors removed. The analysis suggested that global instability of the tower occurred when five floors were removed from the model. Assuming that all columns at the region of the removed floors reached a temperature of 600 °C (reduced modulus of elasticity), the analysis indicates that removal of four floors would induce global instability.

1. Single truss analysis: A model of a single truss and its connection shows that the truss fails at the interior column seat connection, and 'walks off' the seat. This occurs at 650 C. The web diagonals begin to buckle at 340 C, and the exterior columns bow inward at 560 C as the truss to acted as a catenary. (June 2004, Vol. 1 p. 120).

On steel inspected p 88,89

Examination of photographs showed that 16 of the exterior panels recovered from WTC 1 were exposed to fire prior to the building collapse. None of the nine recovered panels from within the fire floors of WTC 2 were directly exposed to fire. NIST used two methods to estimate the maximum temperatures that the steel members had reached: • Observations of paint cracking due to thermal expansion. Of the more than 170 areas examined on 16 perimeter column panels, only three columns had evidence that the steel reached temperatures above 250 °C: east face, floor 98, inner web; east face, floor 92, inner web; and north face, floor 98, floor truss connector. Only two core column specimens had sufficient paint remaining to make such an analysis, and their temperatures did not reach 250 °C. NIST did not generalize these results, since the examined columns represented only 3 percent of the perimeter columns and 1 percent of the core columns from the fire floors. • Observations of the microstructure of the steel. High temperature excursions, such as due to a fire, can alter the basic structure of the steel and its mechanical properties. Using metallographic analysis, NIST determined that there was no evidence that any of the samples had reached temperatures above 600 oC. These results were for a very small fraction of the steel in the impact and fire zones. Nonetheless, these analyses indicated some zones within WTC 1 where the computer simulations should not, and did not, predict highly elevated steel temperatures. 6.5

On the steel p 176

None of the recovered steel samples showed evidence of exposure to temperatures above 600 oC for as long as 15 min. This was based on NIST annealing studies that established the set of time and temperature conditions necessary to alter the steel microstructure. These results provide some confirmation of the thermal modeling of the structures, since none of the samples were from zones where such heating was predicted.

On single truss analysis p 96

Single composite truss and concrete slab section. A floor section was modeled to investigate failure modes and sequences of failures under combined gravity and thermal loads. The floor section was heated to 700 °C (300 °C at the top surface of the slab) over a period of 30 min. Initially the thermal expansion of the floor pushed the columns outward, but with increased temperatures, the floor sagged and the columns were pulled inward. Knuckle failure was found to occur mainly at the ends of the trusses and had little effect on the deflection of the floor system. Figure 6–11 shows that the diagonals at the core (right) end of the truss buckled and caused an increase in the floor system deflection, ultimately reaching approximately 42 in. Two possible failure modes were identified for the floor-truss section: sagging of the floor and loss of truss seat support.

Impact Damage

On damage to WTC1 pp20- 21

The 94 th floor was more severely damaged. The midsection of the left wing, laden with jet fuel, and the left engine cut through the building façade, severing 17 of the perimeter columns and heavily damaging four more. The pieces of the aircraft continued inward, severing and heavily damaging core columns. The insulation applied to the floor trusses above and the columns was scraped off by shrapnel-like aircraft debris and building wall fragments over a wedge almost 100 ft wide at the north face of the tower and 50 ft wide at the south end of the building core.

A 40 ft width of the 96 floor slab was broken 80 ft into the building. The insulation was knocked off nearly all the core columns and over a 40 ft width of floor trusses from the south end of the core to the south face of the tower.

On WTC1 p34

Dislodging of SFRM from structural members due to the aircraft impact, that enabled rapid heating of the unprotected structural steel;

On WTC2 78 flr p 40

Dislodging of SFRM from structural members due to the aircraft impact, that enabled rapid heating of the unprotected structural steel;

On WTC2 81 flr p 41

On the 81 st floor, the fuselage pulverized a section of the floor 40 ft wide that extended into the southeast corner of the core. The SFRM and gypsum fire protection on the full depth of the east side of the core and in the entire east side of the tenant space was stripped.

On impact p 105

The Investigation Team gained valuable knowledge from these component impact analyses, for example: • Moving at 500 mph, an engine broke any exterior column it hit. If the engine missed the floor slab, the majority of the engine core remained intact and had enough residual momentum to sever a core column upon direct impact. • The impact of the inner half of an empty wing significantly damaged exterior columns but did not result in their complete failure. Impact of the same wing section, but filled with fuel, did result in failure of the exterior columns.

On the accuracy of the impact model p 114

Two pieces of landing gear penetrated WTC 1 and landed to the south of the tower. The Case B prediction showed landing gear penetrating the building core, but stopping before reaching the south exterior wall. For WTC 2, a landing gear fragment and the starboard engine penetrated the building and landed to the south. The Case D prediction correctly showed the main landing gear emerging from the northeast corner of WTC 2. However, Case D showed that engine not quite penetrating the building. Minor modifications to the model (all within the uncertainty of the input data) would have resulted in the engine passing through the north exterior wall of the tower.

On damage to insulation, p 117

An intact ceiling tile system could have provided the floor trusses with approximately 10 min to 15 min of thermal protection 6.9.3 Damage to Thermal Insulation The dislodgement of thermal insulation from structural members could have occurred as a result of direct impact by debris and could have occurred by inertial forces due to vibration of structural members as a result of the aircraft impact. In interpreting the output of the aircraft impact simulations, NIST assumed that the debris impact dislodged insulation if the debris force was strong enough to break a gypsum board partition immediately in front of the structural component. Experiments at NIST confirmed that an array of 0.3 in. diameter pellets traveling at 350 mph stripped the insulation from steel bars like those used in the WTC trusses. Determining the adherence of SFRM outside the debris zones was more difficult. There was photographic evidence that some fraction of the SFRM was dislodged from perimeter columns not directly impacted by debris. NIST developed a simple model to estimate the range of accelerations that might dislodge the SFRM from the structural steel components. As the SFRM in the towers was being upgraded with BLAZESHIELD II (CAFCO II) in the 1990s, The Port Authority had measured the force required to pull the insulation from the steel. The model used these data as input to some basic physics equations. The resulting ranges of accelerations depended on the geometry of the coated steel component and the SFRM thickness, density and bond strength. For a flat surface (as on the surface of a column), the range was from 20g to 530g, where g is the gravitational acceleration. For an encased bar (such as used in the WTC trusses), the range was from 40g to 730g. NIST estimated accelerations from the aircraft impacts of approximately 100g. The analyses were not sufficient to establish justifiable, general criteria for a coherent pattern of vibration-induced dislodging. Thus, NIST made the conservative assumption that all other insulation remained adhered to the structural components.

Fire Modeling

Active Fire Protection: Active fire protection systems (i.e., sprinklers, standpipes/ hoses, fire alarms, and smoke management systems) should be enhanced through improvements to design, performance, reliability, and redundancy of such systems.

On Fireballs WTC1 p 24

Less than 15 percent of the jet fuel burned in the spray cloud inside the building. A roughly comparable amount was consumed in the fireballs outside the building. Thus, well over half of the jet fuel remained in the building, unburned in the initial fires.

On loading p 76

NIST estimated the fuel loading on these floors to have been about 4 lb/ft 2 (20 kg/m2), or about 60 tons per floor. This was somewhat lower than found in prior surveys of office spaces. The small number of interior walls, and thus the minimal amount of combustible interior finish, and the limited bookshelf space account for much of the differences.

On WTC fire in 1975 p 89

INFORMATION GAINED FROM OTHER WTC FIRES There had been numerous fires in the towers prior to September 11, 2001. From these, the Investigation Team learned what size fire WTC 1 and WTC 2 had withstood and how the tower occupants and the responders functioned in emergencies. While The Port Authority's records of prior fires were lost in the collapses, FDNY provided reports on 342 fires that had occurred between 1970 and 2001. Most of these fires were small, and occupants extinguished many of them before FDNY arrival. Fortyseven of these fires activated one to three sprinklers and/or required a standpipe hose for suppression. Only two of the fires required the evacuation of hundreds of people. There were no injuries or loss of life in any of these fires, and the interruptions to operations within the towers were local. A major fire occurred in WTC 1 on February 13, 1975, before the installation of the sprinkler system. A furniture fire started in an executive office in the north end of an 11 th floor office suite in the southeast corner of the building. The fire spread south and west along corridors and entered a file room. The fire flashed over, broke seven windows, and spread to adjacent offices north and south. The air conditioning system turned on, pulling smoke into the return air ducts. Telephone cables in the vertical shafts were ignited, destroying the fire-retarded wood paneling on the closet doors. The fire emerged on the 12 th and 13 th floors, but there was little nearby that was combustible. The fire also extended vertically from the 9th to the 19 th floors within the

telephone closet. Eventually the fire was confined to 9,000 ft2 of one floor, about one-fourth of the total floor area. The trusses and columns in this area had been sprayed with CAFCO D insulation to a specified 1/2 in. thickness. Four trusses were slightly distorted, but the structure was not threatened.

On modeling floor fires, p 119

6.10.2 Modeling Approach The time frame of the Investigation and the above requirements led to the use of the Fire Dynamics Simulator (FDS). Under development at NIST since 1978, FDS was first publicly released in February 2000 and had been used worldwide on a wide variety of applications, ranging from sprinkler activation to residential and industrial fire reconstructions. However, it had never before been applied to spreading fires in a building with such large floor areas. Figure 6–30 shows how FDS represented the eight modeled floors (92 through 99) of the undamaged WTC 1. A similar rendition was prepared for floors 78 through 83 of WTC 2. The layout of each floor was developed from architectural drawings and from the information described in Section 5.8. There was a wide range of confidence in the accuracy of these floor plans, varying from high (for the floors occupied by Marsh & McLennan in WTC 1, for which recent and detailed plans were obtained) to low (for most of the space in WTC 2 occupied by Fuji Bank, for which floor plans were not available).

On the fuel load effect p 124

6.10.3 The Four Cases Four fire scenarios (Case A and Case B for WTC 1 and Case C and Case D for WTC 2) were superimposed on the four cases of aircraft-driven damage of the same names (Section 6.9). A number of preliminary simulations had been performed to gain insight into the factors having the most influence on the severity of the fires. The most influential was the mass of combustibles per unit of floor area (fuel load); second was the extent of core wall damage, which affected the air supply for the fires. The aforementioned workstation fire tests had also indicated that the damage condition of the furnishings also played a key role. The scenario variables and their values are shown in Table 6–6. Table 6–6. Values of WTC fire simulation variables. WTC 1 WTC 2 Variable Case A Case B Case C Case D Tenant fuel

load a 20 kg/m2 (4 lb/ft2) 25 kg/m2 (5 lb/ft2) 20 kg/m2 (4 lb/ft2) 20 kg/m2 (5 lb/ft2) Distribution of disturbed combustibles Even Weighted toward the core Heavily concentrated in the northeast corner Moderately concentrated in the northeast corner Condition of combustibles Undamaged except in impact zone Displaced furniture rubblized All rubblized Undamaged except in impact zone Representation of impacted core walls b Fully removed Soffit remained Fully removed Soffit remained a. In addition, approximately 12,000 kg (27,000 lb) of solid combustibles from the aircraft were distributed along the debris path. b. In Cases A and C, the walls impacted by the debris field were fully removed. This enabled rapid venting of the upper layer into the core shafts and reduced the burning rate of combustibles in the tenant spaces. In Cases B and D, a more severe representation of the damage was to leave a 1.2 m soffit that would maintain a hot upper layer on each fire floor. This produced a fire of longer duration near the core columns and the attached floor membranes. FDS contained no algorithm for breaking windows from the heat of the fires. Thus, during each simulation, windows were removed at times when photographs indicated they were first missing. Damage to the ventilation shafts was derived from the aircraft impact simulations. For undamaged floors, all the openings to the core area were assumed to total 5 m 2 in area. 6.10.4 Characterization of the Fires

On the accuracy of spread p 126

The fire simulation results for Case A and Case B were similar, indicating only a modest sensitivity to the fuel load and the degree of aircraft-generated damage. This was because, in general, the size and movement of the fires in WTC 1 were limited by the supply of air from the exterior windows. Since the window breakage pattern was not changed in Case B, the additional and re-distributed combustibles within the building did not contribute to a larger fire. The added fuel did slow the spread slightly because the fires were sustained longer in any given location. Although there was generally reasonable agreement between the simulated and observed fire spread rates, there were instances where the fires burned too quickly and too near the windows. This resulted from an artifact of the model: the combustible vapors burned immediately upon mixing with the incoming oxygen. Simulations performed with doubled fuel loads slowed the

fire spread well below the observed rates. Combined with the above results, this suggested that the estimated overall combustible load of 4 lb/ft 2 was reasonable.

On the predicted fires in WTC1, p 127

The predictions of maximum temperatures (e.g., red zones in Figure 6–37) were consistent with those in the three-workstation fire tests. The use of an "average" gas temperature was not a satisfactory means of assessing the thermal environment on floors this large and would also have led to large errors in the subsequent thermal and structural analyses. The heat transferred to the structural components was largely by means of thermal radiation, whose intensity is proportional to the fourth power of the gas temperature. At any given location, the duration of temperatures near 1,000 °C was about 15 min to 20 min. The rest of the time, the calculated temperatures were near 500 °C or below. To put this in perspective, the radiative intensity onto a truss surrounded by smoke-laden gases at 1,000 °C was approximately 7 times the value for gases at 500 °C.

On the modeling of WTC2, p 127

WTC 2 Simulating the fires in WTC 2 posed challenges in addition to those encountered in simulating the fires in WTC 1. The aircraft, hitting the tower to the east of center, splintered much of the furnishings on the east side of the building and plowed them toward the northeast corner. Neither the impact study nor the validation experiments performed at NIST could be completely relied upon to predict the final distribution, condition, and burning behavior of the demolished furnishings. In addition, only the layouts of the 78th and 80th floors were available to the Investigation; the other floors were only roughly described by former occupants. As a result of these unknowns, the uncertainty in these calculations was distinctly greater than in those for WTC 1. To help mitigate gross differences between the simulations and the observables, NIST made floor-specific adjustments, based on the results of preliminary computations. In particular, the fuel load and volatility on the 80 th floor were reduced, and the fuel load on the 81st and 82 nd floors was increased. In contrast with WTC 1, in WTC 2 there was less movement of the fires. The major burning occurred along the east side, with some spread to the north. There was no significant burning on the west side of the tower. Also unlike WTC 1,

changing the combustible load in WTC 2 had a noticeable effect on the outcome of the simulations. Because so many windows on the impact floors in WTC 2 were broken out by the aircraft debris and the ensuing fireballs, there was an adequate supply of air for the fires. Thus, the burning rate of the fires was determined by the fuel supply. In the Case D simulation, the office furnishings and aircraft debris were spread out over a wider area, and the furnishings away from the impact area were undamaged. Both of these factors enabled a higher burning rate for the combustibles.

ON the heating of the structure by the FDS fire, p 139

Tables 6–8 and 6–9 summarize the regions of the floors in which the structural steel reached temperatures at which their yield strengths would have been significantly diminished. Instances of brief heating of one or two columns early in the fires were not included. Even in the vicinity of the fires, the columns and trusses for which the insulation was intact did not heat to temperatures where significant loss of strength occurred. Unlike the simulations of the aircraft impact and the fires, there was no evidence, photographic or other, for direct comparison with the FSI results. Table 6–8. **Regions in WTC 1 in which temperatures of structural steel exceeded 600 °C.** Trusses Perimeter Columns Core Columns Floor Number Case A Case B Case A Case B Case A Case B 93 – – – – – – 94 – – – – N, S NE, S 95 N N, S – – S NW, S 96 N N, S – S S W, S 97 N, S N, S – S N W, S 98 N N, S – – – – 99 – – – – – – Key: N, north; S, south; W, west; NE, northeast; NW, northwest. Table 6–9. **Regions in WTC 2 in which temperatures of structural steel exceeded 600 °C.** Trusses Perimeter Columns Core Columns Floor Number Case C Case D Case C Case D Case C Case D 79 – – – – – – 80 – – – – – – 81 NE NE NE NE – NE 82 E E E E E E 83 E E – E – E

On the fire duration predicted, p 144

Both the results of the multiple workstation experiments and the simulations of the WTC fires showed that the combustibles in a given location, if undisturbed by the aircraft impact, would have been almost fully burned out in about 20 min.

Insulation Saga

On insulation: p xlvi

NIST found no technical basis or test data on which the thermal protection of the steel was based. On September 11, 2001, the minimum specified thickness of the insulation was adequate to delay heating of the trusses; the amount of insulation dislodged by the aircraft impact, however, was sufficient to cause the structural steel to be heated to critical levels. • Based on four standard fire resistance tests that were conducted under a range of insulation and test conditions, NIST found the fire rating of the floor system to vary between 3/4 hour and 2 hours; in all cases, the floors continued to support the full design load without collapse for over 2 hours.

P55 on insulation

NIST was not able to find any evidence that there was a technical basis to relate SFRM thickness to a fire resistance rating, nor was there sufficient prior experience to establish such thickness requirements by analogy.

On insulation p 69

Floor Systems- At the time the WTC was designed, the ASTM E 119 test method had been used for nearly 50 years to determine the fire resistance of structural members and assemblies. However, The Port Authority confirmed to the Investigation Team that there was no record of fire endurance testing of the innovative assemblies representing the thermally protected floor system used in the towers. The floor assembly was not tested despite the fact that the Architect of Record and the Structural Engineer of Record stated that the fire rating of this novel floor system could not be determined without testing. Prior to construction, the Architect of Record had used information from (unidentified) manufacturers to recommend a 1 in. thickness of SFRM around the top and bottom chords of the trusses and a 2 in. thickness for the web members of the trusses. This was to achieve the fire endurance requirements for Class 1A construction (Section 5.3.3). In 1969, The Port Authority directed that a 1/2 in. thick coating of

CAFCO BLAZE-SHIELD Type D (CAFCO D), a mixture of cement and asbestos fibers, be used to insulate the floor trusses. This was to achieve a Class 1A rating, even though the preponderance of evidence suggests that the towers were chosen to be Class 1B, the minimum required by the NYC Building Code. NIST found no evidence of a technical basis for selection of the 1/2 in. thickness. This coating had been installed as high as the 38 th floor of WTC 1 when its use was discontinued due to recognition of adverse health effects from inhalation of asbestos fibers. The spraying then proceeded with CAFCO DC/F, a similar product in which the asbestos was replaced by a glassy mineral fiber and whose insulating value was reported by Underwriters Laboratories, Inc., to be slightly better than that of CAFCO D. On the lower floors, the CAFCO D was encapsulated with a sprayed material that provided a hard coat to mitigate the dispersion of asbestos fibers into the air. In 1994, The Port Authority measured the SFRM thickness on trusses on floors 23 and 24 of WTC 1. In all, average thicknesses were reported for 32 locations, and the overall average thickness was found to be 0.74 in. NIST performed a further evaluation of the SFRM thickness using photographs taken in the 1990s of floor trusses on (non-upgraded) floors 22, 23, and 27 of WTC 1 (Figure 5–5). By measuring dimensions on the photographs, NIST estimated the insulation thicknesses on the diagonal web members of trusses. (The thickness of chord member insulation could not be measured.) The average thickness and standard deviation of web members was 0.6 in. ± 0.3 in. on the main trusses, 0.4 in. ± 0.25 in. on the bridging trusses, and 0.4 in. ± 0.2 in. on the diagonal struts. These numbers indicated that there were areas where the coating thickness was less than the specified 0.5 in.

P 70

Chapter 5 Draft for Public Comment 70 NIST NCSTAR 1, WTC Investigation Note: Enhancement by NIST. Figure 5–5. Irregularity of coating thickness and gaps in coverage on SFRM–coated bridging trusses. In 1995, The Port Authority performed a study to establish requirements for retrofit of sprayed insulation to the floor trusses during major alterations when tenants vacated spaces in the towers. Based on design information for fire ratings of a similar, but not identical, composite floor truss system contained in the Fire Resistance Directory published by Underwriters Laboratories, Inc., the study concluded that a 1 1/2 in. thickness of sprayed mineral fiber material would provide a 2 hour fire rating, consistent with the Class 1B requirements. In 1999, the removal of existing SFRM and the application of new material to this

thickness became Port Authority policy for full floors undergoing new construction and renovation. For tenant spaces in which only part of a floor was being modified, the SFRM needed only to be patched to 3/4 in. thickness or to match the 1 1/2 in. thickness, if it had previously been upgraded. In the years between 1995 and 2001, thermal protection was upgraded on 18 floors of WTC 1, including those on which the major fires occurred on September 11, 2001, and 13 floors of WTC 2 that did not include the fire floors. The Port Authority reported that the insulation used in the renovations was CAFCO BLAZE-SHIELD II. In July 2000, an engineering consultant to The Port Authority issued a report on the requirements of the fire resistance of the floor system of the towers. Based on calculations and risk assessment, the consultant concluded that the structural design had sufficient inherent fire performance to ensure that the fire condition was never the critical condition with respect to loading allowances. The report recommended that a 1.3 in. thickness be used for the floor trusses. In December 2000, another condition assessment concluded that the structural insulation in the towers had an adequate 1 hour rating, considering that all floors were now fitted with sprinklers. The report also noted the ongoing Port Authority program to upgrade the fire resistive material thickness to 1 1/2 in. in order to achieve a 2 hour fire rating. The Port Authority provided NIST with the records of measurements of SFRM thickness on upgraded floors in both towers. The average thickness and standard deviation on the main trusses was 2.5 in. ± 0.6 in. NIST analysis of several Port Authority photographs from the 1990s of the upgraded 31 st floor of WTC 1 indicated an average thickness and standard deviation on the main trusses of 1.7 in. ± 0.4 in. NIST found no statistically significant difference in the average thickness of the upgraded insulation in the two towers.

Perimeter Columns In 1966, the contractor responsible for insulating the perimeter columns proposed applying a 1 3/16 in. thick coating of CAFCO D to the three external faces (Figure 5-6) to achieve a 4 hour rating, which is a Class 1A rating requirement (1 hour more than Class 1B). NIST found evidence of a technical basis for this decision. In the construction drawings prepared by the exterior cladding contractor, the following SFRM thicknesses were specified: • 7/8 in. of vermiculite plaster on the interior face and 1 3/16 in. of CAFCO D on the other three faces. • 1/2 in. of vermiculite plaster on the interior surfaces of the spandrels and 1/2 in. of CAFCO D on the exterior surfaces. Figure 5-6. **Thermal insulation for perimeter columns.**

Vermiculite plaster had a higher thermal conductivity and thereby increased heat migration from the room air to the column steel and, thus, could keep the steel temperature at 70 °F when the temperature was 0 °F outside. In October 1969, The Port Authority provided the following instructions to the contractor applying the sprayed fire protection, in order to maintain the Class 1-A Fire Rating of the NYC Building Code: • 2 3/16 in. of CAFCO D for columns smaller than 14WF228 11 and 1 3/16 in. for columns equal to or greater than 14WF228. • 1⁄2 in. covering of CAFCO D for beams, spandrels and bar joists. NIST's review of available documents has not uncovered the reasons for selecting CAFCO fire resistive material or the technical basis for specifying 1⁄2 in. thickness of SFRM for the floor trusses. As with the trusses, CAFCO DC/F was applied to the perimeter columns above the 38 th floor of WTC 1 and all the perimeter columns in WTC 2. Core Columns and Beams Multiple approaches were used to insulate structural elements in the core: • Those core columns located in rentable and public spaces, closets, and mechanical shafts were enclosed in boxes of gypsum wallboard (and thus were inaccessible for inspection). The amount of the gypsum enclosure in contact with the column varied depending on the location of the column within the core. SFRM (CAFCO D and DC/F) was applied on those faces that were not protected by the gypsum enclosure. The thicknesses specified in the construction documents were 1 3/16 in. for the heavier columns and 2 3/16 in. for the lighter columns. • Columns located at the elevator shafts were protected using the same SFRM thicknesses. They were not enclosed and thus were accessible for routine inspections. Inspection of the columns within the elevator shaft spaces in 1993 indicated some loss of SFRM coverage. As a result, new insulation was applied to selected columns within the elevator shaft space. Information provided to NIST indicated that a different SFRM, Monokote Type 2-106, was used. Thickness measurements for columns and beams below the 45 th floor indicated average thicknesses of 0.82 in. and 0.97 in., respectively. Information from The Port Authority indicated that the minimum required thickness of the re-applied SFRM was 1⁄2 in. for the columns and 3⁄4 in. for the beams. NIST was unable to locate information from which to characterize the insulation of the core columns and beams that were not accessible. Except as noted above, once completed, the core was generally not inspected. NIST was not able to locate any post-collapse core beams or columns with sufficient insulation still attached to make pre-collapse thickness measurements.

On the selection of insulation, p 192

No technical basis was found for selecting the spray-applied fire resistive material (SFRM) used or its thickness for the large-span open-web floor trusses of the WTC towers. The assessment of the insulation thickness needed to meet the 2 hour fire rating requirement for the untested WTC floor system evolved over time: – In October 1969, The Port Authority directed the insulation contractor to apply 1/2 in. of insulation to the floor trusses. – In 1999, The Port Authority issued guidelines requiring that insulation be upgraded to 1 1/2 in. for full floors undergoing alterations. – Unrelated to the WTC buildings, an International Conference of Building Officials (ICBO) Evaluation Service report (ER-1244), re-issued June 1, 2001, using the same SFRM recommends a minimum thickness of 2 in. for "unrestrained steel joists" with "lightweight concrete" slab.

Recommendations

On major rec's p xlvii

The eight major groups of recommendations are: • Increased Structural Integrity: The standards for estimating the load effects of potential hazards (e.g., progressive collapse, wind) and the design of structural systems to mitigate the effects of those hazards should be improved to enhance structural integrity. • Enhanced Fire Resistance of Structures: The procedures and practices used to ensure the fire resistance of structures should be enhanced by improving the technical basis for construction classifications and fire resistance ratings, improving the technical basis for standard fire resistance testing methods, use of the "structural frame" approach to fire resistance ratings, and developing in-service performance requirements and conformance criteria for spray-applied fire resistive materials. • New Methods for Fire Resistance Design of Structures: The procedures and practices used in the fire resistance design of structures should be enhanced by requiring an objective that uncontrolled fires result in burnout without local or global collapse. Performance-based methods are an alternative to prescriptive design methods. This effort should include the development and evaluation of new fire resistive coating materials and technologies and evaluation of the fire performance of

conventional and high-performance structural materials. ethecal and standards barriers to the introduction of new materials and technologies should be eliminated. • Improved ?????

Appendix B: November 2004 Comments

November 22, 2004

To: **The National Construction Safety Team Advisory Committee**
NCST Advisory Committee
100 Bureau Drive, Stop 8610
Gaithersburg, MD 20899-8610
NCSTAC@nist.gov

From: James G. Quintiere

RE: NIST conclusions on the WTC collapse mechanism reported on October 19, 2004

The October surprise in the NIST investigation was the assertion that all of the core column insulation was knocked off by the airplane impacts. To a lesser extent, reliance on NYNJPA audit insulation data solidified the NIST assertion that the failure of the core columns, and not the trusses, were to blame for the collapses of the South and North towers. That audit information was reported by NIST to have the fire floors of the north tower with truss insulation thicknesses as an average of 2.5 inches up to 4 inches instead of the prescribed 1.5 inches.

NIST needs to produce demonstrable and clear substantive information to support this rationale for its conclusions. The core-damage theory was put forth by the Weidlinger group in the Silverstein civil suit, and I heard it expressed at a local ASME meeting over a year ago by a NIST staffer. Therefore, I think it is incumbent on NIST to explain when and how they came to this conclusion. This collapse mechanism conclusion has profound influence on the recommendations brought from this investigation. The airplane-caused column collapse theory yields significantly, and almost diametrically, opposed recommendations than the fire induced truss collapse mechanism.

NIST needs to validate its conclusion by addressing the following:

1. The NYNJPA North tower insulation data needs to be authenticated. There is a long saga on the insulation coverage of the truss assemblies, and it should not end with an audit report that contains data that are extraordinary. The claim that up to 4 inches of insulation was sprayed onto 1-inch diameter truss elements needs testimony, photographic corroboration, or other tangible evidence to establish the accuracy of this information.
2. It needs to be clearly demonstrated how the core column insulation was removed. This cannot simply be based on an assumption or an extrapolation from impact calculations. It is too important to the conclusions to have modeling as the sole basis. Sandia has been experimenting with airplane crashes into buildings. Have they been consulted for supporting information or assistance? NIST needs to live up to the Daubert-rulling in civil case law, and demonstrate a clear methodology for their conclusion that the insulation was removed.

Finally, NIST needs to clarify inconsistencies that appear in their public information to date. These inconsistencies and apparent weakness lead me to question their collapse theory, and place the collapse cause more on the lack of sufficient truss insulation.

1. NIST metallurgical analyses show no core columns from the fire floors reached temperatures above 250 C. It is claimed that this information is consistent with computer modeling. Moreover, I was pleased to see that after many inquiries for microscopic analysis of the steel debris, it was done and reported in the October briefing. The importance of forensic evidence to document the temperatures reached of the steel cannot be overlooked. First, its consistency with the modeling has little significance since the modeling cannot have that level of detailed accuracy precise fire effects around the core columns. Secondly, the core column theory requires that the columns got sufficiently hot, say 500 C, and tangible evidence from metallurgical analysis is crucial in supporting the NIST conclusion. Unfortunately, that evidence has not been found by NIST. Thirdly, as a consequence, this crucial lack of evidence must indict the selling of the WTC steel debris before an investigation could be launched. Will NIST speak to this as they now have future investigative authority?

2. NIST computations show that floor truss assemblies can fail at temperature measured in the UL tests. UL fire tests showed for ½ and ¾-inch insulation that steel truss temperatures exceeded 1300 F (704 C) in roughly 58 minutes and 62-76 minutes, respectively. They reached average temperatures of 1110 F (593 C) in 66 and 66-86 minutes, respectively. My own data with Isolatek indicate that individual web elements can reach 593 C in about 35 to 50 minutes, respectively for ½ and ¾ inches. NIST's model for a single WTC truss (which is more accurate than the impact computations), predicts a truss would fail at the column connections at these temperatures. The NIST model for a single truss and its connection shows that the truss fails at the interior column seat connection, and 'walks off' the seat. This occurs at 650 C. The web diagonals begin to buckle at 340 C, and the exterior columns bow inward at 560 C because the truss acts as a catenary. Other independent work done by Usmani et al, and Burgess et al., show similar results. If one floor falls on the floor below while both are heated by fire, can the impacted floor carry the load? Is this a plausible global collapse mechanism? To me, this means that truss failure is likely, at least in the South tower; and in the North if the PA audit data are wrong. Collapses of the floors were seen in both of the towers well up to 20 minutes before the buildings collapsed. This indicates the presence of the floor collapse mechanism.

   Incidently, the NIST scaling criterion used for the ½-scaling in the UL tests should be examined, as it is thermally not to scale. The shorter truss members will cause lower temperatures as the web transfers heat into the concrete floor.

3. NIST has relied on state-of-the-art computer models that are at the forefront of their technologies. However, these models have not been proven comprehensively for less complex incidents than the WTC. Will NIST continue to invest in these modeling technologies, or are they proven and ready for general use? If they are ready, will NIST advocate their use in design, or will NIST continue to perform research to improve them? If the latter is true, will NIST articulate the uncertain aspects of the modeling, and comment on how they bear on the investigation's conclusions?

4. NIST has used workstations fire experiments as a basis for their modeling. The stated fuel load is 4 lbs/ft^2 and this loading has been questioned, as it appears very low in the spectrum of office loadings. Because our students are conducting a scale model experiment of the 96th floor of the North tower, it forced us to examine this loading. While we could not pursue our information in depth, I can relate some major concerns. NIST experimental photographs of the office modules show little paper, and NIST has told me that the paper load was reported as light. I was told by a WTC inspector that the load was heavy, storage areas were overloaded and floors were continually cited for having paper stacked on the window sills; a furniture installer of the Marsh floors gave me information that showed extensive file cabinets surrounding the cubicles and these were not included in the NIST fire experiments – he, too, said that the Marsh office spaces were heavy in paper; an anonymous Marsh employee said that the Marsh company were paper "hogs", and a family member said it was heavy as well. The fuel loading is crucial to the duration and the temperatures of the fires. A light fuel load in the modeling will lead to low temperatures and this would affect the overall results.

It is imperative that NIST get the cause of the WTC tower collapses correct. The legacy of its victims bears on future fire safety. The protection of buildings in fire and terrorists attacks will be impacted by these conclusions, so they need to be right. The Advisory Panel plays a clear role to sign off on these conclusions. I know of others that feel the NIST conclusions need, in the least, clarity, and in the main, more support. However, we are few in number, and it falls on you to insure the public that they got it right.

<u>Recommendations</u> that should come from this study are submitted in no priority order as suggestions for your consideration:

1. Experimental studies to establish temperatures and fire duration characteristic of modern facilities including office large plan spaces, places assembly, and underground structures should be undertaken to validate models and establish design methods. The current correlations are incomplete in terms of fuel type and building type.

2. The standard time-temperature structural fire tests should be examined in light of computational methods. Data for the tests yielding temperature and deflection should be integrated with computations to extrapolate to actual assemblies used in practice.
3. Sensor technologies integrated with alarm monitoring for building performance should be integrated into the emergency response network for assessing the nature of the hazard.
4. Forensic techniques and standards should be established to assess failure information from structural debris. The elimination of the steel structure from the WTC site should be fully addressed, and its consequences fully stated.
5. Fire and disaster planning should include full and proper analyses for safe egress and effective response. Responders and building planners need to have the benefit of analyses that quantitatively address these facets. Real time modeling of the fire effects based on sensor information are possible and should be integrated into special building designs and response actions.
6. Novel techniques need to be investigated to rescue people and to fight high-rise fires.
7. Current codes weaknesses, in light the WTC collapses, need to be fully addressed. Issues of lightweight construction designs that are vulnerable to catastrophic collapse of a structure need particular attention.
8. A nationally supported infrastructure is needed to insure that objective scientific input is placed into the code consensus process to bring fire safety to a proper level of engineering analyses. The current code process is lacking in scientific underpinning, and the WTC disaster should stand for change in this direction, especially if the scientific community cannot render a clear and decisive verdict.

October Review:

Review of NIST WTC Investigation
Addressing Tasks 3, 5 and 6.

J. G. Quintiere
September 11, 2004

Modified October 17, 2004

The following constitutes the NIST projects designed to reach the objective of the investigation.

NIST Projects: Federal building and fire safety investigation of the WTC disaster

Project No./Technical Area /Project Purpose

1. Analysis of Building and Fire Codes and Practices
   a. Document and analyze the code provisions, procedures, and practices used in the design, construction, operation, and maintenance of the structural, passive fire protection, and emergency access and evacuation systems of the WTC 1, 2, and 7.
2. Baseline Structural Performance and Aircraft Impact Damage Analysis
   a. Analyze the baseline performance of WTC 1 and 2 under design, service, and abnormal loads, and aircraft impact damage on the structural, fire protection, and egress systems.
3. Mechanical and Metallurgical Analysis of Structural Steel
   a. Determine and analyze the mechanical and metallurgical properties
4. Investigation of Active Fire-Protection Systems
   a. Investigate the performance of the active fire protection systems in WTC 1, 2, and 7 and their role in fire control, emergency response, and fate of occupants and responders.
5. Reconstruction of Thermal and Tenability Environment
   a. Reconstruct the time-evolving temperature, thermal environment, and smoke movement in WTC 1, 2, and 7 for use in evaluating the structural performance of the buildings and behavior and fate of occupants and responders.
6. Structural Fire Response and Collapse Analysis
   a. Analyze the response of the WTC towers to fires with and without aircraft damage, the response of WTC 7 in fires, the performance of open-web steel joists,

and determine the most probable structural collapse sequence for WTC 1, 2, and 7.

7. Occupant Behavior, Egress, and Emergency Communications
   a. Analyze the behavior and fate of occupants and responders, both those who survived and those who did not, and the performance of the evacuation system.
8. Fire Service Technologies and Guidelines
   a. Building on work done by the Fire Department of New York and McKinsey & Company, document what happened during the response by the fire services to the WTC attacks until the collapse of WTC 7;
   b. identify issues that need to be addressed in changes to practice, standards, and codes;
   c. identify alternative practices and/or technologies that may address these issues; and
   d. identify research and development needs that advance the safety of the fire service in responding to massive fires in tall buildings.

The NIST investigation objectives are:

1. To determine (a) why and how the WTC 1 and WTC 2 collapsed following the initial impact of the aircraft, and (b) why and how the 47-story WTC 7 collapsed.

2. To determine why the loss of life and injuries were so low or so high depending on location, including technical aspects of fire protection, occupant behavior, evacuation, and emergency response.

3. To determine the procedures and practices which were used in the design, construction, operation, and maintenance of the WTC buildings.

4. To identify, as specifically as possible, areas in national building and fire codes, standards, and practices that warrant revision.

Among the **specific questions that NIST is investigating** within the above four objectives are the following:

- How and why did WTC 1 stand nearly twice as long as WTC 2 before collapsing (103 min versus 56 min), though they were hit by virtually identical aircraft?
- What factors related to normal building and fire safety considerations not unique to the terrorist attacks of September 11, 2001, if any, could have delayed or prevented the collapse of the WTC towers?
- Would the undamaged WTC towers have remained standing in a normal major building fire?
- What factors related to normal building and fire safety considerations, if any, could have saved additional WTC occupant lives or could have minimized the loss of life among the ranks of first responders on September 11, 2001?
- How well did the procedures and practices used in the design, construction, operation, and maintenance of the WTC buildings conform to accepted national practices, standards, and codes?

I will address Tasks 3, 5 and 6 in the format indicated below:

<u>Issue</u> for the project
<u>Approach</u> taken by NIST
<u>Questions</u> on the Approach
<u>Comments</u> on ability to address objectives

3. Mechanical and Metallurgical Analysis of Structural Steel

Objective: Determine and analyze the mechanical and metallurgical properties

Issue

NIST has established the mechanical and thermal properties of the steel used in the WTC, and generally has found no remarkable departures from the literature for steel. However, an important aspect of this fire and large fires in general is the temperature reached by the fire, and that achieved by the steel.

NIST approach

In the December 2003 Public Update it states that part of this task objective is "estimating the maximum temperature reached by available steel" (p.8). In the May 2003 (p. 33) and June 2004 Vol. 1, p. 87), it appears that this objective is being done by examining paint degradation at 250 and 750 C.

Questions

A common forensic technique for determining the temperature reached by steel in a fire is to microscopically examine the grain size. It has been said that very precise determinations can be made if compared to an unheated similar steel sample. Why has NIST not used this method?

Comments

The importance of knowing the temperature achieved by the steel on the fire floors is crucial to establishing the cause of the buildings collapse. This is like a thermometer in the building, so its significance cannot be overlooked. The temperature of the fire and the steel are important in determining the time and the nature of the collapse of the buildings. NIST is using computational methods to predict these temperatures. It is incumbent on NIST to use all methods for ascertaining the steel temperatures to achieve confirmation of its predictions.

Also, NIST has steel samples salvaged from the dumpsite, and has said those samples were adequate. NYC made a unilateral decision to remove and sell the steel before the NIST investigation began. What is the NIST recommendation on how to preserve evidence in future investigations in order to render complete structural and thermal analysis to the debris samples? Was the steel prematurely discarded in the WTC before adequate analysis could occur?

5. Reconstruction of Thermal and Tenability Environment

Objective: Reconstruct the time-evolving temperature, thermal environment, and smoke movement in WTC 1, 2, and 7 for use in evaluating the structural performance of the buildings and behavior and fate of occupants and responders.

Issue

The accuracy of the computer modeling predictions for the fire environment need to be assessed, and their consistency with literature data for fully developed fires and with the factual evidence of the WTC fires needs addressing. A computation of this magnitude is beyond the state of the art for fire modeling, and although NIST and the investigators should be commended for their efforts at pushing the state of the art, they must not solely rely on computer-driven computations for estimating the fire temperatures. They have other sources from which to also draw information on the state of the fire: They include: conducted fire tests, correlations for fully developed fires in the literature, data on window breakage and the fire progress, and people reaction to the fire heat and smoke from potential interviews. Consistency must be assessed between the various sources of information and from alternative, albeit, simpler computational methods.

NIST Approach

Information about the fire can come from several sources. NIST has extensively examined and compiled the fire behavior and its effect on the building through the correlation of various photographic evidence. This task has been done with excellence it appears, and should offer valuable information. Another source of fire could come from the collection of data from people. This appears to have lagged and it is not clear that anything of value in a timely manner will be reported on the fire and damage effects observed directly by people and ascertained through interviews. In all of the fire predictions NIST has chosen to use its Fire Dynamics Simulator (FDS) as the sole computational tool. In order to evaluate its accuracy, experiments have been conducted on small features of the WTC office occupancies in order to calibrate and

assess the accuracy of the fire predictions. Hence, both the modeling and the experimental data offer information on the WTC fires. As with other aspects of the investigation, NIST appears to be weighting the computational approach as their primary result, especially since that result must be supplied to the structural modelers in order to make their prediction of the building's ability to carry its load.

NIST has approached the validation effort by conducting two series of tests. The first series consisted of a spray fuel fire in a compartment containing structural members. The second involved a larger compartment containing three workstations that NIST decided were representative of the WTC offices. That fuel load is roughly 4 lb/ft^2 (psf) (or about 20 kg/m^2 and 50 MJ/ m^2), June 2004 Vol. 1, p xxxvii, Vol. 5, J-37.

Series 1 consisted of the following (June 2004 Vol. 5, J-2):

> The test compartment consisted of a steel stud frame lined with calcium silicate board. The internal dimensions of the compartment were 3 m high, 7 m deep, and 4 m wide. There were four openings in the west wall through which air entered the room; they totaled 1.75 m 2 (10.8 ft^2) in area and were located 1 m (3.3 ft) above the floor. There were four openings in the east wall through which heat and combustion products were emitted; they also totaled 1.75 m^2 (10.8 ft^2) in area and were located 2 m above the floor. In each of the six tests, the four test subjects were a bar, two trusses, and a thin-walled tubular column. Depending on the test, these specimens were either left unprotected or were coated with spray-applied fire protective insulation material, Blaze Shield DC/F. The fibrous insulation was applied by an experienced applicator who took considerable care to apply an even coating of the specified thickness. As such, the insulated test subjects represent a best case in terms of thickness and uniformity. The fires consisted of liquid hydrocarbon fuels sprayed by a two-nozzle spray burner onto a 1 m × 2 m (3.3 ft × 6.6 ft) pan. The fuels were (a) heptanes and (b) a mixture of nominally 60 percent (by mass) heptanes with 40 percent toluene. The latter fuel produced a significantly sootier flame.

Six tests were done. The instrumentation for the tests comprised up to 352 channels of data.

Series 2 consisted of 3 workstations in a large room (June 2004, Vol. 5, J-27):

Six experiments were designed to assess the accuracy with which FDS predicts the fire spread, heat release rate, and thermal environment in a compartment burning multiple workstations in a configuration characteristic of that found in the WTC buildings. In each of these experiments, sets of three workstations were burned in a large compartment (about 11 m x 7 m x 3.4 m high). The challenges to the model included varying the location of the ignition burner (and thus the fire ventilation), adding jet fuel and/or noncombustible material occluding a fraction of the workstations' surfaces, and "rubblizing" the workstations.

It should be noted that the workstation fuel load was "suggested by personnel from a company that supplied office furnishings to the occupants of WTC 1. Information on the distribution of papers and other office items was provided by a frequent visitor to these offices". (p J-12)

NIST performed some additional computations based on FDS. They have early on reported on the smoke dynamics from the building (Rehm et al., IAFSS 2002), and recently on the fireball dynamics (Baum, Comb. Inst., 2004). These are considered somewhat ancillary to the prediction of the fire conditions on the floors that bear directly on the heating of the structure and the effect of the fire on the ultimate collapse. However, the work by Prasad and Baum (Comb. Inst. 2004) on linking the predictions of FDS for the fire with the heating of core columns under different core damage scenarios is very significant. It is the closure of the fire and the structure modeling that is critical to answering the issues pertaining to collapse. McGrattan has simulated the fires on a floor based on the workstation fuel load. That loading was indicated at about 4 pounds per square ft of office space (psf). McGrattan indicates the fire at this low fuel loading burn in an under-ventilated state as "oxygen consumed drives fires to the windows" (p. J-44). In addition, these full-scale WTC computer simulations are reported to for about 20 minutes in a region and then move on with an entire floor burning out in about 1 hour (Fact Sheet June 2004 pp. 2, 3).

Also it was indicated that these simulated fire burn at an average temperature over the floor at about 600 C.

<u>Questions</u>

It is well known that FDS results depend on the grid size and its scaling to the fire conditions. The experiments done by NIST may well serve the credibility and accuracy of using FDS with a grid size of 40 cm, but enough comparison has not been shown between the computations and the experiments. Only about 4 or 5 plots have been presented for comparison in the reports, and they show very good prediction for the fire gas temperatures and heat release rate. Some of NIST's own funded work (Ierardi and Barnett, 2003) have shown that the accuracy of predicting a single fire plume from a 30 cm burner give drastic variations in temperatures with the fire plume for grids of 1.5 to 15 cm. Temperatures within 20 per cent of the experiment results required grids of 1.5 to 5 cm. So it is incumbent on NIST to address this accuracy question completely. They have done 13 experiments with over 300 measuring stations in each test. In the least, NIST needs to demonstrate the ability of FDS to compute all aspects that FDS has in common with these measurements.

The issue of accuracy for computer models is a serious matter when they are to be used as general engineering tools. The literature is filled with data and correlations for fully develop fires. NIST should at least demonstrate how its approach using FDS compares to these other empirical approaches in the literature. Japan uses one of these empirical approaches as a design method in regulations, and the SFPE has just completed a guide on the prediction of fire conditions for structural considerations. It has been said that the full WTC floor simulation agree with the phenomenon observed by (I. Thomas et al.) in which the fire moves about the compartment seeking air. Can FDS predict the data of Thomas? These questions are broader that the effort that has gone into the WTC simulation, and therefore it would be important for NIST to examine FDS in light of its validation needs. Moreover, FDS is using a charring model to compute the burning rate and flame spread on the workstations, and NIST should state the accuracy of using FDS for the prediction of flame spread on charring materials. Boeing would not take the use of CFD models in its aircraft design lightly, and neither should those assessing fire behavior, especially from NIST.

The fuel load selected in the representative experiments and the modeling raises some questions. NIST is using roughly 4 psf, and a floor burns for an average of about 1 hour (Key Findings of NIST's June 2004 Progress Report...). This selection of loading is critical to establishing the burning time, crucial to predicting the impact of fire on the structure. The literature (Robertson and Gross, ASTM STP 464, 1970) suggests an average office load of 18.4 psf, ranging from 7 to 43 psf according to surveys. Why is the WTC representative office so low? This needs examining and supportive data.

The FDS simulations indicate a one-hour burning period for a floor at 600 C. This may be due to the light fuel, but appears inconsistent with the under-ventilated burning achieved in the simulation. Also the actual fires appear to have burned longer with WTC burning until collapse at 103 minutes. Finally, the average temperature of 600 C is about coincident with critical failure temperature associated with steel structures, and would never allow the steel to reach this temperature.

In an investigation where information comes in different forms, the final analysis must show that the information pieces are consistent. NIST has observational information, hopefully people information, experimental test information, and the FDS simulations. These must be shown to be consistent.

Ultimately FDS results must be linked to a structural model. Prasad and Baum (C.I. 2004) have attempted this for the heating of the core columns. They show that simplifications need to be made in representing the FDS temperature spatial distributions in order to better interface with the structural heating model. Their approach has demonstrated the needed closure of the fire and structural heating. However, they have not considered the vulnerable floor assembly in their calculations. This will need to be added to fully assess the role of the fire on the complete structure. NIST has not made clear how the fire and structural computations will come together, particularly since the structural modeling is being done under contract. We would like to see NIST speak to the accuracy and issues related to the modeling of the fire and structure together.

Since NIST has test data on the heating of insulated structural members in their fire tests, some comparisons, at least, need to be presented for these simpler fire scenarios.

Can NIST successfully modeling the 1975 WTC fire (June 2004, Vol. 4, G-1) that did extensive damage to a floor? This fire prompted the use of sprinklers, and local structural damage occurred. Since the damage and extent of the fire was known, it could be a useful benchmark for NIST to compare their simulations.

Comments

The fire computations are perhaps the most important determination since its heating impact and its duration determine the ultimate temperature of the protected steel. The heat transfer by conduction into the insulation and the steel is trivial by comparison. Also when it realized that failure in furnace testing of structures is often based on steel temperature, and temperature strongly affects the strength of steel, e.g. the modulus of elasticity is reduced by 50 % when steel attains about 600 C. Since the modulus is directly related to the critical load to cause buckling, the buckling of elements in compression can occur more easily at elevated temperatures. The ability of the fire modeling to relate to the structural heating model is very import step in this investigation. NIST should make this step as transparent as possible in order to judge its conclusions. FDS will yield a spatial and time varying temperature throughout a floor. Its accuracy needs to be supported at this level of sophistication. Alternative estimates on the level of temperature and its duration might need to be couched in simpler forms for the best structural analysis to be produced. It might serve just as well to specify uniform temperature in a range. The duration will depend on the fuel load, and it has been pointed out that the NIST selected load is very low compared to office load surveys. Some variation of uncertainty must be considered here.

Finally, it appears almost foolish to have received $16 million for the investigation and to not have conducted a test more representative of a WTC floor. A quarter of a floor could have been tested for fire and the heating of the structure. It would only involve a plan space at 100 x 100 feet. This could have settled many issues. Especially when it is realized that no experimental results exist for compartments with small ratios of height to their lateral dimension as 1/20 in the

WTC. The smallest has been ¼ in the well known CIB studies, and those results should be examined by NIST for their applicability. However, the interaction of air from the perimeter and fuel within the compartment need to be examined under these conditions by an experiment, to at least see if FDS is qualitatively correct. Moreover, it is known that in large fire plumes that smoke can trap radiation and drive the core fire temperatures to 1300 C and more. This can happen at fires of 30 ft in diameter, so the question must be raised if this might apply to the WTC with lateral floor dimensions of 200 ft.

6. Structural Fire Response and Collapse Analysis

Objective: Analyze the response of the WTC towers to fires with and without aircraft damage, the response of WTC 7 in fires, the performance of open-web steel joists, and determine the most probable structural collapse sequence for WTC 1, 2, and 7.

Issue

The principal issue here is to examine the NIST working hypothesis in conjunction with its collection of findings and to assess their consistency. The working hypothesis is found in June 2004 Vol. 6, Q-3.

> The working hypothesis addresses the following chronological sequence of major events; specific load redistribution paths and damage scenarios are currently under analysis:
>
> 1. Aircraft impact damage to perimeter columns with redistribution of column loads to adjacent perimeter columns and to the core columns via the hat truss;
> 2. After breaching the building's exterior, the aircraft continued to penetrate into the buildings, damaging core columns with redistribution of column loads to other intact core and perimeter columns via the hat truss and floor systems;
> 3. The subsequent fires, influenced by post-impact condition of the fireproofing, further weakened columns and floor systems (including those that had been damaged by aircraft impact), triggering additional local failures that ultimately led to column instability;

4. Initiation and horizontal progression of column instability ensued when redistributing loads could not be accommodated any further. The collapses then ensued.

NIST Approach

NIST and its contractors are using computational analyses to compute the impact damage by the aircrafts, the performance of a single floor truss under temperature elevation, the evaluation of a portion of the floor assembly in the ASTM E 119 test, and the history of the insulation applied in the WTC, especially to the floor assembly.

2. Impact computations: These computations are portrayed in figures on pp 78-79 of June 2004, Vol. 1, and they show an engine impacting and shredding a floor and then buckling a core column.

NIST reports further (June 2004, Vol. 1, p 81):

• A 500 mph engine impact against an exterior wall panel results in a penetration of the exterior wall and failure of impacted exterior columns. If the engine does not impact a floor slab, the majority of the engine core will remain intact through the exterior wall penetration with a reduction in velocity of about 10 percent and 20 percent. The residual

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

> velocity and mass of the engine after penetration of the exterior wall is sufficient to fail a core column in a direct impact condition. Interaction with additional interior building contents prior to impact or a misaligned impact against the core column could change this result.

Also an analysis of the stability of the towers, assuming no damage to the core, gives the number of floors that need to be removed to cause global failure (June 2004, Vol. 1, p.81):

The following presents some preliminary findings obtained from the preliminary stability analyses under service live loads and subject to the assumptions and the limitations of these models (see Appendix D): Linear stability analysis was used to examine the stability of the undamaged WTC 1 under service loads through increased un-braced column lengths (floor removal). The tower was stable when two floors were removed. Two core columns buckled when three floors were removed, but the tower maintained its overall stability. The tower also maintained its stability when four columns buckled with four floors removed. The analysis suggested that global instability of the tower occurred when five floors were removed from the model. Assuming that all columns at the region of the removed floors reached a temperature of 600 °C (reduced modulus of elasticity), the analysis indicates that removal of four floors would induce global instability.

3. Single truss analysis: A model of a single truss and its connection shows that the truss fails at the interior column seat connection, and 'walks off' the seat. This occurs at 650 C. The web diagonals begin to buckle at 340 C, and the exterior columns bow inward at 560 C because the truss begins to act as a catenary. (June 2004, Vol. 1 p. 120).

4. E 119 tests: Standard fire tests were conducted at UL. Two were done at a 35 ft span representing the short span in the WTC towers. These had ¾ in. thickness of insulation applied. A third test was conducted with public viewing with ½ in. insulation, and at a span of 17 ft. In that test the truss was scaled –down so that it was half its depth. The failure criterion used was primarily structural integrity for the most part. The third test was conducted *restrained* and obtained a 2 hour restrained rating meaning it did not structurally collapse, and it obtained a 1 hour unrestrained rating which results from exceeding a critical temperature of the steel.

5. Insulations history: NIST has traced documents and recommendations related to the thickness of insulation, particularly on the floor joist assembly. They have found and stated the following:
   a. The truss specified thickness was 0.5 in., but as applied was 0.6 +/- 0.3 inch.

b. The upgraded truss insulation was 1.5 inches (based on UL G805, May 2003, p. 78), but was later measured in application as 1.7 +/- 0.4 inches based on photographic analysis, but was reported in audit documents over 1997 to 1999 as 2.5 +/0.6 inches, with thickness as high as 4 inches (June 2004, Vol. 4, I 15-18).

c. A model code recommended 2 inches for 2 hours in a 2001 assessment of a similar truss (June 2004).

d. A report by Burro-Happold recommended in 2001 that the upgraded insulation could be dropped to 0.5 inches based on an ambient value of the conductivity used in a calculation, but settled on a recommendation of 1.3 inches. (May 2003, p. 82)

Questions

Column impact: It is very important to determine an accurate estimate of the core column damage. In view of the variability of the impact computer codes, what does NIST consider is their accuracy? It was reported by the NY Times that the Weidlinger computations indicated that the South tower would fall solely upon impact of the aircraft. It is know that calculations were made in 1966 that indicated only local damage would occur. Why is there so much variability in these computations? In addition, the NIST reported results indicate that an engine needs to directly strike a core without loss of momentum for the column to fail. This would suggest very limited core column damage is possible as might be inferred from the NIST computational graphic shown above. Can an engine possibly hit a core column without hitting anything on the floor occupancy and structure? That does not seem possible, so how can an engine damage a core column? Perhaps I am missing something. Why is NIST then considering in its "working hypothesis" that considerable core damage is likely? Moreover, it is known that landing gear and at least one engine was found in the surrounding streets suggesting a flight path through the building. Can NIST use information on the location of the engines to assess the likelihood of core column damage?

Temperature importance for floor failure: The single truss analysis done by NIST and the work done both Usmani et al, and Burgess et al., indicate that the truss deflections occur at temperatures ranging from roughly 400 to 600 C. During these deflections, the truss can cause failure to its connections, or to column instability. It would seem that temperature is a key feature

in causing failure. How does NIST relate its work to those cited above in the literature? If one floor falls on the floor below while both are heated by fire, can the impacted floor carry the load? Will this be a mode of global collapse? NIST considers the number of floors to be removed before the columns would become unstable, but would not the loss of 2 or 3-floors cause the failure before this instability? Is a critical temperature a good measure of structural failure as it might appear from the element computations, and the implication of the loss in strength at elevated temperatures?

Role of E119: Ratings have been achieved at UL for the E-119 test. Will NIST be analyzing these results to see how they would apply to the WTC? If the temperatures reached by the steel in these tests is sufficient to cause failures in the WTC computations, but the structure did not fall in the E 119 test, how will NIST reconcile these differences? NIST scaled the depth of the truss to ½ full-scale in its 17 ft E 119 test. This was done for stress purposes, but the heat transfer along the web into the concrete deck is now changed. Since temperature is a criterion for failure of the test in some modes of testing, the temperature of particularly the full-scale 35 ft. truss should be examined. Moreover, as UL G805 was used for justifying the 1.5-inch insulation thickness, why would the recent tests give such different results? Also UL N 826 might have been more appropriate, and gives 2 1/16 inches. So what is the meaning of the E 119 test and how should it be used in this WTC analysis?

Reconciliation of insulation thicknesses: As seen by the various E 119 results for the Cafco insulation, and the varied specifications and recommendations on the WTC truss insulation, it is incumbent on NIST give some rationality to these variations. Since the amount of insulation is so crucial to the outcome of finding the cause, NIST needs to be very sure about how much insulation was actually in place. The latest information from PANYNJ indicates that the upgrade in WTC 1 could have been as much as 4 inches over the 1.5 specification, when field workers were having difficulties in application, and that was the main reason for the Burro-Happold report. A 4-inch radius on a 1 inch steel rod would give a 9-inch diameter cylinder – a very big result. How much confidence does NIST have on these large amounts? Do they have photographic evidence as in the previous smaller amounts? Would not a hearing on the insulation thickness issues serve NIST well in documenting the facts and rationality of these

variations? If so much variation occurred for the WTC, how does this relate to the protection in other buildings?

Comments

It appears that NIST has to answer some very focused questions with clarity and accuracy.

1. How many core columns were removed and why?
2. How much insulation was in place during the fire?
3. What are the critical temperatures needed for failure?
4. Could the fire cause these temperatures?

The global collapse mechanism of the buildings must be made as clear as possible. A vague answer expressed by the current NIST working hypothesis is not sufficient. NIST has expended a lot of good individual effort, and it has done some very good fact finding and analyses. Now all of that has to be put together, and it seems contractors (who we have not heard from) play a significant role. NIST needs to harness those individual efforts and expertise in a balanced evaluation. Reliance solely on complex computer models should not be the sole basis of the answers. If the core of the answers are really revealed and understood, NIST should be able to explain them in simple fundamental physics, and not shroud them in computer graphics. This was the purpose of the investigation, and this project task is critical.

Appendix C:

Analysis of the Fuel Load Calculations for the 96th Floor of the WTC North Tower

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April 2005

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Abstract

An impartial examination into the combustible fuel load for the 96th floor of the North World Trade tower is described in this paper.

Introduction

The dimensions used for analysis of the WTC North tower are as follows, the overall building dimensions are 207.2' x 207.2' = 42,932 ft^2 (3988.5 m^2), building core dimensions are 87' x 137' =11,919 ft^2 (1107.3 m^2), and the area that office equipment sits on is therefore 31,013 ft^2 (2881.2 m^2), while FEMA reports that area for office furniture is 30,930 ft^2 (2,873.5 m^2) [1].

Typical structural live loads used in design or analysis for offices are 50 psf (pounds per square foot) (244.35 kg/m^2), and for lobbies, 100 psf (488.7 kg/m^2).

The paperweight found in the Marsh & Mc Lennan office is significant because it directly impacts the fire size/duration, which in turn, affects results obtained for performance of structural members.

UMCP considerations and examination:

- The cabinets used by NIST contained two reams of packed paper, which is not consistent with the files that I weighed. The significance is that the tighter the packed paper is, the less air can get in to feed the fire whereas, typical files are not uniform in size or spacing and leave room for air to supply the fire.
- The following are graphical representations of the difference between the paper weight not included (NIST) and the total weight inclusion (UMCP):

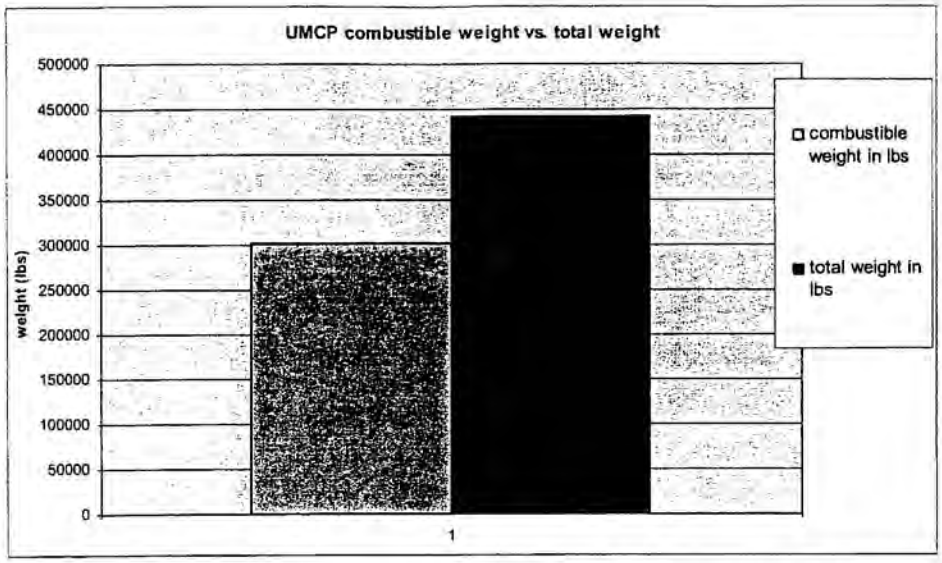

Figure 1. UMCP estimate of how the total workstation weight is distributed.

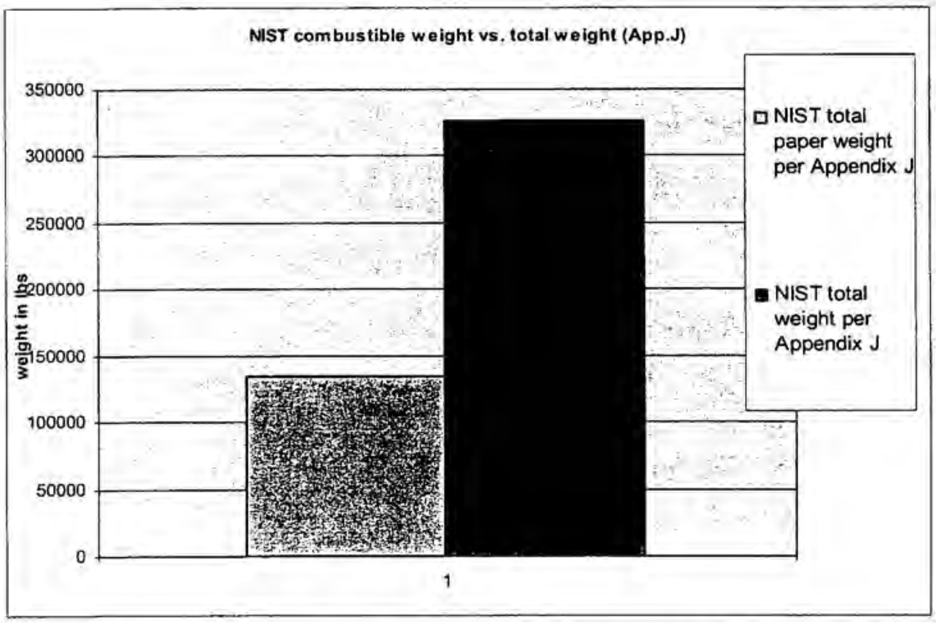

Figure 2. NIST estimate of how the total workstation weight is distributed.

Summary of results from NIST

- The book case, which was 48" high (1.22m), was stuffed with 10 boxes containing 13 reams of copier paper (260 lb ~ 118 kg).
- Total workstation weight considered to be 1600 pounds (726 kg) and the amount of combustible material contained in that workstation was estimated as 660 pounds (300 kg) by NIST. Based on the information obtained in these simulations, McGrattan then passed the FDS results onto others who analyzed the temperature of the steel and concrete [2].
- NIST used a per desk weight rather than obtaining combustibles for the entire floor and attributing that to their experiments. However, in the impact zone, there are two conference rooms (~1,590 lbs (721 kg) of combustible materials), 8 sets of four drawer lateral files (48 cabinets=192 drawers~13,824 lbs (6270.5 kg) (of paper that was likely dislodged by the impact) and the paper storage area (~28,000 lbs (12,701 kg) of paper & paper/office products) that directly contribute to the initial fire started by the jet fuel.

Information obtained from FEMA

- Estimated combustible fuel load as 8 psf.
- Additionally, the report acknowledges that typical office loading is 50 psf, per Load Resistance Factored Design published by American Society of Civil Engineers. (50*31013=1,550,650 lbs (7,577,988 kg) live load- i.e. combustible and non-combustible materials)

Methodology used for this examination

- The assumptions made for this project are as follows:
  1. That the symbols had not changed for the Knoll furniture between those used in 1997 and those used today.
  2. Veneer panels close in weight to panels used by NIST.
  3. Used FEMA building and core dimensions and assumed NIST did the same.
  4. Based on NIST drawing, I counted 204 workstations but according to plans from Dr. Quintiere, there were 210 workstations. I used 210 workstations.

5. Estimated that there were 20 units of five shelf storage files by the stairwell area. Each unit was determined to have dimensions 63" high x 36" wide (1.6 m x 0.9 m) and it was assumed that items were stored on top of the shelving units.
6. One Calibre cabinet held 15 lbs ~ 6.8 kg (of contents and one 3-drawer pedestal contained one paper file with 17" (0.4 m) of file storage (24 lbs ~ 10.9 kg of paper weight).
7. Southeast corner of building plan did not photocopy well therefore assumptions were made consistent with other corners of the 96th floor layout.

- The approximations made are as follows:
  1. The weights for chair models that were not found in the symbol library (perhaps not manufactured by Knoll), like "CH6", were estimated based on other known chair weights.
  2. Wall panels and workstation layout based on information provided by NIST [3]: (5) 4'panels-36"wide, (1) 5' panel-36"wide and (5) 4' panels-24"wide. In SI units: (5) 1.2 m panels- 0.91 m wide, (1) 1.5 m panel- 0.91 m wide, and (5) 1.2 m panels-0.61 m. The two foot panel weights were estimated using 10.55 lbs (4.8 kg) per foot of height.
  3. Based on files weighed in the ENFP office, an average file weight was obtained of 2 lbs/inch using standard paper size, type 20 wt.
  4. Only desks that could be positively identified as having a computer were given 'credit' for one (i.e. 165 computers for 210 workstations)
  5. Trapezoidal conference room table weight was estimated based on locating it once in AutoCAD, noting that there were several sizes, and then not being able to locate the table again.
  6. Knoll representative did not want to be quoted on specific amounts of combustible material in furniture.
  7. A request of the Manufacturer must be made in order for the privacy panels to be chemically treated to meet ASTM E-84 class "A" flame spread rating.

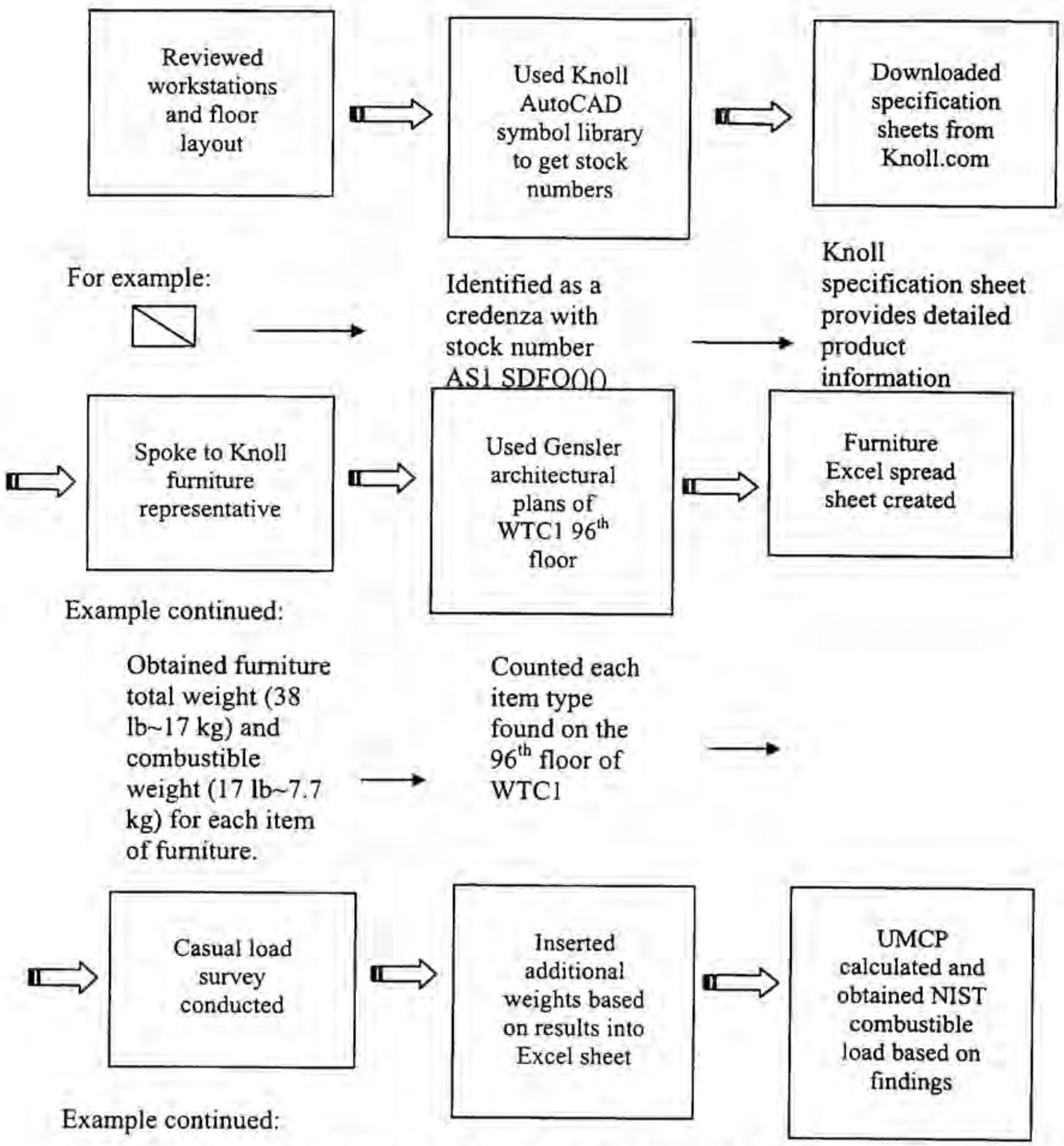

Figure 3. This flow chart demonstrates the methodology used to obtain furniture identifications.

Comparisons

The following comparison table is provided to sum-up the previously mentioned information and to clearly layout the three groups being compared.

Table 1.

	COMPARISON				
TOTAL WORKSTATION WT.	Average	High	Low		
description	UMCP			NIST	FEMA
Number of desks	211			204	
Total psf(*combined contents)	14.3				
Combustibles only desk wt	179441	1429	341		
Paper weight (lbs)	302062			134640	
Empty furniture weight (lb)	265162			191760	
Full furniture weight (lb)	441868			326400	248103
30% paper weight (lb)	90619				
Building area (ft^2)	42932				42932
Core area (ft^2)	11919			11745	11919
Area that furniture sits on	30930			31000	31013
Common file cabinets (lb):					
noncombustible	37626			0	
combustible	36,437			0	
combust. stored on top	255				
Total	74318				
Conf. rms/areas & pantries(lb)	7117			0	
***Combustible Material (psf)**	**10**			4 psf	8psf (39 kg/m^2)
SINGLE WORKSTATION WT.					
Combustible wrkstn weight	862	1443	341	660 lbs	
Total				1600lbs	
Wrkstn. weighted average (lb)	862				
Added Combustibles:					
workstation paper (lb)		370	6	160	
additional (lb)		30	0	0	
File cabinets:					
contents (lb)		424	124	40	
top (lb)		6	3	0	
workstation foot print	8'x8' (2.41 m * 2.41 m)			8'x8'	
paper NIST left out	71,844 lbs				

Comparison of fuel load between UMCP and NIST:

Table 2.

	NIST	UMCP
Total floor weight (combustible + noncombustible)	1600 lbs x 204 stations=326,400lb	210 stations x 1433 lb =301,012 lb
Total Combustibles Weight	134,640 lb/30930 ft^2= 4.3 lb/ft^2 combustibles only	301,012 lb/30930 ft^2 = 9.7 ~ 10 psf
*Paper weight for floor distributed per station	60,242 lb/204 wrkstns = 295 lbs.	176,706 lb /210wrkstns = 841 lbs.

*paper weights for NIST and UMCP are different because UMCP included common lateral files and paper storage whereas NIST did not.

**The reason for 1141.4 lbs of combustible per station is based on the accessible fuel per NIST. However, this is too low an estimate due to the fact that common files were not taken into account, nor conference rooms etc...

***This is the weighted average of the workstations.

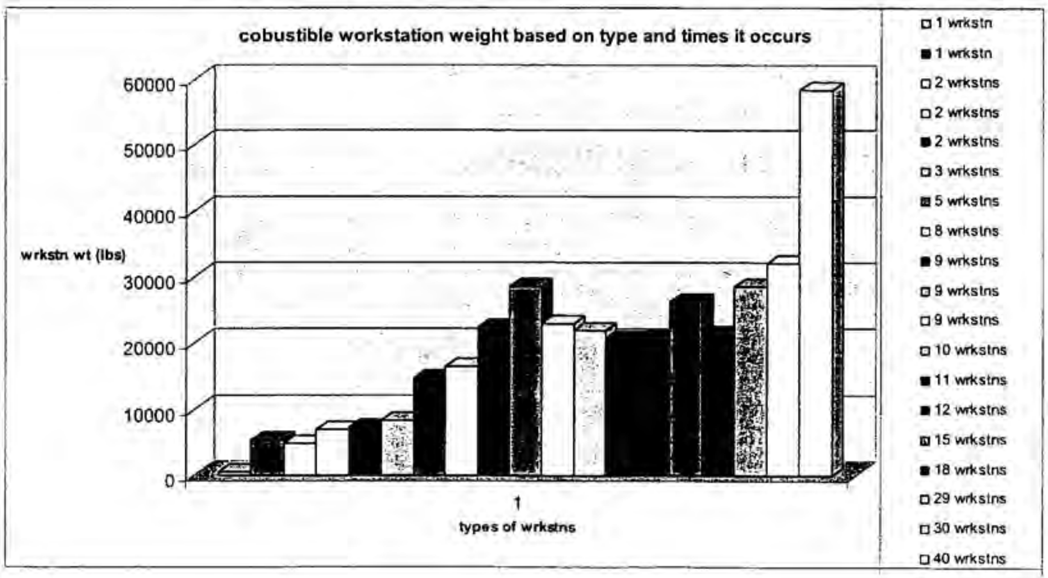

Figure 4. UMCP chart showing weight of workstation type plotted against the number of times the workstation type occurs on the 96th floor.

Recommendation

Use the NIST data for the temperature of steel then make a plot versus temperature of the outer steel insulation. The purpose of this plot is to help linearly estimate, based on corrected fuel load/fire size, the possible range of steel temperatures. Then, using something like SAFIR or lumped heat capacitance or maybe T. T. Lie's work, there would be a reference check as to the validity of the results.

From the above described course of action, a strong enough case can be made, which may prove to NIST that a re-examination of their original fuel load estimates is worthwhile.

References

1. McAllister, T., et al. FEMA WTC report "Chapter 2" page 2-1
2. McGrattan, K. "Simulation of the fires in WTC 1 and 2" BFRL, NIST, US Department of Commerce, October 19, 2004, slide 2.
3. NIST Preliminary WTC report 2004, Appendix J.

Other References not specifically cited:

4. NIST AND THE WORLD TRADE CENTER website "Status of Data Collection Efforts"
5. McGrattan, K. "Simulation of the fires in WTC 1 and 2" October 19, 2004. BFRL, NIST, US Department of Commerce.
6. McGrattan, K. "Simulation of the fires in WTC 1 and 2" October 19, 2004. BFRL, NIST, US Department of Commerce.
7. Knoll furniture catalog www.knoll.com/products

	wish to send confirmation of combustible weights via email).
H5 & I5	Combustible weight in lbs and kgs respectively
J3-J4	Weight of paper in one item is an estimate of the amount of paper to be found in/on a particular piece of furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
J5 & K5	Paper weight in lbs and kgs respectively
J9	Calibre cabinet was not given a paper weight of 15 lbs each but rather an estimate for clothing, note pads and other office items. The 15 lbs were put under weight of paper for ease of reference.
L2-L4	Total weight of paper for all items means that the weight of paper for one furniture item has been multiplied by the number of items on the floor.
L5 & M5	Total paper weight in lbs and kgs respectively
N2-N4	Combined weight for one full item means combustible and noncombustible weight of one full item. This column provides the total weight of one piece of a particular furniture type; self weight plus paper weight.
N5 & O5	Total furniture weight in lbs and kgs respectively
P2-P4	Total weight of combustible material for full item, this column provides the combustible weight of the furniture plus the added paper weight for one piece of a particular furniture type.
P5 & Q5	Combustible material weight in lbs and kgs respectively
R2-R4	Total combustible weight is the weight of combustible material times (x's) number of items. This means that the total combustible weight (P column) was multiplied by the number of times that piece of furniture was found on the 96th floor (G column).
R5 & S5	weight in lbs and kgs respectively
T2-T4	Total combustible and noncombustible weight provides the furniture self weight plus the added paper weight.
T5 & U5	Total weight (combustible + noncombustible) for 96th floor in lbs and kgs respectively

V3-V4	Total weight of the furniture only (both combustible and non-combustible furniture weight. Note, there is no added paper weight here)
V5 & W5	Furniture weight, only, for 96th floor in lbs and kgs respectively
B6-B25	Items that may be located in a workstation, there were different designs; these office items were found among the workstations on the 96th floor.
B27-B30	Common files refer to the lateral files that were either at the end of a workstation grouping or in a common area. (previously left out by NIST)
B32-B39	These are the different types of conference chairs found on the 96th floor.
B41-B45	These are the different types of conference tables found on the 96th floor.
B47-B51	These are the different types of common items found on the 96th floor.
B53-B61	These are the different common/shared rooms located on the 96th floor.
B63	Despite there being different sizes and weights of paper used, the estimate was based on Boise 20weight, 500 sheet 5 lb reams.
Notes:	
C7	The three file credenza was only included by NIST for the brand mane workstation. Appendix J shows that there was not a credenza for the generic workstation but rather a third two drawer file cabinet. If this was to account for the lack of a credenza then the combustible furniture weights were significantly different. (Credenza combustible weight of 17 lbs vs. all metal for the two drawer lateral file). If this was an attempt to account for the files at the end of workstation groupings then they should have been placed outside the workstation and the credenza would have been negated.
C9	The Calibre cabinet was not shown in any of the Appendix J photos but was present on the 96th floor, per Gensler, in the amount of 62 units with a **combustible** weight estimate of 175 lbs each!
Row 66	Provides 'sum' of columns
NIST	
A1	For ease of identification when printed I inserted column and row details.
A68	Row and designations for ease of reference.

B70	Heading to show that the following data is from NIST, Appendix J of preliminary report.
B71	Classification for the description of where the furniture item may typically found on the 96th floor from Appendix J.
C70	Item type refers to the physical description of an individual item found on the 96th floor as obtained from Gensler Architectural plans and Appendix J of the NIST preliminary WTC report.
D70	Stock identification numbers were obtained from comparing the Gensler Architectural plans to the AutoCAD symbol library obtained from www.Knoll.com
E69	Total weight of each item refers to the weight of one piece of furniture as it is, complete and unpacked. These weights were obtained from a Knoll Sales person.
E70	Weight of furniture in pounds (lbs)
F70	Weight of furniture in kilograms (kgs)
G68-G69	Number of items refers to the number of items found on the 96th floor of WTC 1. This information was obtained from Gensler Architectural plans except that the number of desks came from the FDS office graphic in Appendix J.
H68-H69	The weight of combustible material for empty furniture item refers to the amount of material for a single, unused piece of furniture (obtained from Knoll sales person who was referring to either a binder or computer when we spoke but did not wish to send confirmation of combustible weights via email).
H70 & I70	Combustible weight in lbs and kgs respectively
J68-J69	Weight of paper in one item is an estimate of the amount of paper to be found in/on a particular piece of furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
J70 & K70	Paper weight in lbs and kgs respectively
L68-L69	Total weight of paper for all items means that the weight of paper for one furniture item has been multiplied by the number of items on the floor.
L70 & M70	Total paper weight in lbs and kgs respectively

N68-N69	Combustible and noncombustible weight of one full item, this column provides the total weight on one piece of a particular furniture type, self weight plus paper weight.
N70 & O70	Total furniture weight in lbs and kgs respectively
P68-P69	Total weight of combustible material for full item, this column provides the combustible weight of the furniture plus the added paper weight for one piece of a particular furniture type.
P70 & Q70	Combustible material weight in lbs and kgs respectively
R68-R69	Weight of combustible material times (x's) number of items means that the total combustible weight (P column) was multiplied by the number of times that piece of furniture was found on the 96th floor (G column).
R70 & S70	weight in lbs and kgs respectively
T68-T69	Total combustible and noncombustible weight provides the furniture self weight plus the added paper weight.
T70 & U70	Total furniture weight for 96th floor in lbs and kgs respectively
B71-B84	Items that may be located in a workstation, there were different designs; these office items were found among the workstations on the 96th floor.
Notes:	
C73	The three file credenza was only included by NIST for the brand mane workstation. Appendix J shows that there was not a credenza for the generic workstation but rather a third two drawer file cabinet. If this was to account for the lack of a credenza then the combustible furniture weights were significantly different. (Credenza combustible weight of 17 lbs vs. all metal for the two drawer lateral file). If this was an attempt to account for the files at the end of workstation groupings then they should have been placed outside the workstation and the credenza would have been negated.
C72	The Calibre cabinet was not shown in any of the Appendix J photos but was present on the 96th floor, per Gensler, in the amount of 62 units with a **combustible** weight estimate of 175 lbs each!

Row 86	Provides 'sum' of columns
R86	Is the amount of combustible weight calculated by UMCP using NIST data however, it does not include carpet tiles and ceiling tiles. That contributes to the discrepancy UMCP(106,705 lbs) vs. NIST (660 lbs * 204 desks-134,640 lbs)
T86	Is the amount of total weight calculated by UMCP using NIST data however, it does not include carpet tiles and ceiling tiles. That contributes to the discrepancy UMCP(247,098 lbs) vs. NIST (1600 lbs * 204 desks-326,400 lbs)

Table 2. For Excel sheet 'wrkstn wts'

Column designation	Description of how the value was obtained and/or what it means/relevance
A1	Row and column designations for ease of reference.
B2	Heading to show that the following data is calculated from information obtained by Quintiere & Stewart of UMCP.
C2	WTC1 96th floor ('wrkstn wts') to let reader know which printed sheet they are viewing.
E3, H3, P2, Z2 & AM2	These are sub category designations.
G2	All weights on this sheet are in pounds.
B4	Description refers to designation of the employee who was originally assigned to that desk location on the 96th floor.
C4	Station identification is the number assigned on the architectural plans for a particular desk location.
D4	Telephone extension for a particular workstation
E4	Staff refers to the COMBUSTIBLE weight of one staff chair.
F4	Visitor refers to the combustible weight on staff chairs that can be attributed to that workstation.
G4	Conference refers to the conference area/room chairs that correspond to the

	designated location.
H4	J-shape refers to the style of knoll table that can be found at that workstation location; combustible weight is provided and does not include mounting or legs.
I4	Is the paper weight most likely to be found on the J-shape table and is an estimate of the amount of paper to be found on furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
J4	½ round table refers to the style of knoll table that can be found at that workstation location; combustible weight is provided and does not include mounting or legs.
K4	Is the paper weight most likely to be found on the ½ round table and is an estimate of the amount of paper to be found on furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
L3-L4	Teardrop or circular table refers to the style of knoll table that can be found at that workstation location; only combustible weight is provided and does not include mounting or legs.
M2-M4	Is the paper weight most likely to be found on the teardrop or circular tables and is an estimate of the amount of paper to be found on furniture. These two tables were grouped together because they have nearly identical weight as provided by Knoll customer service representative. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
N4	This is the boat shaped conference table that is located in the following conference rooms: NE, NW, SE, & SW
O3-O4	Is the paper weight most likely to be found on the boat shaped table and is an estimate of the amount of paper to be found on this furniture. This information was obtained by casual load observations and calculations of file cabinet weight and desk weight where applicable. These are conservative estimates!
P2-P4	Wall Panels: 4 foot high and two feet wide privacy panels used at each desk. The weight of 3 panels*14 lbs = 42 lbs.
Q3-Q4	Is the paper weight most likely to be found on the three privacy panels and is an

	estimate of the amount of paper to be found on these pieces of furniture. One privacy panel was observed to have 0.15 lbs of paper attached to it which is ~ 15 sheets of standard paper. This information was obtained by casual load observations and calculations of privacy panel decorations, calendars and other items.
R3-R4	Wall Panels: 4 foot high and three feet wide privacy panels used at each desk. The weight of 3 panels*24 lbs = 72 lbs.
S3-S4	Is the paper weight most likely to be found on the three privacy panels and is an estimate of the amount of paper to be found on these pieces of furniture. One privacy panel was observed to have 0.15 lbs of paper attached to it which is ~ 15 sheets of standard paper. This information was obtained by casual load observations and calculations of privacy panel decorations, calendars and other items.
T3-T4	Wall Panels: 5 foot high and three feet wide privacy panels used at each desk. The weight of 1 panel*35 lbs = 35 lbs.
U3-U4	Is the paper weight most likely to be found on the three privacy panels and is an estimate of the amount of paper to be found on these pieces of furniture. One privacy panel was observed to have 0.15 lbs of paper attached to it which is ~ 15 sheets of standard paper. This information was obtained by casual load observations and calculations of privacy panel decorations, calendars and other items.
V3-V4	Overhead cabinet refers to the double door cabinet that attaches to the five foot high privacy panel. The estimated combustible weight provided.
W2-W4	Paper weight for the overhead cabinet obtained from NIST Appendix J
X3-X4	Combustible weight of the Calibre cabinet (not included by NIST at all)
Y3-Y4	Additional weight is the added combustible weight for this furniture item.
Z2-Z4	Credenza 3-drawer is another furniture item that NIST did not include but rather per appendix J, equated cabinet fronts, presumably to justify negation
AA2-AA4	Paper weight for the one horizontal file drawer, one slender drawer and another miscellaneous storage drawer. Again, this information was obtained by weighing the file contents of two different ENFP horizontal drawers and adding additional

	weight for note pads etc…
AB2-AB4	Lateral file two-drawers refer to the all metal personal lateral files found at each workstation.
AC2-AC4	This is the paper weight contained in the lateral files, capacity is 150 lbs per drawer but I used 100 lbs per drawer based on the file contents of the horizontal drawer survey mentioned previously.
AD3-AD4	Common files used a wood counter-top
AE2-AE4	Paper weight likely to be found on wood counter-tops
AF3-AF4	This is the standard desk, Morrison, as obtained the Gensler architectural drawings and AutoCAD symbol library. This is the combustible weight of the desk only and does not include the mounting or table legs.
AG3-AG4	Paper weight that is likely to be found on this desk, it is a conservative estimate, and the information was obtained from a casual load survey.
AH2-AH4	Supplementary worktable (square or one rounded edge), these are added to the Morrison desk set-up based upon the workstation design, as obtained from Gensler architectural drawings. This is the combustible weight of the desk only and does not include the mounting or table legs
AI3-AI4	Paper weight that is likely to be found on this desk, it is a conservative estimate, and the information was obtained from a casual load survey.
AJ3-AJ	Computer monitor at workstation. Not all workstations appear to have a computer and there is '?' for any location that I was unsure about.
AK2-AK4	Computer hard drive at workstation.
AL3-AL4	Additional – unable to id means that there was something at that workstation that unidentifiable from Gensler architectural drawings.
AM2-AM4	Some workstations have additional chairs attributed to them; that is all this column is referencing.
AN2-AN4	Lateral files: 3 drawer metal file cabinets that is part of the common files.
AO2-AO4	Lateral files: 4 drawer metal file cabinets that is part of the common files.
AP2-AP4	Common files used a wood counter-top
AQ2-AQ4	Paper weight likely to be found on wood counter-tops

AR2-AR4	Corresponding panels refer to the panels that line some parts of the file cabinet groups.
AS2-AS4	Comment on which workstation design repeats; designated by employee.
AT2-AT4	Total times it occurs refers to the number of times that workstation design can be found on the 96th floor.
AU2-AU4	Combustible weight for an individual workstation type
AV2-AV4	Combustible sum of workstation weight per type
AW2-AW4	Combustible weight of file cabinets that NIST left out from their experimental burns.
AX2-AX4	Noncombustible weight of file cabinets that NIST left out from their experimental burns, 3 drawer cabinet.
AY2-AY4	Noncombustible weight of file cabinets that NIST left out from their experimental burns, 4 drawer cabinet.
AZ2-AZ4	Noncombustible weight of open metal shelving units that NIST left out from their experimental burns, 6 metal shelves.
BA	Sum of the combustible weight of other rooms on the 96th floors.

A.8 Excel Sheets
(attached)

In

To: wtc@nist.gov
From: Daniel Madrzykowski <madrzy@nist.gov>
Subject: Fwd: WTC Report
Cc: robert.neale@dhs.gov

Mr. Cauffman:

Please submit Mr. Neale's comment (below) for consideration by the WTC authors.

Thank you

Dan

X-Sieve: CMU Sieve 2.2
From: "Neale, Robert" <Robert.Neale@dhs.gov>
To: "Daniel Madryzkowski (madrzy@nist.gov)" <madrzy@nist.gov>
Subject: WTC Report
Date: Thu, 7 Jul 2005 10:14:18 -0400
X-Mailer: Internet Mail Service (5.5.2657.72)
X-MailScanner:
X-MailScanner-From: robert.neale@dhs.gov

Dan,

I would like to comment on the draft WTC report, but am not sure to whom it should go. Could you please forward to the appropriate folks?

On page xlviii of the Exec Summary, there is a recommendation for upgrading professional skills through a "national education and training effort for fire protection engineers, structural engineers and architects." Do you think we could get "code enforcement officials" inserted in that recommendation somewhere?

Thanks.

Robert A. Neale, Training Specialist

Fire Prevention: Technical Curriculum

Prevention and Leadership Development Section

National Fire Programs/United States Fire Administration

16825 S. Seton Avenue

Emmitsburg, MD 21727

Telephone: 301.447.1209

E-mail: robert.neale@dhs.gov

David Biggs
Ryan-Biggs Associates PC
518-272-6266

Reason For Comments; Comments 1 through 5 are related to what appears to be missing from the reports:

1. Where in the reports are the description of and the analysis of the column splices? The FEMA report documents the bolted splices.

2. Again with the column splices: Since the building was designed for impact by an airplane, where is the analysis showing the bolted splices are adequate the resist the impact anticipated in the original design?

3. What would have been the affect on the building by the aircraft impact had the column splices been welded?

4. The composite bar joists were not the original design. What would have been the result had the steel trusses been used?

5. Report: NCSTAR1
p 201- Recommendation 1
Comment: The recommendation does not specifically indicate if this applies to buildings over 20 stories. The rationale does not indicate how the WTC collapse can be used to justify design changes on 20 story buildings.
Suggested revision: Define proposed building height and give rationale.

6. . Report: NCSTAR1
p 212 - Recommendation 18
Comment: Maximizing remoteness of egress components is not specific enough. It should specifically state that it means the entire floor plan and not just the core.

Comment: The design for accidental loads is not specific enough. What is the suggestion..100psf overpressure??

7. Report: NCSTAR1
p 216 - Recommendation 25
Comment: The reports seem to indicate the WTC met or exceeded the code of the time. Is that the NIST assessment? If so, what is the justification for such a recommendation?

8. Report: NCSTAR1
p 217 - Recommendation 27
Comment: The calculations for projects are not part of the construction documents and are not provided to Owners. Misuse or copying of documents are some reasons for this. They remain the work product of the engineers and architect. Many professionals destroy the calculations once a project is completed and only maintain the drawings and specifications.

9. Report: NCSTAR1
p 218 - Recommendation 29
Comment: It is presumptive to say architects need to have education in structural engineering principles and design. That is already in their course work and licensing examination. What specifically is being recommended that needs to be included in training?

To: wtc@nist.gov
From: Sander Hicks <sander@voxpopnet.net>
Subject: public comment

Memo to:

National Institute of Standards and Technology
To Whom it May Concern,

I'm a reporter and independent publisher.

I know that NIST is working on an examination of collapse of the World Trade Center towers on 9/11, from an engineering perspective. I would urge you to look at the attached report, from fellow 9/11 researcher Webster Tarpley. I am acquainted with the man and have known him to be a reasonable fellow.

He very succinctly collects the evidence of:

A) Multiple witness commentary that indicate that explosions prior to the Towers' collapse.
B) The logic of the official story of a "pancake effect" is physically impossible (drawing largely on the work of scientist Jim Hoffman)

I have personally heard leading researcher Jim Hoffman speak at a conference on the topic in California. I found his research findings well-reasoned.

I hope you'll find the attached 25 page paper on these conclusions helpful. I know from personally polling people for my impending 9/11 book, that the collapse of the WTC, especially building 7, is an issue that is keeping a lot of us awake at night.

I've done breakthrough work on the 9/11 attack for *New York Press, Long Island Press,* Guerrilla News Network, http://gnn.tv, and INN World Report Television.

More information on me:

> Sander Hicks is the investigative journalist/independent publisher who started Soft Skull Press and Vox Pop/DKMC. He has appeared on 60 Minutes, on HBO/Cinemax in the documentary, "Horns and Halos," and has been featured in *PunkPlanet* magazine. He was the first, in the *New York Press*, to savage the *9/11 Commission Report* for its litany of omissions. Hicks is proud to possibly be the only reporter to have been verbally abused by a member of the 9/11 Commission. Sander and his wife, Holley Anderson, run the Vox Pop coffeehouse, bookstore and media company in Brooklyn, NY. They are the proud parents of a newborn son, Coleman.

--

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-Jeff Bullard, Taos, NM

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Tarpley_ch_6.pdf

VI: THE COLLAPSE OF WORLD TRADE CENTER 1, 2, AND 7

We now reach the center of the tragedy, the hecatomb of innocent airline passengers and office workers occasioned by the unprecedented and inexplicable collapse of the two World Trade Center towers. Here is where vast numbers of ordinary persons were immolated by the terrorist controllers for the sake of their insane geopolitical plans. Coming from a family which lived in New York for six decades after about 1910, having lived in New York City (Flushing, Queens) from the age of 4 to the age of 16, having attended New York City public schools from the first grade through the twelfth (PS 23, PS 20, JHS 185, Flushing High School), having worked in the city for a year as an adult living in Brooklyn, and having had an uncle who was a New York City policeman, the author is as much of a New Yorker as anyone. 9/11 has marked a decisive new step downward in the city's decline, and the bitter recognition of this tragic situation can only spur on the exposure of the actual process involved in 9/11.

THE KEY: SECONDARY EXPLOSIONS

According to the official version, which the 9/11 commission hardly comments on, the twin towers fell because of the impact of the planes and of the effects of the subsequent fires. The problem is that this is physically impossible, as we will show. The fall of the towers thus depends on some other cause: controlled demolition of some kind is the only possible hypothesis. The key to seeing beyond the official version is to chronicle the presence of secondary explosions, since these are the tell-tale signs of controlled demolition. When we examine the literature, we find a multitude of references to such secondary explosions.

Louie Cacchioli, aged 51, was a firefighter attached to Engine Company 47, based uptown in Harlem. "We were the first ones in the second tower after the plane struck," Cacchioli recounted later. "I was taking firefighters up in the elevator to the twenty-fourth floor to get in a position to evacuate workers. On the last trip up a bomb went off. We think there were bombs set in the building." Cacchioli was trapped in an elevator but was able to escape with the help of some fireman's tools. (*People Weekly*, September 24, 2001)

Auxiliary Fireman Lt. Paul Isaac Jr. also spoke of bombs in an interview with internet reporter Randy Lavello. Isaac had served with Engine Company 10 in lower Manhattan during the late 1990s, so he knew the area around the WTC. Isaac said that many New York firemen were very concerned about the ongoing cover-up of why the World Trade Center collapsed. "Many other firemen know there were bombs in the buildings," he revealed, "but they are afraid for their jobs to admit it because the higher-ups forbid discussion of this fact. There were definitely bombs in those buildings." Among those suppressing real discussion about what had happened, Isaac cited the neocon heavy

James Woolsey, who had been CIA Director under Clinton, who had become the New York Fire Department's antiterrorism consultant. (Marrs 34)

Teresa Veliz was a manager for a software development firm. She was on the 47th floor of the North Tower when American 11 struck. Veliz was able to reach the ground level at about the same time that the South Tower collapsed. Flung to the ground in total darkness, Veliz and a colleague followed another person who happened to have a flashlight. As she narrated later: "The flashlight led us into Borders bookstore, up an escalator, and out to Church Street. The explosions were going off everywhere. I was convinced that there were bombs planted all over the place and someone was sitting at a control panel pushing detonator buttons. I was afraid to go down Church Street towards Broadway, but I had to do it. I ended up on Vesey Street. There was another explosion. And another. I didn't know which way to run." (Murphy; Marrs 34)

Ross Milanytch viewed the scene from the 22nd floor of a nearby building. He reported seeing "small explosions on each floor. And after it all cleared, all that was left of the buildings, you could just see the steel girders in like a triangular sail shape. The structure was just completely gone." (*America at War*; Marrs 34)

Steve Evans, a reporter for the BBC, happened to be in the South Tower that morning. "I was at the base of the second tower, the second tower that was hit," he reported. "There was an explosion – I didn't think it was an explosion – but the base of the building shook. I felt it shake ... then we were outside, the second explosion happened and then there was a series of explosions....We can only wonder at the kind of damage – the kind of human damage – which was caused by those explosions, those series of explosions." (Christopher Bollyn, *American Free Press*; www.zeitenschrift.com/news/wtc/_wahrheit.ihtml)

Fox 5 News, a New York television channel, was able to catch on videotape a large white cloud billowing out near the base of the South Tower. The newsman commented: "There is an explosion at the base of the building....white smoke from the bottom ...something has happened at the base of the building... then, another explosion. Another building in the World Trade Center complex...." (Marrs 35)

Tom Elliott was at work at his desk in the offices of Aon Corp. on the 103rd floor of the South Tower just before 9 AM. When the North Tower was hit, he decided to leave the building and began walking down the stairs with a small group of people. At the 70th floor, Elliott was encouraged by a woman to disregard the announcement on the public address system that there was no need to evacuate. When Elliott had reached the 67th floor, United 175 struck the South Tower, above where he was. Elliott later told a reporter what he was able to observe after that: "Although its spectacularly televised impact was above Elliott, at first he and those around him thought an explosion had come from below. An incredible sound – he calls it an 'exploding sound' – shook the building and a tornado of hot air and smoke and ceiling tiles and bits of drywall came flying up the stairwell. "In front of me, the wall split from the bottom up," Elliott recounted. Elliott was able to get out of the South Tower by 9:40. (*Christian Science Monitor*, September 17, 2001)

At 11:56 AM, NBC News broadcast a segment in which reporter Pat Dawson summarized a conversation he had just had with Albert Terry of the FDNY. Terry had told the reporter that he had about 200 firefighters in the WTC buildings at around 9 AM. Then, Terry said, he had heard a kind of secondary explosion. Dawson:

> Just moments ago I spoke to the Chief of Safety for the New York City Fire Department, who was obviously one of the first people here after the two planes were crashed into the side, we assume, of the World Trade Center towers, which used to be behind me over there. Chief Albert Terry told me that he was here just literally five or ten minutes after the events that took place this morning, that is the first crash. The Chief of Safety of the Fire Department of New York City told me that shortly after 9:00 he had roughly ten alarms, roughly 200 men, trying to effect rescues of some of those civilians who were in there, and that basically he received word of a secondary device, that is another bomb, going off. He tried to get his men out as quickly as he could, but he said that there was another explosion which took place. And then an hour after the first hit here, the first crash, that took place, he said there was another explosion that took place in one of the towers here. So obviously, according to his theory, he thinks that there were actually devices that were planted in the building. One of the secondary devices, he thinks, that [detonated] after the initial impact he thinks may have been on the plane that crashed into one of the towers. The second device, he thinks, he speculates, was probably planted in the building. So that's what we have been told by Albert Terry, who is the Chief of Safety for the New York City Fire Department. He told me that just moments ago. (Wisnewski 135-136)

Proponents of the official version have attempted to explain some of these explosions as having been caused by gas escaping from leaks in gas mains, but this cannot account for the phenomena described by Terry. Nor can such other explanations as exploding transformers, etc.

Ann Thompson of NBC reported at 12:42 PM that she had reached the corner of Broadway and Fulton on her way to the World Trade center that morning when she heard an explosion and a wall of debris came toward her. She took refuge in a building. When she came out again about 10:30, she heard a second explosion. Firemen warned her about another explosion. (Wisnewski 136; Trinkhaus, 4 ff.)

The eyewitness Michael Benfante told a German TV camera team: "As I was leaving, I heard it. I looked back, and the top of the North Tower was exploding. And even then I did not believe that the whole tower could fall. I thought, only the top exploded and is now going to fall on me. I turned around again and ran away. I felt the rumble of the explosions, the thunder of the collapsing building." (German ARD network, "Tag des Terrors – Anschlag aus heiterem Himmel," August 30, 2002, Wisnewski 136)

A reporter tried to film a standup with the WTC in the background, but was interrupted by the sound of an explosion: "We can't get any closer to the World Trade Center. Here you can see the firemen who are on the scene, the police and FBI officers, and you see the two towers – A huge explosion! Debris is coming down on all of us!" ("Verbrechen gegen die Menschheit," West German Television, Cologne, July 24, 2002; Wisnewski 136)

Yet another eyewitness reported: "We heard a huge explosion, and everything got black. Glass was falling down, people were getting hurt when the glass hit them. It was a big explosion, everything got dark, this here is not snow, it's all from the building, a horrible nightmare." "I was on Sixth Avenue and I had just tried to call somebody when I heard an explosion and saw how the people were throwing themselves on the ground, screaming and crying, I looked up and saw all that smoke, as the tower came down, and all that smoke in one tower." (Segment by Oliver Voegtlin and Matthias Fernandes, NTV, September 11, 2001)

Another European documentary showed a man with glasses recovering in a hospital bed who recalled: "All of a sudden it went bang, bang, bang, like shots, and then three unbelievable explosions." ("Terror gegen Amerika," RTL, September 13, 2001)

An eyewitness who worked in an office near the WTC described his experiences to a reporter for the *American Free Press*. He was standing in a crowd on Church Street, about two and a half blocks from the South Tower. Just before the South Tower collapsed, he saw "a number of brief light sources being emitted from inside the building between floors 10 and 15." He saw about six of these flashes and at the same time heard a "a crackling sound" just before the tower collapsed." (Christopher Bollyn, *American Free Press*, December 2, 2001; Wisnewksi 137)

Kim White, 32, who worked on the 80th floor of the South Tower, was another eyewitness who reported hearing an explosion. "All of a sudden the building shook, then it started to sway. We didn't know what was going on," she told *People* magazine. "We got all our people on the floor into the stairwell . . . at that time we all thought it was a fire . . .We got down as far as the 74th floor . . . then there was another explosion." (Christopher Bollyn, *American Free Press*, December 2, 2001)

A black office worker wearing a business suit that was covered with dust and ashes told the Danish television network DR-TV1: "On the eighth floor we were thrown back by a huge explosion." (Wisnewski 138)

The German network SAT 1 broadcast a report featuring survivors who also were talking about explosions. One of these eyewitnesses, by the name of Tom Canavan, was cut off in mid-sentence by two FBI agents who barged in, grabbed him as he was speaking, and hustled him away; this scene was captured on tape. (Wisnewski 138)

NBC TAPES SHOW CONTROLLED DEMOLITION EXPLOSIONS

In his best-selling study and also in his prime-time special broadcast on German television in August 2003, Gerhard Wisnewski employed out-takes from NBC News cameras near the World Trade Center to provide actual examples of what are almost certainly controlled demolition charges being detonated. On the NBC tape, we see the two towers burning and emitting clouds of black smoke. Then, at about frame 131 of the tape, there emerges a cloud of white-grey smoke along about two thirds of the 79th floor of the South Tower. Two thirds of the southeast façade correspond to the dimensions of the central core column complex, which would be where controlled demolition charges would have to be placed. This line of white-grey smoke billows up, contrasting sharply with the black smoke from the fire. At about frame 203, another line of white-grey smoke emerges several floors below the first, and billows up in its turn. This represents decisive photographic evidence of controlled demolition charges being triggered in the World Trade Center. (Wisnewski 216)

Andreas von Bülow, the former Social Democratic Technology Minister of Germany under Chancellor Helmut Schmidt, noted in his study of 9/11 that news tapes show smoke being forced out of the hermetically sealed windows of both towers in the minute or so just before they fell. (Von Buelow 146-147) This is very likely also evidence of controlled demolition charges or other artificial processes going on inside the buildings.

FIREMEN WERE CONFIDENT OF EXTINGUISHING THE FIRE

The Guiliani administration in New York City, and its successor, the Bloomberg administration, refused for a long time to allow the public to hear tapes of the radio conversations among the FDNY firemen on the scene at the WTC. In the summer of 2002, press accounts surfaced which indicated that firemen had been able to climb to the Sky Lobby on the 78nd floor and been able to survey the extent of the fire from there. The fuselage of United 175 had struck the 80th floor, and one of its wings had clipped the 78th floor itself. The FDNY officers describe a situation with only two pockets of fire, and they express confidence that they will be able to fight the fire successfully with two hose lines. Two officials who are mentioned by name on the tape are Battalion Chief Orio J. Palmer and Fire Marshal Ronald P. Bucca, both of whom died when the South Tower collapsed. "Once they got there," the *Times* says, "they had a coherent plan for putting out the fires they could see and helping victims who survived." According to the *New York Times* summary, the two officers "showed no panic, no sense that events were racing beyond their control.... At that point, the building would be standing for just a few more minutes, as the fire was weakening the structure on the floors above him. Even so, Chief Palmer could see only two pockets of fire and called for a pair of engine companies to fight them....

The limited transcripts made available on the internet were as follows:

> Battalion Seven…Ladder Fifteen, we've got two isolated pockets of fire. We should be able to knock it down with two lines. Radio that, 78th floor numerous Code Ones.

The audio tape has never been released to the public. The Justice Department claims that it is evidence in the trial of Zacarias Moussawi in Alexandria, Virginia. (*New York Times*, August 4, 2002) Christopher Bollyn, already cited, commented: "The fact that veteran firefighters had 'a coherent plan' for putting out the 'two pockets of fire' indicates they judged the blazes to be manageable. These reports from the scene of the crash provide crucial evidence debunking the government's claim that a raging steel-melting inferno led to the tower's collapse." (Marr 38-39)

Earlier in the morning, Pete Ganci, the Chief of the Department, and thus the highest-ranking uniformed firefighter in the city, had told Giuliani: "We can save everybody below the fire. Our guys are in the building, about halfway up the first tower." (Giuliani 8) Ganci was killed in action later in the day.

THE CASE OF WTC 6

CNN broadcast the image of smoke rising up from street level near the base of Building 6, the Customs House. This video footage had originated at 9:04, about one minute after United 175 struck the South Tower. Remember that WTC 6 was on the north side of the north tower, so any explosions there cannot be regarded as having been generated by the impact to the South Tower. A powerful explosion inside WTC 6 had hurled a cloud of gas and debris 170 meters high. A CNN archivist commented, "We can't figure it out." (Marrs 36) This incident was soon eclipsed by the collapse of the South Tower, and has tended to be forgotten. The various official reports have had precious little to say about WTC 6. Overhead views of the ruins later showed a large crater in the steel structure of WTC 6; it was clear that this crater could not have been caused by fire. (Von Bülow 163-164)

THE AGONY OF THE FDNY

FDNY lost 343 firefighters that day, more than their casualties in the previous hundred years. It is worth asking why this came about. In the case of fires in high-rise skyscrapers, outside ladders cannot be used above a certain level. Therefore, the firemen are trained to use staircases to climb up to the fire and fight it within the building. They could do this with a certain degree of confidence because no modern, steel-framed, fireproof building had ever collapsed as a result of fire. On 9/11, three of them – WTC 1, WTC 2, and WTC 7, all collapsed. Veteran firefighters knew what they were doing. Their losses are not attributable to any mistake on their part, but, in all probability, to the fact that the twin towers and WTC 7 were brought down by some form of controlled demolition.

The 1 Meridian Plaza fire in Philadelphia had burned lustily for many hours in 1991, but came nowhere near collapsing. The 1 Meridian fire burned for 19 hours, leaping from floor to floor and burning out as combustible materials were used up. On May 4-5, 1988, the 62-story First Interstate Bank Building in Los Angeles – a structure that was more or less comparable to the twin towers – burned for more than three hours, with bright, intense flames licking up the sides of the building. In a post-blaze assessment, Iklim Ltd., a company that specializes in building inspections and structural analyses after fires, concluded: "In spite of the total burnout of four and a half floors, there was no damage to the main structural members and only minor damage to one secondary beam and a small number of floor pans."

These comparisons were noted with some discomfort by the *New York Times*, which commented that "High-rise buildings are designed to be able to survive a fire, even if the fire has to burn itself out. The strategy is to ensure that the steel support structures are strong enough or protected well enough from fire that they do not give way in the time it takes for everything inside an office building, like furniture, to burn. In major high-rise fires elsewhere in the country, such as the 1 Meridian Plaza fire in Philadelphia in 1991 and the First Interstate Bank fire in Los Angeles in 1988, this approach has worked. But the fires at 7 World Trade Center raged mainly on lower floors and never burned out, and in the chaos of Sept. 11, the Fire Department eventually decided to stop fighting the blazes." One can sense the acute embarrassment of the mythographs; this is all just absurd. "What the hell would burn so fiercely for seven hours that the Fire Department would be afraid to fight it?" said one member of the investigation team quoted in this same article. (*New York Times*, March 2, 2002)

THE ROMERO ANALYSIS

An important early contribution to the discrediting of the official version regarding the WTC came in an interview with a New Mexico expert in mining technology which appeared a few days after 9/11. This highly realistic analysis appeared in the *Albuquerque Journal* of September 14, 2001 under the headline "Explosives Planted in Towers, New Mexico Tech Expert Says," the byline belonged to Olivier Uyttebrouck.

> Televised images of the attacks on the World Trade Center suggest that explosive devices caused the collapse of both towers, a New Mexico Tech explosion expert said Tuesday. The collapse of the buildings appears "too methodical" to be a chance result of airplanes colliding with the structures, said Van Romero, vice president for research at New Mexico Institute of Mining and Technology.
>
> "My opinion is, based on the videotapes, that after the airplanes hit the World Trade Center there were some explosive devices inside the buildings that caused the towers to collapse," Romero said. Romero is a former director of the Energetic Materials Research and Testing Center at Tech, which studies explosive materials and the effects of explosions on buildings, aircraft and other structures.
>
> Romero said he based his opinion on video aired on national television broadcasts. Romero said the collapse of the structures resembled those of

> controlled implosions used to demolish old structures. "It would be difficult for something from the plane to trigger an event like that," Romero said in a phone interview from Washington, D.C.
>
> Romero said he and another Tech administrator were on a Washington-area subway when an airplane struck the Pentagon. He said he and Denny Peterson, vice president for administration and finance, were en route to an office building near the Pentagon to discuss defense-funded research programs at Tech.
>
> If explosions did cause the towers to collapse, the detonations could have been caused by a small amount of explosive, he said. "It could have been a relatively small amount of explosives placed in strategic points," Romero said. The explosives likely would have been put in more than two points in each of the towers, he said.
>
> Romero said that if his scenario is correct, the diversionary attack would have been the collision of the planes into the towers.
>
> The detonation of bombs within the towers is consistent with a common terrorist strategy, Romero said. "One of the things terrorist events are noted for is a diversionary attack and secondary device," Romero said. Attackers detonate an initial, diversionary explosion that attracts emergency personnel to the scene, then detonate a second explosion, he said. Romero said that if his scenario is correct, the diversionary attack would have been the collision of the planes into the towers. (http://www.abqjournal.com/aqvan09-11-01.htm -removed from archive; see http://emperors-clothes.com/news/albu.htm)

Here was an honest appraisal from a qualified expert. Romero successfully identified some of the main anomalies presented by the spectacle of collapse, and proceeded from there to the only tenable hypothesis: controlled demolition. He was also acutely perceptive in seeing that the aircraft impacts could not in themselves have been the cause of the fall of the twin towers; they rather had to be regarded as a diversion or cover story to make the fall of the buildings plausible to public opinion. However, the America of late September 2001 was marked by a climate of neo-McCarthyite hysteria wholly antithetical to public truth; Van Romero later retracted his highly insightful remarks, and is rumored to have since found preferment from the federal government.

But numerous foreign experts arrived independently at similar conclusions. Steffen Kretz, the news anchor of the Danish television channel DR-1, reported that "the World Trade Center Tower collapsed after two more explosions." In a commentary of this same network, it was stated that the World Trade Center collapsed after an *additional* explosion. (Wisnewski 138) On 9/11, Denmark's DR-1 broadcast an interview with Jens Claus Hansen, a high-ranking officer of the Danish Military Academy. His view was: "Additional bombs must have been placed inside the WTC towers – otherwise they would not have collapsed as they actually did." Another guest was the former NATO General Keld Hillingsøe, who commented: "Additional bombs must have been installed in the buildings." (Wisnewski 138) The Danish newspaper *Berlingske Tidende*, the leading conservative paper in the country, published an interview with the explosives expert Bent Lund, who pointed out that fire alone could not have caused the collapse of the twin towers. He estimated that about a ton of explosives must have exploded inside the buildings in order to bring them down in this way. (*Berlingske Tidende*, September 12, 2001; Wisnewski 138)

THE VIEW OF A SWISS ENGINEER

Another leading authority who raised the issue of sabotage from within the towers was Hugo Bachmann, professor emeritus of building dynamics and earthquake engineering at the world-famous Swiss Eidgenössische Technische Hochschule in Zürich – where Einstein had taught. As Bachmann told the *Neue Züricher Zeitung Online* on September 13, 2001, at first glance there seemed to be two possibilities in the fall of the towers. The first was the fire and its effect on the steel supports. But Bachmann had an alternative: "In the second scenario, an additional terrorist action would have caused the collapse of the buildings. In this way, according to Bachmann, buildings like the World Trade center can be destroyed without great logistical exertion." The article went on to say that "Bachmann could imagine that the perpetrators had installed explosives on key supports in a lower floor before the attack." If the perpetrators had rented office space, then these "explosive tenants" could have calmly placed explosive charges on the vulnerable parts of the building "without having anyone notice." Bachmann thought that it was less likely that explosives in the below ground parts of the building could have caused the collapse. Here the logistic problems would be harder to solve in order to put the charges in the right places, and the foundations were probably of more stable construction than the steel towers. Bachmann commented that "the question of whether in fact one of these two scenarios is applicable cannot be answered at this time." But he felt it was a central issue that the second scenario should get more attention, whether or not it applied to the WTC. Bachmann observed that anyone who had enough knowledge of static structures and explosives technology could in principle destroy any building, since every structure has its Achilles heel. An attack aimed at that weak point would be relatively easy to carry out, but would require careful and time-consuming planning. Not all buildings were equally vulnerable, but the twin towers of the World Trade Center were in Bachmann's opinion probably among the more sensitive targets. (Wisnewski 141-143)

OPPORTUNITIES FOR TAMPERING

There are numerous pieces of unconfirmed anecdotal evidence suggesting strange and unusual activities in the World Trade Towers in the days and weeks before their destruction. One New York businessman told me in an interview three years after the fact that he had visited a client in one of the towers numerous times during the months preceding the attack, and had always found that certain elevators were out of service. Another report came from Scott Forbes, an employee of Fiduciary Trust, a firm which was located on floors 90 and 94-97 of the South Tower. Eighty-seven employees of

Fiduciary Trust were killed on 9/11. In an email account, Forbes reported that over the weekend of September 8-9, 2001, floors 50 and above of the South Tower experienced a "power down," meaning that all electrical current was cut off for about 36 hours. The reason officially cited was that the electrical cables in the building were being upgraded. Forbes was an information technology officer in charge of Fiduciary Trust's computer network; his attention was engaged by the power down because it fell to him to shut down all the company's computers and related systems before the power went out. After the power down, he had to turn the computers back on again, and restore service on the network. Because there was no electric power above the fiftieth floor, there were also no security cameras and no security locks. There were however many outside engineering personnel coming in and out of the tower at all hours during the weekend. Forbes lived in Jersey City and could see the WTC towers from his home; when he saw the conflagration on the morning of 9/11, he immediately related it to the events of the previous weekend. (www.serendipity.li/wot/forbes01.htm)

SEISMIC EVIDENCE

The seismic effects of the collapse of the towers were observed and measured by Columbia University's Lamont-Doherty Earth Observatory just up the Hudson River in Palisades, New York. Here seismographs recorded two spikes reflecting two shock waves in the earth on the morning of 9/11. The crucial fact is that these two spikes came just *before* the collapse of the towers began. Specifically, Columbia scientists at the facility registered a tremor of 2.1 on the Richter scale at 9:59:04 EDT, just before the beginning of the collapse of the South Tower, and a 2.3 shock just as the North Tower began to come down at 10:28:31 EDT. Both tremors were recorded before the vast majority of the mass of the buildings hit the ground. Although they were not of earthquake proportions, these were considerable shocks, about twenty times more potent than any previously measured shock wave generated by a falling building. The 1993 WTC truck bomb had produced no seismic effects at all – it had failed to register. At 5:20 local time on the afternoon of 9/11, there was also a 0.6 tremor from the collapse of WTC 7, also at the beginning, rather than the end, of this building's collapse. Dr. Arthur Lerner-Lam, the director of the Columbia Center for Hazards and Risk Research, commented that "during the collapse, most of the energy of the falling debris was absorbed by the towers and neighboring structures, converting them into rubble and dust or causing other damage – but not causing significant ground shaking." But Lerner-Lam declined to draw any conclusions from the glaring anomaly represented by his data, which the 9/11 commission has also avoided. (Marrs 39 ff.)

After most of the pile was removed, experts found that there were pools of what appeared to have been molten metal which had congealed on foundations of the buildings many levels underground. Some steel appeared to have partially melted, other steel had undergone alternations to its crystalline structure, and still other steel was full of holes, like a Swiss cheese.

GIULIANI OBLITERATES THE WTC CRIME SCENE

Mayor Giuliani, by pedigree, was a creature of the highly repressive bureaucratic-authoritarian apparatus which had consolidated itself in the Justice Department during the Reagan years. He now performed yeoman service in defense of the 9/11 myth, a myth which had its most obvious vulnerability in its most spectacular point: the unprecedented and physically inexplicable collapse of the twin towers. Giuliani used the pretext that his term was ending on December 31, 2001 to organize the massive obliteration of the WTC as a crime scene. Parallel to this, Giuliani engineered a confrontation with the New York firemen, both to divert public attention from his tampering with the evidence, and also to neutralize the potential of the firemen, the one group which might have denounced the presence of controlled demolition charges in WTC 1, 2, and 7, of which, as we have seen, they were well aware.

During the crisis, Giuliani had been eager to exploit for his own political image the immense admiration and gratitude which had been expressed around the nation and the world for the epic feats of the New York firefighters. The firemen were now the most revered symbols in the country: typical was the cover of *Newsweek*'s post-9/11 issue, which showed some firemen raising a flag over the ruins, with an evident allusion to the flag raising on Iwo Jima. Giuliani made a practice of appearing in public wearing a baseball cap emblazoned with the letters "FDNY." The police he relegated to his windbreaker, which bore the legend "NYPD." Giuliani proved to be treacherous in practice to both, and he did this by playing the firefighters against the police, and vice versa – all in the service of the 9/11 coverup. The firemen, once revered, would soon be "inexcusable," according to Giuliani.

CONTROLLED DEMOLITION AGAIN

Giuliani brought in Controlled Demolition, the same highly suspect firm which had finished the demolition of the Murragh Federal Building in Oklahoma City in 1995, and which had disposed of the evidence there in the process.

This contract was let surreptitiously just eleven days after 9/11, and empowered Controlled Demolition to recycle the steel of the World Trade Center. Giuliani has not a word to say about this in his memoirs. The city accepted rock-bottom prices for the steel; the priority was to make it disappear fast. Trucks hauling the steel away were equipped with $1,000 Global Positioning System locators to ensure that none of them went astray, and that no suspect steel ended up in the back yard of a maverick 9/11 researcher. All investigators, in fact, were banned from ground zero. Now Controlled Demolition would eradicate any chance of using the abundant physical evidence present in "the pile," as the mass of twisted rubble of the WTC quickly came to be called. It was a scene out of Kafka – it was impossible to find out which officials were superintending the destruction of the evidence, to save a myth that was being used to set in motion a world war.

Giuliani, along with ghostwriter Ken Kurson, has produced a relentlessly self-laudatory and self-promoting autobiography entitled *Leadership*. This work constitutes a monument of hypocrisy. During one of his visits to the WTC site, the Mayor noticed that many visitors were taking pictures of the site. Because there was so much to hide, he found this troubling: "I noticed a disturbing phenomenon – hundreds of people carrying disposable cameras and handheld video cameras. I understood the impulse – this was a historic event, and experiencing it up close had a tremendous impact. At the same time, this was a crime scene, and a dangerous one. I did not want anyone to get hurt, or to damage evidence as they scouted out the best angle for their snapshots. If we didn't do something about it immediately, it would soon be out of control, a voyeur's paradise, and we risked the site developing a distasteful freak show aspect." (Giuliani 49) An independent photographic documentation of the crime scene, one the FBI would not be able to confiscate? Horrors! Giuliani promulgated his infamous order that all photos were illegal in the area around the WTC complex. Those who risked a snapshot also risked going to jail.

When it was a question of preventing public scrutiny, Giuliani considered the WTC pile a crime scene where there was evidence that had to be preserved. But when it was a question of sending the crucial evidence to the other end of the world, Giuliani's motto became "scoop and dump" – with the help of Controlled Demolition. As Thomas Van Essen, Giuliani's fawning appointee as Fire Commissioner, described the scene: "…a full-blown recovery operation was under way, and the site had become an enormous construction zone. Trucks and plows rolled around everywhere. Giant cranes lofted massive steel beams over the heads of the men below." (Van Essen 263) The steel was being sent to a city land fill at Fresh Kills, Staten Island.

According to Van Essen, by the end of October Giuliani was filled with humanitarian concern about the danger of accidents to those working on the pile. One of the main groups present there were firefighters who were seeking the bodies or other remains of their hundreds of fallen comrades. According to the literary provocateur Langewiesche, "there were some among the construction workers and the police who grew unreasonably impatient with the firemen, and became overeager to repeat the obvious – in polite terms, that these so-called heroes were just ordinary men. On the other hand, the firemen seemed to become steadily more self-absorbed and isolated from the larger cleanup efforts underway. " (Langewiesche 158) "Firemen were said to prefer watches from the Tourneau store, policemen to opt for kitchen appliances, and construction workers (who were at a disadvantage here) to enjoy picking through whatever leftovers they came upon – for instance, wine under the ruins of the Marriott hotel, and cases of contraband cigarettes that spilled from the US Customs vault in the Building Six debris." (Langewiesche 159) Langewiesche reported with great gusto the discovery of evidence that the firemen had been looting even before the towers came down. "Fifty feet below the level of the street they began to uncover the hulk of a fire truck that had been driven deep by the collapse." According to Langewiesche, the field superintendent who only wanted to get on with the job at hand felt "delight, then, after the hulk of the fire truck appeared, that rather than containing bodies (which would have required decorum), its crew cab was filled with dozens of new pairs of jeans from The Gap, a Trade Center store. When a grappler pulled off the roof, the jeans were strewn about for all to see. It was exactly the sort of evidence the field superintendent had been waiting for. While a group of initially bewildered firemen looked on, the construction workers went wild." (Langewiesche 161) The firemen, we must remember, were those who knew most about the controlled demolition of the World Trade Center, and they were also the group most likely to tell what they knew. In this sense, the firemen posed perhaps the greatest immediate threat to the 9/11 myth upon which the oligarchy had staked so much. The obvious campaign of psychological warfare against the firemen, therefore, was of world-historical importance. Given the stakes, it would be impossible to exclude that the dungaree incident which Langewiesche found so delightful had been cynically staged as a means of keeping the angry and rebellious firemen off-balance, distracted and confused. The jeans could easily have been planted at a quiet moment during the graveyard shift. Langewiesche's reporting came out during the fall in the *Atlantic Monthly*, and rankled deeply among the angry firemen and the bereaved families.

On October 31, Halloween, Giuliani decreed without any meaningful consultation that there would be an upper limit of 25 firefighters on each shift at the WTC pile, along with 25 New York City policemen and 25 Port Authority patrolmen. Soon "the rescue workers were up in arms. Stories went around that we had simply given up on finding bodies; that the mayor wanted to speed the cleanup so it would be finished before he left office; that we had recovered gold from the trade center and didn't care about anything else....Union officials started telling the workers we were haphazardly trucking everything to Fresh Kills – a 'scoop and dump' operation." (Van Essen 265)

Langewiesche defends the Mayor's justification of cutting the firemen's representation on the pile: "when Giuliani gave 'safety' as the reason for reducing their presence on the pile, he was completely sincere." (Langewiesche 161) In his view, the big problem on the pile was "firemen running wild." (Langewiesche 162) In mid-October, an audience of firemen, policeman, widows, and orphans loudly booed several members of the Giuliani administration, but also Senator Hillary Clinton and a local Democratic politician. (Van Essen 258) On Friday, November 2, Giuliani was able to harvest the results of his provocations. In the morning, more than 1,000 firemen came together at the WTC. Their chants included: "Bring the brothers home! Bring the brothers home!", "Do the right thing!", "Rudy must go!", and "Tom must go!", a reference to Fire Commissioner Thomas Van Essen, a Giuliani appointee. Their signs read, "Mayor Giuliani, let us bring our brothers home." Speakers denounced Giuliani's hasty carting off of wreckage and remains to Fresh Kills as a "scoop and dump" operation. One well-respected former captain appealed to the crowd: "My son Tommy of Squad 1 is not home yet! Don't abandon him!" This was met with a cry of "Bring Tommy home!" from the assembled throng. This scene soon degenerated into an altercation between the firefighters and the police guarding the site, and then into a full-scale riot. Twelve firefighters were taken to jail, while five policemen were injured. Giuliani had gladly sacrificed the 9/11 myth of national solidarity to the needs of his campaign of psychological warfare and provocations against the firemen. It was All Souls Day, the day of the dead, November 2, 2001.

At a press conference that same day, Giuliani hypocritically condemned the actions of the firemen as inexcusable. The police wanted to make more arrests, and were scanning videotapes of the riot to identify firefighters. The city was appalled by what had happened; many newspapers were anti-Giuliani this time. One trade union leader, Gorman, called Giuliani a "fascist," and referred to the Police Commissioner and the Fire Commissioner as Giuliani's "goons."

On Monday, November 11, Giuliani and his officials were again confronted by 200 angry firefighters and bereaved families at a meeting. Giuliani was accused again and again of running a "scoop and dump" operation. One widow protested: "Last week my husband was memorialized as a hero, and this week he's thought of as landfill?" When Van Essen stammered that the department had been overwhelmed, a widow replied, "Stop saying you are overwhelmed! I am overwhelmed! I have three children and my husband is dead!" Dr. Hirsch of the "biological stain" theory discussed below tried to defend Giuliani by arguing that nothing resembling an intact body was being found any longer, but he was shouted down by firemen who knew from their experience on the pile that this was not so. Van Essen was forced to concede that, based on photographic evidence he personally examined, remains were indeed still be found that had to be "considered intact bodies." (Van Essen 270-271)

Giuliani's rush to eradicate the crime scene without regard to the preservation of human remains thus served two important goals. He was able to destroy much pertinent evidence, and he succeeded in throwing the firefighters on the defensive and playing them off against the police, the construction workers, and other groups. He was able to split the firefighters themselves. The firefighters were tied into knots emotionally, and were left with no time or energy to pursue the issue of justice for their heroic fallen comrades, which could only have been served by directly raising the issue of the indications of controlled demolition in numerous points of the World Trade Center complex. Nor was the cynical oligarchical strategy limited to Giuliani: at the 9/11 commission's last set of hearings in New York City, the FDNY, NYPD, and other line departments of the city were mercilessly baited by the likes of former Navy Secretary John Lehman, who told them that their operational coordination was inferior to that of a Boy Scout troop. So far the firefighters have not been able to mount a challenge to the 9/11 myth, which necessarily portrays them as incompetent, in spite of their heroism and huge losses. Only by demolishing the myth, only by unearthing the story of controlled demolition, can the immense historical merits of the firefighters be duly recognized.

Giuliani's memoir is mainly for self-aggrandizement, but it also attempts to shore up the official version at certain key vulnerable points, since the Giuliani legend and the 9/11 myth are now inextricably intertwined. The following remarks are attributed to Dr. Charles S. Hirsch, the Medical Examiner of New York City in the late afternoon of 9/11: "Most of the bodies will be vaporized. We're going to end up with biological stains, where the tissue has become shapeless, amorphous masses of matter." According to Giuliani, Hirsch estimated that the temperature inside the building had reached 2,000 degrees (presumably Fahrenheit). Such a temperature is impossible in the physical universe as we otherwise know it to be constituted. (Giuliani 22)

CONGRESSIONAL HEARINGS: "BORDERLINE CRIMINAL"

The scandalous eradication of the WTC crime scene was one of the main themes of hearings held by the House Science Committee on March 2, 2002. Congressman Anthony D. Weiner, a New York Democrat, led off by contrasting the businesslike handling of the crash scene of Flight 186 on November 12, 2001 with the chaos and disdain for the integrity of evidence that had prevailed on the WTC pile under Giuliani's management: "Within literally moments of that plane crash, the National Transportation Safety Board was on the ground sequestering evidence, interviewing witnesses, subpoenaing information, if necessary, and since then, they have offered periodic reports. One month and a day earlier, when the World Trade Center collapsed, nothing could have been further from the truth. According to reports that we have heard since, there has been no comprehensive investigation. One expert in fire engineering concluded that there was virtually a nonexistent investigation. We haven't examined any aspects of the collapse that might have impacted rescue worker procedures even in this last month. Second, reports have emerged that crucial evidence has been mishandled. Over 80 percent of the steel from the World Trade Center site has already been sold for recycling, much of it, if not all of it, before investigators and scientists could analyze the information."

Weiner pointed out that at the flight 186 Rockaway crash scene on November 11, he had been able to "watch the National Transportation Safety Board point to pieces of evidence, [and] say to local law enforcement, don't touch this or it is going to be a felony if you do." (House March 104) That had been the procedure before 9/11, and it had become procedure once again after 9/11; only in regard to the 9/11 events did these methods, mandated by federal law, go out the window. It was a massive breakdown of the rule of law, and all in the service of the coverup.

Weiner pointed out that there was also plenty of blame to go around for the federal government as well. This centered on inter-agency turf wars, always a favorite means used by moles to disguise the scope and motivation of what they are really doing: "...we have allowed this investigation to become woefully bogged down and in fighting and lack of cooperation among agencies. Researchers from FEMA did not get timely access to the designs of the building. News accounts have said there has been friction between engineers in FEMA because of concerns about where the information would wind up. Even the National Science Foundation, which has awarded grants to several scientists to study the collapse, but didn't coordinate these efforts with FEMA or the American Society of Civil Engineers."

The reality was even worse. FEMA's Building Performance Assessment Team (BPAT) was carried out not by full-time government officials, but rather by a group of volunteer investigators, with a budget of just $600,000. (Ken Starr's budget for hounding Clinton: more than $40 million.) FEMA volunteers had no subpoena power, and could not stay the hand of steel recyclers or confiscate evidence if they required it. They were denied the blueprints of the buildings. They generally could not enter ground zero, apart from an early walking tour. They never saw a piece of steel wreckage until October. Out of millions of fragments, the FEMA BPAT was able to save only 156 from the recyclers.

Weiner also deplored the parsimonious budget that had been granted to the investigation: "...finally, we have seen and noted the painfully that the financial commitment to this investigation simply is not there. It is not uncommon to spend tens of millions of dollars investigating why a plane crashed. But we have yet to spend even a million dollars on this investigation, and the Bush Administration has refused to commit to release the full funding necessary." (House March 48)

In a later hearing, Weiner elaborated that "thousands of tons of steel were carted away and recycled before any expert could examine what could have been telltale clues. Support trusses, fireproofing fragments, and even burned-out electrical switches that might have given scientists and engineers insight were lost forever even before an investigation was underway. (House May 20-21)

Weiner was also well aware that the Giuliani administration, just like the Bush regime in Washington, was behaving with implacable hostility towards any and all investigations. "We just heard testimony that the city was the opposite of cooperative. That they had refused to provide basic information," said Congressman Weiner at the March hearings. He told the government witnesses from FEMA and other agencies: "The idea that there was some level of cooperation, I have to tell you, the anecdotal record is replete with stories of people having cameras confiscated from them, being stopped at checkpoints. You are officials of the United States Government. The idea that this should have to be a subject of a long negotiation over what information would be at your disposal, to me is most troubling." (House March 133) Indeed, the FEMA's Building Performance Assessment Team (BPAT) was not even allowed on the scene until October.

Weiner's concerns were shared by Virginia Republican J. Randy Forbes, who complained that he was "disappointed to learn that investigators were unable to examine recovered pieces of steel from the Twin Towers before they were recycled. I am also troubled that investigators had difficulty in obtaining blueprints, design drawings, and maintenance records because of liability concerns from the buildings' owners. (House March 55) It even turned out that, despite repeated urgent requests, the investigators were being denied the out-takes of the video tapes shot by the various television networks operating around the WTC on 9-11. This is a reminder that moles are sometimes just as necessary in the private sector as they are in government.

Glenn P. Corbett, Professor at the John Jay College of Criminal Justice, reminded the committee that "handling the collapse study as an assessment has allowed valuable evidence—the steel building components—to be destroyed. The steel holds the primary key to understanding the chronology of events and causal factors resulting in the collapse. The collapse of the world Trade Center towers were the largest structural collapses in world history. A disaster of such epic proportions demands that we fully resource a comprehensive, detailed investigation. Instead, we are staffing the BPAT with part-time engineers and scientists on a shoestring budget." (House March 78) Corbett called for a World Trade Center Disaster Commission, but the Bush administration was not interested.

Abolhassan Astaneh-Asl, a Berkeley professor of civil engineering, related his own shock in discovering that the structural steel was simply being shipped out: "I believe I was the first one to find out that the steel was being recycled. *New York Times* reporter Jim Glanz told me two weeks after the quake—after the collapse. And I tried to contact the city and also the New York Times reporters tried to make sure we could have access to the steel to do the research. It was not happening. And I went myself—directly contacted the recycling plant and made the arrangement." (House March 128) Even so, most of the steel was soon gone.

Congressman Crowley of New York correctly suggested that the flagrant illegalities and abuses of the crime scene would permanently undercut whatever explanation the government was seeking to purvey: "I do believe that conspiracy theorists are going to have a field day with this. They are going to make the Warren Commission look like a walk in the park. And that is unfortunate not only for the Members of Congress who are trying to work on this issue, but for all the families out there that are listening very carefully to what we are talking about today, what these experts are saying. And I just think there is so much that has been lost in these last six months that we can never go back and retrieve. And that is not only unfortunate, it is borderline criminal." (House March 129)

Congressman Christopher Shays of Connecticut, a liberal Republican like Giuliani, ran interference for the Mayor. He rejected the idea that the WTC was a crime scene where there was still something to be discovered, something to be proven: Shays said he had "a particular bias that the actions against us weren't criminal acts, they were acts of war, acts of terror. And I kind of bristle when I think of our treating this as a criminal act in which we have to prove, beyond a shadow of a doubt, that someone did it and they were at the scene or whatever you need to deal with in a crime." (House May 115) This chauvinistic rhetoric was a cover for the urgent need of annihilating the evidence. For this school of thought, there was no need for evidence because there was nothing to prove and nothing to learn; they thought they knew what happened *a priori* thanks to CNN and Bush. The supposed government of laws was in eclipse.

Small wonder, all in all, that the august, 125-year old fireman's trade paper *Fire Engineering* blasted the entire inadequate investigation process in January 2002 editorial. Editor Bill Manning wrote that "for more than three months, structural steel from the World Trade Center has been and continues to be cut up and sold for scrap. Crucial evidence that could answer many questions about high-rise building design practices and performance under fire conditions is on a slow boat to China, perhaps never to be seen again in America until you buy your next car." Manning charged that "Fire Engineering has good reason to believe that the 'official investigation' blessed by FEMA and run by the American Society of Civil Engineers (ASCE) is a half-baked farce that may already have been commandeered by political forces whose primary interests, to put it mildly, lie far afield of full disclosure." "The destruction and removal of evidence must stop immediately," Manning demanded. Elsewhere in the same issue, a fire official deplored that "we are literally treating the steel removed from the site like garbage, not like crucial fire scene evidence." (*Fire Engineering*, January 2002)

An extremely serious aspect of the botched investigation of the World Trade Center events involved the issue of the four black boxes from the two planes (American 11 and United 175) – a cockpit voice recorder and a flight data reporter from each plane. The official version, as codified by the 9/11 commission, claims that not one of these black boxes was ever found. But a New York City firefighter named Nicholas De Masi claimed that he escorted FBI agents into the WTC ruins and helped them to find and recover three of the four missing black boxes. DeMasi's account is supported by the WTC volunteer Mike Bellone, who said that he had seen at least one black box being taken from the wreckage. The three black boxes were removed from the wreckage with the help of DeMasi's all terrain vehicle, according to this account. Then the three black boxes were taken away by the FBI, and have never been heard of again. The black boxes of the two planes that apparently hit the WTC are the only cases in which black boxes from jetliners have not been recovered. DeMasi wrote about this experience in his book *Ground Zero: Behind the Scenes*, which was published by Trauma Recovery and Assistance for Children (TRAC Team) in 2003. Here DeMasi recalls: "There were a total of four black boxes. We found three." DeMasi's story has been denied by the FBI and the FDNY. It has been largely ignored by the controlled corporate media, except for an article in the neocon *New York Post* which alleged that TRAC team was heavily in debt. (*Philadelphia News*, October 28, 2004)

THE FEMA BPAT REPORT OF MAY 2002: "A HALF-BAKED FARCE"

The worthy culmination of this "half-baked farce" was the FEMA BPAT report issued in May 2002. A key section is the one entitled "Structural Response to Fire Loading," where the central tenets are developed in all their intimate poverty. According to the FEMA/ASCE experts:

- As fire spread and raised the temperature of structural members, the structure was further stressed and weakened, until it eventually was unable to support its immense weight. Although the specific chain of events that led to the eventual collapse will probably never be identified, the following effects of fire on structures may each have contributed to the collapse in some way. Appendix A presents a more detailed discussion of the structural effects of fire.

- As floor framing and supported slabs above and in a fire arm are heated, they expand. As a structure expands, it can develop additional, potentially large, stresses in some elements. If the resulting stress state exceeds the capacity of some members or their connections, this can initiate a series of failures.

- As the temperature of floor slabs and support framing increases, these elements can lose rigidity and sag into catenary action. As catenary action progresses, horizontal framing elements and floor slabs become tensile elements, which can cause failure of end connections and allow supported floors to collapse onto the floors below. The presence of large amounts of debris on some floors of WTC 1 would have made them even more susceptible to this behavior. In addition to overloading the floors below, and potentially resulting in a pancake-type collapse of successive floors, local floor collapse would also immediately increase the laterally unsupported length of columns, permitting buckling to begin. As indicated in Appendix B, the propensity of exterior columns to buckle would have been governed by the relatively weak bolted column splices between the vertically stacked prefabricated exterior wall units. This effect would be even more likely to occur in a fire that involves several adjacent floor levels simultaneously, because the columns could effectively lose lateral support over several stories.

- As the temperature of column steel increases, the yield strength and modulus of elasticity degrade and the critical buckling strength of the columns will decrease, potentially initiating buckling, even if lateral support is maintained. This effect is most likely to have been significant in the failure of the interior core columns.

Concerning the twin towers FEMA, had only agnostic conclusions to offer: "With the information and time available, the sequence of events leading to the collapse of each tower could not be definitively determined." Concerning WTC 7: "The specifics of the fires in WTC 7 and how they caused the building to collapse remain unknown at this time. Although the total diesel fuel on the premises contained massive potential energy, the best hypothesis has only a low probability of occurrence. Further research, investigation, and analyses are needed to resolve this issue." (911research.wtc7.net) The World Trade Center disaster was the centerpiece of an event which the Bush administration had seized on to start what may well turn out to be a world war, but that main event could not be explained, many months after the fact.

The FEMA report is redolent of conscious distortion and of fraud. The illustrations in the spring 2002 FEMA report do everything possible to make the twin towers look like flimsy, unstable structures. In one cross-section (Figure 2-1), the core columns are depicted in about one third of their actual dimensions. FEMA gives short shrift or no shrift at all to the cross-bracing core beams and the core columns. One picture (D-13) shows what is purportedly a core column with a construction hard hat on it to convey its dimensions, but this column is about half the size of the real core columns.

FEMA's illustrations offered in support of their theory of truss failure (2-20, 21, 22) show no steel columns in the core of the building at all. These fake diagrams duly impressed the radical empiricists at the *New York Times*, who quickly reported that the interior core of the buildings was a hollow steel shaft, not 47 massive steel box columns.

The heart of the FEMA argument is that the astronomical temperatures allegedly reached by the fires weakened the floor trusses, leading to each floor pancaking onto the one below. As the floors fell away, the columns in the façade as well as the core columns remained standing, but they then quickly buckled at the points where they were bolted together, and came crashing down. This theory is not based on observation, but on pure speculation. It is a purely cinematic explanation of what happened – it tries to account for the phenomenon of collapse, but takes no notice of whether such a process could occur in the real world. In fact, the floor truss/pancake theory cannot function in the real world. Even if the floors failed, the strong structure of the 47 central columns, minus a very few which might have been severed by the impact of the airlines (even fewer in the South Tower) would have remained standing. That would have left a 110-floor steel spine intact, and this is not what was observed. Many of the deceptive drawings contained in the FEMA report then became the inspiration for the graphics used in the NOVA documentary program on this subject which was aired on PBS.

Because of the difficulties of the pancake theory, busy academics have whipped up new theories to try to meet obvious objections. Apologists for the official version start with the notion of *killer fires* – fires which, even though they are fed by carpets, paper, and office furniture, are able to melt steel. From here they develop the notion of *progressive total collapse* – the buildings do not fall to one side, but simply collapse in place upon their own foundations. Since no modern steel framed skyscraper had ever succumbed to fire, the attempted coverup then required new pseudo-theoretical constructs. One of these was the *column failure*, or wet noodle, theory. This suggested that fires melted the core columns, and that was that. Of course, even the coverup cannot change the fact that the fires were not hot enough to melt the core columns. Steel is a very effective conductor of heat, meaning that a serious hot spot on one floor is likely to be dissipated up and down the columns that pass through that hot spot. The internal and external columns, that is to say, act as cooling ribs. According to a study by Corus Construction cited at www.911research.wtc7.net, the highest temperature reached by steel in the presence of hydrocarbon fires was logged at about 360 degrees Fahrenheit – far below what is needed to weaken steel.

Given the disadvantages of the column failure theory, the *truss failure* theory was advanced. The trusses were relatively lightweight metal structures which attached the metal decks bearing the concrete slabs of each floor to the core columns and the columns in the façade. The trusses offered the added advantage of being invisible from the outside, so that it was possible to assert without fear of being refuted that they had gotten extremely hot.

MIT Professor Thomas Eagar is one who has rushed into the many breaches of the FEMA report in an attempt to shore up its credibility. Not content with *trusses* and *pancakes*, Eagar has propounded the *zipper* theory, which he has judiciously combined with the *domino* effect. Eagar's argument is that if the angle on one side of the building had given way, then the unbearable load on the other angle clips would have caused the entire floor to become totally unzipped in just a few seconds. According to Eagar, "If it had only occurred in one little corner, such as a trash can caught on fire, you might have had to repair that corner, but the whole building wouldn't have come crashing down. The problem was, it was such a widely distributed fire, and then you got this domino effect."

(www.911research.wtc7.net/talks/wtc/trusseseagar.html) In reality, the buildings had been designed to resist a Boeing 707, not just a trash can fire.

FACT CHECK

The melting point of steel is 1,538 degrees Celsius, equal to 2,800 degrees Fahrenheit, although it will weaken and buckle at somewhat lower temperatures. But the absolute maximum that can be achieved with hydrocarbons, such as the kerosene-like mixture used for jet fuel is 825 degrees Celsius or 1517 Fahrenheit – unless the mixture is pressurized or pre-heated through the admixture of fuel and air, which in this case it could not be. Diffuse flames burn at a lower temperature, and fires fed by inadequate oxygen are cooler still. The best estimate is that the fires in the towers were burning at a temperature substantially less than 800 Celsius. The collapse of the towers through the effects of the fires is thus a physical impossibility.

LOIZEAUX PREDICTED THE COLLAPSE

In the March hearings of the House Science Committee, Robert F. Shea, the Acting Administrator of the Federal Insurance and Mitigation Administration noted that "the World Trade Center was a tragedy. And, frankly, it was an anomaly. No one who viewed it that day, including myself, believed that those tower would fall. Our collective thought process for laymen and engineers and firefighters changed that day forever." (House March 60)

At those same hearings, a leaflet was distributed by the Skyscraper Safety Campaign, an organization which included many members of the victims' families. Here the Congressmen were reminded: "The collapse of the Twin towers caused the biggest loss of life in a single incident on U.S. soil since the Civil War. Their collapse constituted the first failures of high-rise protected steel structures in history. Not a single structural engineer, including those working for the firm that built the Twin Towers and those working in the Fire Department of New York, seems to have anticipated their collapse, even when those individuals saw the extent of the fires raging in the buildings. The Twin Towers were designed to withstand the impact of the largest passenger jets of their day, a Boeing 707…." (House March 167)

However, it turned out that there was at least one expert who claimed that he had immediately intuited that the towers could collapse. As John Seabrook wrote in the *New Yorker*, "among the dozens of people I have spoken to recently who are experts in the construction of tall buildings (and many of whom witnessed the events of September 11th as they unfolded), only one said that he knew immediately, upon learning, from TV, of the planes hitting the buildings, that the towers were going to fall. This was Mark Loizeaux, the president of Controlled Demolition Incorporated, a Maryland-based family business that specializes in reducing tall buildings to manageable pieces of rubble. 'Within a nanosecond,' he told me. 'I said, "It's coming down." And the second tower will fall first, because it was hit lower down.'" Loizeaux was billed as a "structural undertaker" whose job was to destroy old buildings. Here is Loizeaux' version of how he foresaw the disaster:

> I thought, "Somebody's got to tell the Fire Department to get out of there....I picked up the phone, dialed 411, got the number, and tried it – busy. So I called the Mayor's Office of Emergency Management" – which was in 7 World Trade. "All circuits were busy. I couldn't get through."

But how could Loizeaux know what no other expert claimed to know, and which went against a hundred years accumulated by civil engineers in building skyscrapers? If suspects are those who had the means, the motive and the opportunity, then Loizeaux may well have had the means. According to the demolitions man:

> First of all, you've got the obvious damage to the exterior frame from the airplane – if you count the number of external columns missing from the sides the planes hit, there are about two-thirds of the total. And the buildings are still standing, which is amazing – even with all those columns missing, the gravity loads have found alternate pathways. O.K., but you've got fires – jet-fueled fires, which the building is not designed for, and you've also got lots of paper in there. Now, paper cooks. A paper fire is like a coal-mine fire, it keeps burning as long as oxygen gets to it. And you're high in the building, up in the wind, plenty of oxygen. So you've got a hot fire. And you've got these floor trusses, made of fairly thin metal, and fire protection has been knocked off most of them by the impact. And you have all this open space – clear span from perimeter to core – with no columns or partition walls, so the airplane is going to skid right through that space to the core, which doesn't have any reinforced concrete in it, just sheetrock covering steel, and the fire is going to spread everywhere immediately, and no fire-protection systems are working – the sprinkler heads shorn off by the airplanes, the water pipes in the core are likely cut. So what's going to happen? Floor A is going to fall onto floor B, which falls onto floor C; the unsupported columns will buckle; and the weight of everything above the crash site falls onto what remains below – bringing loads of two thousand pounds per square foot, plus the force of impact, onto floors designed to bear one hundred pounds per square foot. It has to fall." (*The New Yorker,* November 19, 2001)

Naturally, the pancake theory was original neither to Loizeaux nor to FEMA. The pancake theory had been advanced by "Osama Bin Laden" in the remarks attributed to him, allegedly made in mid-November 2001, and widely publicized by the US government in December 2001. Here Bin Laden is alleged to have commented: "We calculated in advance the number of casualties from the enemy, who would be killed based on the position of the tower. We calculated that the floors that would be hit would be three or four floors. I was the most optimistic of them all. (Inaudible) Due to my experience in this field, I was thinking that the fire from the gas in the plane would melt the iron structure of the building and collapse the area where the plane hit and all the floors above it only. This is all that we had hoped for." But there are indications that the stocky figure shown on the tape may not be the supposedly ascetic Bin Laden at all, but a double or ham actor. (Meyssan 2002 192)

REDUCTIO AD ABSURDUM: WTC 7

In the May House Science Committee W. Gene Corley, the American Society of Civil Engineers representative on the BPAT, conceded that "Building 7, which was across the street from the main towers, also collapsed and provided us with the first example that we recognized of a building collapsing as a result of fire." (House May 30) WTC 7 presents the image of a classical controlled demolition. Whereas the twin towers are seen to explode, WTC 7 implodes – it falls in upon itself with none of the spectacular mushroom plumes of smoke and powder which had marked the demise of the larger twin towers. The foundations collapse before the façade, the middle of the building collapses before the outer walls, and streamers of smoke are emitted from the façade. WTC 7 did imitate the twin towers by collapsing almost exclusively upon its own foundations. WTC 7 contained electrical generators and a supply for diesel fuel to operate these, and apologists of the official version like Gerald Posner have seized on this circumstance to make the collapse of this building plausible. But there has been no sign of raging diesel fuel fires, as can be seen from the photos of the fall of WTC 7, so the apologists are grasping at straws.

The owner of the WTC complex was Larry Silverstein, who recounted the fall of WTC 7 in the September 2002 PBS documentary, *America Rebuilds*, complete with this astounding revelation: "I remember getting a call from the…fire department commander, telling me that they were not sure they were going to be able to contain the fire, and I said, 'we've had such terrible loss of life, maybe the smartest thing is to pull it. And they made the decision to pull and we watched the building collapse." "To pull" would appear to be the jargon term in controlled demolition circles for the deliberate detonation of charges leading to the destruction of a building. And if WTC 7 was pulled, why not WTC 1 and 2? (Marrs 43)

ANOMALIES OF THE WTC COLLAPSE

The twin towers did not simply collapse as a result of gravity; they were violently pulverized in mid-air in an explosive process which hurled debris hundreds of meters in all directions – they were vaporized by an explosive force. Anomalies abound. The North Tower was hit first, was hit hardest in its core columns, and had more jet fuel burn inside its structure than the South Tower – but the North Tower exploded later. The South Tower was hit later, with a more glancing blow which had less impact on its core columns, and which also caused more jet fuel to be consumed outside of the building in a spectacular plume; the South Tower's fires were less severe – but the South Tower fell first. WTC 7 was never hit by anything, and had fires only on two floors (there are no photos of WTC 7 enveloped in flames and smoke) – but WTC 7 fell anyway. WTC 6 witnessed an explosion and fire which has never been explained or even addressed. Finally, we have the embarrassing fact that steel frame skyscrapers are virtually indestructible by fire. The official version of events argues that, at least as far as the towers are concerned, it was the combined effect of crash impact plus fire which caused the collapses. But even the South Tower collapsed well after most of the jet fuel had burned away, and a fire based on paper, rugs, and furniture melts steel even less than one based on jet fuel. By all indications, the South Tower began the collapse sequence precisely at the moment when, well after the impact had been absorbed, the fires too were subsiding. The hole made in the North Tower by American 11 had cooled so much that, just before the collapse of the North Tower, survivors were observed looking out through the gash in the side of the building. (Marr 41)

The upper floors of both towers, after showing symptoms of high pressure which forced smoke out through the widows, exploded into spectacular mushroom clouds. Debris and other ejecta were thrown at speeds of 200 feet per second to distances of up to 500 feet in all directions. The clouds then descended, always emanating from the towers as these fell. The mushroom clouds had expanded to two or three times the diameter of the towers after five seconds, and had expanded to five times the diameter of the towers after 15 seconds. Blast waves broke windows in buildings over 400 feet away. In the thick mushroom clouds, solid objects were hurled out ahead of the dust, another telltale sign of explosive demolition.

One might have expected the buildings to tip over at an angle starting at the points where they had been hit like a tree which leaves a stump as it falls towards the side where it has been most chopped, but instead they did not topple and there were no stumps; apart from some initial asymmetry in the top of the South Tower, the two towers both collapsed down on themselves in a perfectly symmetrical way – a suspicious sign, since this is one of the prime goals and hallmarks of controlled demolition.

The fall of the twin towers took place at breathtaking speed. The tops of the buildings reached the ground as rubble no more than 16 seconds after the collapse process had begun. A weight in a vacuum would have taken 9.2 seconds to cover the same distance. This meant that air resistance and little else had slowed the fall of the upper stories. This indicates that the lower floors must have been demolished and pulverized before the upper stories fell on them. The building, in other words, had been pulverized, and in many areas vaporized, in mid-air. No gravity collapse could have created this phenomenon.

The non-metallic elements of the twin towers, especially the cement slabs which formed the horizontal surface of each floor, were pulverized into a fine dust, with particles of less than 100 microns in diameter. This was the dust which pervaded lower Manhattan as the explosive clouds spread from hundreds of yards in all directions. This dust took a long time to settle, but the Giuliani administration tried to convince office workers in the area that there was no danger. All the steel in the building superstructures was simply shredded. The exceptionally strong central core columns were neatly diced into 10 or 20 floor segments – something which has never been explained.

According to Jim Hoffman, the leading expert on the collapse of the World Trade Center and the source heavily relied on here, the energy necessary to create the mushroom clouds and expand them to the extraordinary dimensions actually observed to pulverize virtually all the concrete in the towers, and to chop the steel into segments is far greater than the gravitational energy represented by the buildings in the first place. According to Hoffman, there must have been powerful additional energy sources at work. When prodded to do so at recent conferences, Hoffman has been willing to speculate that these energy sources might have been unconventional ones. High energy microwave interferometry using coaxial beams for constructive and destructive interference might be a possibility, but this would require so much energy that, if it had to be delivered as conventional electric current, it would necessitate a cable about half a meter in diameter – and there is no evidence of this. So the problem remains intractable.

THE TWIN TOWERS WERE ROBUST STRUCTURES

The twin towers were robust structures. The structure of the twin towers was represented first of all by an internal core of 47 steel box columns which measured 36 by 90 centimeters; the steel was thickest near the base, where it attained a thickness of 10 centimeters (about four inches), and tapered gradually down to 6 centimeters on the upper floors. There were 236 exterior columns in the buildings' facades; these were 10 centimeters thick at the base, but only 6 millimeters thick in the highest floors. Each floor was a steel plate into which concrete had been poured. In the center of the building was a reinforced core featuring four steel columns encased in concrete. The structure is abundantly cross-braced, so that stress in one sector could be efficiently shifted to other parts of the structure. All steel columns rested directly on the bedrock under Manhattan. This structures had been designed to withstand 140 mile per hour winds, and had resisted them successfully for more than thirty years. They had been designed by Lee Robertson, the structural engineer who built the towers to absorb the impact of a Boeing 707, an aircraft roughly comparable in size and fuel capacity to the aircraft that appear to have struck the towers on 9/11.

In the case of the twin towers, the technical problem of how to account for the immense quantities of energy released would seem to point to an energy source beyond the capabilities of conventional controlled demolition. For a possible explanation of what kind of energy source could have been at work, we must turn our attention to the realm of new physical principles, and thus to the class of directed energy weapons which are probably most familiar to the general public in connection with President Reagan's so-called star wars speech of March 23, 1983. We may be dealing here with high energy microwave interferometry using coaxial beams for constructive and destructive interference. The inherent problem with this conjecture, as engineer Ken Jenkins has pointed out, is that such a device would require a power cable half a meter in diameter, and the presence of such a power cable has not been demonstrated. The solution to this problem will indeed require more time and research.

From: Wayne.D.Holmes, P.E., FSFPE <wholmes@hsb.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : wholmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : Various
Paragraph : Recommendation No. ALL
Comment : Each recommendation should propose specific improvements to building standards, codes, and practices based on the technical causes of the WTC Tower failures or technical aspects of evacuation and emergency response to the 9/11 WTC incidents.
Comment Reason : In order to affect changes through codes and standards making organizations, specific recommendations are necessary.

The recommendations contained in NCSTAR 1 outline general actions to be taken by others with respect to proposed changes in codes, standards, and practices. There are no specific improvements or revisions in the recommendations that can be implemented directly into codes, standards, and procedures.

Public Law 107-231, National Construction Team Act, establishes National Construction Safety Teams whose duties include to □recommend, as necessary, specific improvements to building standards, codes, and practices based on findings&□ In the preface to NCSTAR 1, it is stated that a specific objective of the NIST WTC Investigation is to □identify, as specifically as possible, areas in current building and fire codes, standards, and practices that warrant revision.□

While the wording in the duties and objectives of Public Law 107-231 and NCSTAR 1, respectively, differ slightly, each identifies the need to be specific in recommended improvements or revisions to codes and standards. In compliance with the Act and so that the organizations responsible for implementing changes in codes and standards can take appropriate actions to make specific changes in codes and standards deemed appropriate by the National Construction Safety Team, each of the recommendations should contain specific recommendations for proposed changes in codes and standards.

Revision Suggestion : Revise each recommendation to make specific recommendations for specific improvements to building codes, standards, and practices.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
To: wtc@nist.gov
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Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : Various
Paragraph : Recommendation No. ALL
Comment : Each of the Recommendations, and their supporting text, should be revised based on their risk-significance and cost-benefit.
Comment Reason : I support making risk-effective and cost-beneficial changes in codes and standards for fire protection of buildings and fire safety of occupants.

However, NCSTAR 1 and other NIST reports related to the WTC incidents do not indicate the level of risk reduction to be derived or the benefit to be gained by implementing the recommendations based on the cost to implement the recommendations.

Executive Order 12866 requires that federal agencies consider cost and benefit in changes to regulations. Agencies must consider the degree and nature of risks to assure that regulations are cost-effective. In assessing costs and benefits, agencies must assure that regulations impose the least burden on society taking into account the consequences and costs of intended regulations.

It is recognized that NIST is not implementing any regulations with the recommendations in NCSTAR 1 but it is clear that NIST recommending changes in regulations that, if implemented, will likely result in significant societal costs. Neither the costs to implement nor the reduction in risk to the public have been identified, quantified, or analyzed.

While NIST may not be subject to E.O. 12866 because it is not implementing any regulations, NIST is recommending the implementation of recommendations to change regulations or create new regulations at some levels. Section 9 of Public Law 107-231, National Construction Safety Act, states that NIST shall promote the adoption by the Federal Government of the recommendations for specific improvements to building standards, codes, and practices. The intent of E.O. 12866 for cost-benefit analysis of significant regulations should be followed. Irrespective of the Executive Order, cost-benefit analysis and risk significance information from NIST are necessary to support the recommendations and to assist standards-making organizations in making informed decisions to implement the recommendations in codes and standards.

While it might be possible to implement the recommendations, it is not clear that it is necessary to implement the recommendations based on their cost-effectiveness, risk-effectiveness, response to credible risks, need for implementation for all tall or low-rise buildings, and their overall societal impact.

Revision Suggestion : Additional supporting information on cost-benefit should be provided in the recommendations and NIST WTC report(s) supporting documentation.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
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Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 202, 204, 211
Paragraph : Recommendation No. 1, 4, 9, 17
Comment : Recommendations should be restated to address only hazards that are reasonably credible and risks that are significant for broad application.
Comment Reason : Building design processes and national consensus codes and standards should be supported by analytical design tools and practical design guidance. However, it must be recognized that building design practices must provide benefits commensurate with their costs to implement.

It is seldom cost-beneficial for building designs to include provisions to mitigate the effects of all accident scenarios, including all possible but non-credible scenarios, and all hazards, including possible but non-credible hazards. Rather, practical designs should include evaluation of reasonably credible scenarios and hazards in lieu of all possible scenarios and hazards. While it might be possible to design and construct buildings to withstand all scenarios and hazards, such buildings might not be cost-beneficial or practical to construct and use.

The Society of Fire Protection Engineers recognizes this approach in the SFPE Engineering Guide to Performance-Based Fire Protection. This guide advises in Section 8.4 that it is usually necessary to reduce the number of event scenarios to be evaluated from the entire population of possible scenarios to a manageable number of scenarios for design. Representative, bounding, or reasonably worst case scenarios may be used. Building characteristics, loads, and initiating events must be considered when developing design scenarios.

Current practice in fire protection engineering does not consider all possible fire hazards or fire scenarios when developing fire hazard analyses, fire risk analyses, or fire design analyses. Rather, hazards and scenarios to be considered are limited to those which are deemed to be credible. This is true even for very high consequence structures and occupancies.

For example, the U.S. Department of Energy (USDOE) has very rigorous requirements for fire hazard analyses for facilities processing, handling, or storing special nuclear materials. Such analyses are not required to consider events that are of such low likelihood as to be considered non-credible. Depending on how it is applied, the definition of a credible event is subject to interpretation but can be and is quantified in many applications.

The fact that a particular event has occurred does not necessarily make that event a credible event for future design consideration. Events of extremely low likelihood need not be used for future design as a credible event. NIST describes the □Maximum Credible Fire□ for WTC in NIST Special Publication 1000-5, Appendix Q. Therein, NIST describes the Maximum Credible Fire as one that has:

- No sprinkler protection credited for suppression or control
- No active fire fighting
- Fuel load of 10 psf
- Two stories of fire involvement
- Free ventilation by broken windows
- 50 sq. ft. of air leakage between floors

Note that the Maximum Credible Fire for WTC as assumed by NIST does not include breach of nine floors, massive damage to important structural columns, and extensive damage to SFRM While such damage did occur in an unusual event, this scenario is not a credible event scenario.

All buildings in the United States need not be designed to mitigate the effects of highly unusual events such as those that might be introduced by maliciously placed incendiary devices, bombs, missiles, or incoming aircraft. All tall buildings in the United States do not need to be designed to mitigate such events. While it might be possible to do so, it would not likely be cost-beneficial, would not likely be risk-significant, and could result in buildings which are impractical for use or comfort.

Risk is defined by two components: the likelihood of an event and the consequences of an event. The recommendations in NCSTAR 1 address only the consequences of an event as a risk reduction strategy. It is doubtful that it is a risk-beneficial or cost-beneficial national strategy to endure the high costs to implement the recommendations for a large population of buildings. The risk of terrorist attacks, although quite real, is low when compared to the large inventory of buildings that would be affected by the recommendations and the cost to implement the recommendations. A more effective risk reduction strategy would be to reduce the likelihood of an attack on a building. This strategy, of course, is beyond the purview of NIST or the building design, construction, and operations community. The recommendations to mitigate the effects of building accidents to include all scenarios, including terrorist attacks, are inappropriate.

NIST should limit its comments and recommendations to credible hazards and event scenarios. Society will judge what are credible and acceptable risks and this societal response will be reflected in the development of requirements in consensus codes and standards.

Revision Suggestion : 1. Revise Recommendations 1, 4, and 9 to address only credible hazards and event scenarios. (See Holmes Comment Nos. 5, 8, 9, 10, 11, 12, and 17)

2. Delete Recommendation No. 17. (See Holmes Comment Nos. 20 and 21)

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 203-206, 208, 216
Paragraph : Recommendation No. 2, 3, 4, 6, 9
Comment : Recommendations should address only aspects of building and fire code requirements that might have had some effect on the results of the WTC failures and are applicable to other buildings subject to credible fire events or similar events.
Comment Reason : Improvements are desirable for fire protection of buildings and fire safety of occupants. However, it is recognized that the results of a specific fire event are not always applicable to a wide range of buildings or unrelated events.

Under Public Law 107-231, National Construction Safety Team Act, which established the bases for the NIST WTC Investigation National Construction Safety Team, the Team was directed to make recommendations, as necessary, for specific improvements in building standards, codes, and practices based on findings related to technical causes of the WTC Tower failures and technical aspects of the WTC evacuation and emergency response procedures. In developing the recommendations contained in NCSTAR 1, NIST has expanded the application of technical information derived from the WTC investigation to apply to other buildings and other events even though the findings are unrelated to the outcome of the 9/11 WTC events.

It is inappropriate to extrapolate findings that would have had no effect on the outcome of the extreme events of the 9/11 WTC attacks and apply them broadly to buildings subject to credible fire events.

Revision Suggestion : 1. Delete Recommendation No. 2.
2. Delete Recommendation No. 3.
3. Revise Recommendation No. 4.
4. Delete Recommendation No. 6.
5. Delete Recommendation No. 9, Sub-item b.
6. Delete Recommendation No. 9, Sub-item d., last sentence.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
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Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 202
Paragraph : Recommendation No. 1, Paragraph a., Sentence 1; and Paragraph b, Sentence 1.
Comment : Revise Paragraph a, Sentence 1 to read, □Progressive collapse should be prevented for credible accident scenarios in buildings.□

Revise Paragraph b, Sentence 1 to read, □A robust, integrated predictive capability should be developed, validated, and maintained to routinely assess the vulnerability of whole structures to the effects of credible hazards.□ (Delete □potential□.)

Comment Reason : Consistent with NIST Recommendation No. 1, building design processes and national consensus codes and standards should be supported by analytical design tools and practical design guidance. However, it should be recognized that building design practices must provide benefits commensurate with their costs to implement.

It is seldom cost-beneficial for building designs to include provisions to mitigate the effects of all accident scenarios, including all possible but non-credible scenarios, and all hazards, including possible but non-credible hazards. Rather, practical designs should include evaluation of reasonably credible scenarios and hazards in lieu of all possible scenarios and hazards. While it might be possible to design and construct buildings to withstand all scenarios and hazards, such buildings might not be cost-beneficial or practical to construct and use.

The Society of Fire Protection Engineers recognizes this approach in the SFPE Engineering Guide to Performance-Based Fire Protection. This guide advises in Section 8.4 that it is usually necessary to reduce the number of event scenarios to be evaluated from the entire population of possible scenarios to a manageable number of scenarios for design. Representative, bounding, or reasonably worst case scenarios may be used. Building characteristics, loads, and initiating events must be considered when developing design scenarios.

Current practice in fire protection engineering does not consider all possible fire hazards or fire scenarios when developing fire hazard analyses, fire risk analyses, or fire design analyses. Rather, hazards and scenarios to be considered are limited to those which are deemed to be credible. This is true even for very high consequence structures and occupancies.

For example, the U.S. Department of Energy (USDOE) has very rigorous requirements for fire hazard analyses for facilities processing, handling, or storing special nuclear materials. Such analyses are not required to consider events that are of such low likelihood as to be considered non-credible. Depending on how it is applied, the definition of a credible event is subject to interpretation but can be and is quantified in many applications.

The fact that a particular event has occurred does not necessarily make that event a credible event for future design consideration. Events of extremely low likelihood need not be used for future design as a credible event. NIST describes the □Maximum Credible Fire□ for WTC in NIST Special Publication 1000-5, Appendix Q. Therein, NIST describes the Maximum Credible Fire as one that has:

" No sprinkler protection credited for suppression or control
" No active fire fighting
" Fuel load of 10 psf
" Two stories of fire involvement
" Free ventilation by broken windows
" 50 sq. ft. of air leakage between floors

Note that the Maximum Credible Fire for WTC as assumed by NIST does not include breach of nine floors, massive damage to important structural columns, and extensive damage to SFRM While such damage did occur in an unusual event, this scenario is not a credible event scenario.

On Page 193 of NCSTAR 1-1 it is inferred that requirements for fire protection should be risk-consistent with respect to the design-basis hazard. Design-basis hazards for buildings should be limited to reasonably credible hazards and not include highly unusual hazards of incredibly low likelihood.

NIST should limit its comments and recommendations to credible hazards and event scenarios. Society will judge what are credible and acceptable risks and this societal response will be reflected in the development of requirements in consensus codes and standards.

Consideration of fire scenarios or progressive collapse scenarios should be limited to credible scenarios and should not include all possible scenarios. The text in NIST Recommendation No. 1 should be revised accordingly.

Revision Suggestion : Revise Paragraph a, Sentence 1 to read, □Progressive collapse should be prevented for credible accident scenarios in buildings.□

Revise Paragraph b, Sentence 1 to read, □A robust, integrated predictive capability should be developed, validated, and maintained to routinely assess the vulnerability of whole structures to the effects of credible hazards.□ (Delete □potential□.)

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
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Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 203
Paragraph : Recommendation No. 2
Comment : Delete Recommendation No. 2 as not relevant to the results of the September 11, 2001 WTC events and not pertinent to national standards development as mitigating requirements for building response to this type of event.
Comment Reason : It is an interesting revelation from the NIST evaluation that there are inconsistent methods and results of methods for evaluation of wind loads on tall buildings. However, there is no evidence presented that the wind load design of the WTC had a significant effect on the consequences that resulted from the 9/11/2002 attacks on the towers. Further, there is no historical evidence that wind load design requirements or test methods have resulted in unsafe design of tall buildings.

Thus, there is no basis for NIST to recommend that standards development activities be diverted to address performance standards for wind tunnel testing or estimating wind loads and their effects. Rather, the limited resources of the standards development community should be focused on more important issues as identified in other NIST recommendations.

NCSTAR 1, Table 9-1, documents that this recommendation is unrelated to the outcome of the 9/11/2001 attacks on the WTC towers.

Revision Suggestion : Delete Recommendation No. 2.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 203
Paragraph : Recommendation No. 3
Comment : Delete Recommendation No. 3 as not relevant to the results of the September 11, 2001 WTC events and not pertinent to national standards development as mitigating requirements for building response to this type of event.
Comment Reason : It is an interesting revelation from the NIST evaluation that conventional strength-based design methods do not limit deflections due to wind or earthquake. However, there is no evidence presented that this had a significant effect on the consequences that resulted from the 9/11/2002 attacks on the towers. Further, there is no historical evidence that the lack of design requirements have resulted in unsafe design of tall buildings.

Thus, there is no basis for NIST to recommend that standards development activities be diverted to address criterion to limit sway under lateral load design conditions. Rather, the limited resources of the standards development community should be focused on more important issues as identified in other NIST recommendations.

NCSTAR 1, Table 9-1, documents that this recommendation is unrelated to the outcome of the 9/11/2001 attacks on the WTC towers.

Revision Suggestion : Delete Recommendation No. 3.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 204
Paragraph : Recommendation No. 4
Comment : Delete □(especially for tall buildings greater than 20 stories in height)□ in Recommendation No. 4.
Comment Reason : The establishment of technical bases for construction classification and fire rating requirements is desirable. Technical bases are useful in establishing goals, objectives, and criteria for performance-based design and analysis.

However, there is no technical basis for establishing a threshold of 20 stories in height. If it is important to evaluate and establish technical bases for construction classification and fire rating requirements for buildings, it is likely important for buildings of heights less than 20 stories.

NCSTAR 1, Table 9-1, documents that this recommendation is unrelated to the outcome of the 9/11/2001 attacks on the WTC towers.

Revision Suggestion : Delete □(especially for tall buildings greater than 20 stories in height)□ in Recommendation No. 4.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
To: wtc@nist.gov
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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
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Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 204
Paragraph : Footnote No. 21
Comment : Revise Footnote No. 21 as follows:
1. Delete □which were originally developed for buildings with less than 20 stories in height□ in the second sentence.
2. Delete the word, □generally□ in the second sentence.
3. Delete the last three sentences.

Comment Reason : The establishment of technical bases for construction classification and fire rating requirements is desirable. However, the following comments are offered to improve Recommendation No. 4, Footnote No. 21:

1. There is no technical basis for establishing a threshold of 20 stories in height. There is no technical evidence presented in the NIST WTC reports that fire resistance rating requirements developed for buildings less than 20 stories are inappropriate for buildings greater than 20 stories. If one accepts the unsubstantiated hypothesis that the existing fire resistance rating requirements are inappropriate for tall buildings, then it is also quite likely that the fire ratings are inappropriate for buildings less than 20 stories where the fire hazards might be more severe and the consequences of fire or building collapse might be even more severe for occupants than in tall buildings.

2. The use of the descriptor, □generally□ makes this a very vague statement. The statement in this footnote that there is □considerable conservatism in those requirements□ indicates that the requirements are adequate for safety. This infers that requirements which have □generally decreased□ are not insufficient.

3. The statement that consequences to occupants on upper floors (20 stories and above) are more severe is a generality or speculation which is unsupported. Depending on specific circumstances, occupants on lower floors could be more severely impacted by a given fire than those on upper floors.

Revision Suggestion : Revise Footnote No. 21 as follows:

1. Delete □which were originally developed for buildings with less than 20

stories in height□ in the second sentence.

2. Delete the word, □generally□ in the second sentence.

3. Delete the last three sentences.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
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Name : Wayne D. Holmes, P.E., FSFPE
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Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 204
Paragraph : Recommendation No. 4
Comment : Delete □and full evacuation of occupants□ from Bullet No. 1.
Comment Reason : The establishment of technical bases for construction classification and fire rating requirements is desirable. However, no technical basis has been established to support the supposition that building designs should anticipate full evacuations in all cases.

For most fire events, or other emergency events, full evacuation of occupants is unwarranted and could, in fact, create greater exposure to harm for building occupants. Except for extreme events, it is not necessary to design buildings for full evacuation. Building designs, building design requirements, and occupant emergency movement procedures should not require full evacuation except where indicated by credible event scenarios. It is not prudent, risk-effective, or cost-effective to design all buildings for full evacuation.

The concepts of protect in place, horizontal exits, places of refuge, and similar schemes are recognized in existing building and life safety codes and have been effectively used in existing buildings. There are no technical bases presented to indicate that these concepts are inadequate for existing and new buildings, except for extreme conditions, and there is no basis for not recognizing these concepts in new and existing buildings. As evidenced by NFPA statistics, the historical fire and life safety record in commercial and high rise buildings is excellent with the current practices that do not require design for full building evacuation.

NCSTAR 1, Table 9-1, documents that this recommendation is unrelated to the outcome of the 9/11/2001 attacks on the WTC towers.

Revision Suggestion : Delete □and full evacuation of occupants□ from Bullet No. 1.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
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Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 204
Paragraph : Recommendation No. 4
Comment : Add a footnote to Bullet No. 4 as follows:

A Maximum Credible Fire Scenario includes conditions that can be reasonably anticipated related to building construction, occupancy and fire loads, ignition sources, compartment geometry, fire control methods, and similar factors as well as reasonably anticipated adverse conditions. A Maximum Credible Fire Scenario does not include highly unlikely, although possible, events or combinations of events.

Comment Reason : The establishment of technical bases for construction classification and fire rating requirements is desirable. However, technical bases should be related to reasonably credible events. Additional guidance is needed to define credible fire scenarios so as not to imply that all possible events need to be addressed.

It is seldom cost-beneficial for building designs to include provisions to mitigate the effects of all accident scenarios, including non-credible scenarios. Rather, practical designs should include evaluation of reasonably credible scenarios in lieu of all possible scenarios. While it might be possible to design and construct buildings to withstand all fire scenarios, such buildings might not be cost-beneficial or practical to construct and use.

The Society of Fire Protection Engineers recognizes this approach in the SFPE Engineering Guide to Performance-Based Fire Protection. This guide advises in Section 8.4 that it is usually necessary to reduce the number of event scenarios from the entire population of possible scenarios to a manageable number of scenarios for design. Representative, bounding, or reasonably worst case scenarios may be used. Building characteristics, loads, and initiating events must be considered when developing design scenarios.

Current practice in fire protection engineering does not consider all possible fire scenarios when developing fire hazard analyses, fire risk analyses, or fire design analyses. Rather, fire scenarios to be considered are limited to those which are deemed to be credible. This is true even for very high consequence structures and occupancies.

For example, the U.S. Department of Energy (USDOE) has very rigorous requirements for fire hazard analyses for facilities processing, handling, or storing special nuclear materials. Such analyses are not required to consider events that are of such low likelihood as to be considered non-credible. Depending on how it is applied, the definition of a credible event is subject to interpretation but can be and is quantified in many applications.

The fact that a particular event has occurred does not necessarily make that event a credible event for future design consideration. Events of extremely low likelihood need not be used for future design as a credible event. NIST describes the □Maximum Credible Fire□ for WTC in NIST Special Publication 1000-5, Appendix Q. Therein, NIST describes the Maximum Credible Fire as one that has:

" No sprinkler protection credited for suppression or control
" No active fire fighting
" Fuel load of 10 psf
" Two stories of fire involvement
" Free ventilation by broken windows
" 50 sq. ft. of air leakage between floors

Note that the Maximum Credible Fire for WTC as assumed by NIST does not include breach of nine floors, massive damage to important structural columns, extensive damage to SFRM, and the introduction of 10,000 gallons of jet fuel and 13 tons of combustible materials from the aircraft. While such damage and additional hazards did occur in an unusual event, this type of scenario is not a credible event scenario.

On Page 193 of NCSTAR 1-1 it is inferred that requirements for fire protection should be risk-consistent with respect to the design-basis hazard. Design-basis hazards or assumed Maximum Credible Fires for buildings should be limited to reasonably credible hazards and scenarios and not include highly unusual hazards or scenarios of incredibly low likelihood.

NIST should limit its comments and recommendations to credible event scenarios. Society will judge what are credible and acceptable risks and the societal response will be reflected in the development of requirements in consensus codes and standards.

Revision Suggestion : Add a footnote to Bullet No. 4 as follows:

A Maximum Credible Fire Scenario includes conditions that can be reasonably anticipated related to building construction, occupancy and fire loads, ignition sources, compartment geometry, fire control methods, and similar factors as well as reasonably anticipated adverse conditions. A Maximum Credible Fire Scenario does not include highly unlikely, although possible, events or combinations of events.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
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Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 204
Paragraph : Recommendation No. 4
Comment : In Recommendation No. 4, Bullet No. 6, insert □large but reasonably credible, in-situ□ to replace □unusually large□.
Comment Reason : The intent of this recommendation should not be to include usually large fuel concentrations that might be introduced by maliciously placed incendiary devices, bombs, missiles, or incoming aircraft. The statement in Bullet No. 6 is subject to misinterpretation to include such unusual fuel loads. An □unusually large□ fuel load is very nonspecific and subjective. Rather, the intent of the recommendation should be to include large, in-situ fuel loads that can be reasonably and credibly anticipated.

Revision Suggestion : In Recommendation No. 4, Bullet No. 6, insert □large but reasonably credible, in-situ□ to replace □unusually large□.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

X-Sieve: CMU Sieve 2.2
From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1
Date: Thu, 28 Jul 2005 10:18:35 -0400
Organization: NIST/BFRL Web Site
X-Mailer: SA-SMTPMail 1.0 (http://www.aspstudio.com)
X-MailScanner:
X-MailScanner-SpamScore: sss
X-MailScanner-From: wayne_holmes@hsb.com

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Name : Wayne D. Holmes, P.E., FSFPE
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Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 204
Paragraph : Recommendation No. 4
Comment : In Recommendation No. 4, Bullet No. 6, insert □large but reasonably credible, in-situ□ to replace □unusually large□.
Comment Reason : The intent of this recommendation should not be to include usually large fuel concentrations that might be introduced by maliciously placed incendiary devices, bombs, missiles, or incoming aircraft. The statement in Bullet No. 6 is subject to misinterpretation to include such unusual fuel loads. An □unusually large□ fuel load is very nonspecific and subjective. Rather, the intent of the recommendation should be to include large, in-situ fuel loads that can be reasonably and credibly anticipated.

Revision Suggestion : In Recommendation No. 4, Bullet No. 6, insert □large but reasonably credible, in-situ□ to replace □unusually large□.

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Report Number : NCSTAR 1
Page Number : 205
Paragraph : Recommendation No. 5
Comment : Delete □century-old□ from the first sentence of Recommendation No. 5.
Comment Reason : The establishment of technical bases for construction classification and fire rating requirements is desirable. Technical bases are useful in establishing goals, objectives, and criteria for performance-based design and analysis. Recommendations related to this should be succinct and objective.

The fact that ASTM E-119 was initially developed in 1907 is not germane. This standard, and other similar standards, have been continuously updated through the consensus standards process to the current time. Fundamental materials testing standards for fire and other exposures do not necessarily become obsolete solely due to age as inferred by this statement. Fundamental material properties and response of materials due to fire exposure have not changed in 100 years.

This is true in all engineering disciplines including, but not limited to Fire Protection Engineering. In Mechanical Engineering or Materials Engineering, the Charpy Test is globally used to evaluate ductile-brittle behavior of metals and the resistance of metals to sudden, brittle facture. The Charpy Impact Test was developed very early in the twentieth century and is widely used as described in ASTM E-23, Standard Test Methods for Notched Bar Impact Testing of Metallic Materials. This test is as applicable today as it was in the early 1900□s because the fundamental properties of materials and response to external stimuli have not changed. The same is true for the fundamental properties of materials and response to fire exposure.

Improvements in the technical bases for fire resistance testing might be desirable. However, it is not considered pertinent that the fundamental testing method was developed in the last century and this type of statement should not be cited in the recommendation.

NCSTAR 1, Table 9-1, documents that this recommendation is unrelated to the outcome of the 9/11/2001 attacks on the WTC towers.

Revision Suggestion : Delete □century-old□ from the first sentence of Recommendation No. 5.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
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Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
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Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 206
Paragraph : Recommendation No. 6
Comment : Delete Recommendation No. 6
Comment Reason : The performance and durability of SFRM are important in the overall performance of many buildings in response to fire. However, the performance and durability of SFRM was not a significant factor in the results of the terrorist attack on the WTC. The damage to the structural steel members and SFRM was due to incredible circumstances. The applied thickness, durability, and inspection procedures for the SFRM at the WTC were also not a significant contributor to the results of the WTC incidents.

In NCSTAR 1, Section 6.14.4 (p. 145) and Section 8.2, Objective 2, (p. 172) it is stated that □the existing condition of the insulation prior to aircraft impact, which was found to be mostly intact, and the insulation thickness on the WTC floor system did not play a significant role in initiating collapse of the towers□ and □an intense, conventional fire, in the absence of structural and insulation damage, would not have led to the collapse of a WTC tower.□ Reasonable conclusions from these statements are that the SFRM was in good condition prior to aircraft impact, was of sufficient thickness to prevent collapse of the towers from intense fires, and the towers would not have collapsed if it had not been for the extreme damage by aircraft impact. It is not reasonable to expect that SFRM in-service performance should include the ability to withstand the extreme loads imposed by aircraft impact.

There is no evidence, based on NCSTAR 1, that the in-service performance of SFRM as used in buildings for conventional fires, even extreme conventional fires, is deficient.

While further development of methods for evaluating the in-service performance of SFRM is desirable, Recommendation No. 6 is not a relevant conclusion based on the WTC incidents.

NCSTAR 1, Table 9-1, documents that this recommendation is unrelated to the outcome of the 9/11/2001 attacks on the WTC towers.

Revision Suggestion : Delete Recommendation No. 6.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
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Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 207
Paragraph : Recommendation No. 8
Comment : Revise Recommendation No. 8 to delete □tall□ in the second sentence and add □required by the building code to have a fire resistance rating□ at the end of the sentence such that the sentence reads, □Such a provision should be applied to all buildings required by the building code to have a fire resistance rating.□
Comment Reason : This recommendation contains a statement that burnout without collapse □should apply to all tall buildings.□ The need for a building to sustain burnout without collapse is not unique to tall buildings. This recommendation might be applicable to buildings regardless of height.

On the other hand, it is not necessary that all buildings be capable of sustaining burnout without collapse. Small or inconsequential buildings of ordinary construction need not be required to sustain burnout without collapse.

The societal need for some buildings to sustain burnout without collapse will be reflected in the model buildings codes. Thus, the recommendation should be addressed toward those buildings for which the building code requires fire resistant structural ratings.

Revision Suggestion : Revise Recommendation No. 8 to delete □tall□ in the second sentence and add □required by the building code to have a fire resistance rating□ at the end of the sentence such that the sentence reads, □Such a provision should be applied to all buildings required by the building code to have a fire resistance rating.□

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
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Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 208
Paragraph : Recommendation No. 9
Comment : Delete Recommendation No. 9, Sub-item b.
Comment Reason : The use of standard methodologies and performance-based methods for fire scenarios for use in design and analysis of structures to resist fire is desirable. Some methods are described in the SFPE Engineering Guide to Performance-Based Fire Protection. This guide advises in Section 8.4 that it is usually necessary to reduce the number of event scenarios from the entire population of possible scenarios to a manageable number of scenarios for design. Representative, bounding, or reasonably worst case scenarios may be used. Building characteristics, loads, and initiating events must be considered when developing design scenarios.

Consideration of fire scenarios should be limited to credible scenarios and should not include all possible scenarios. Depending on specific circumstances, multiple compartment or multiple floor fire scenarios might not be credible fire scenarios.

It is therefore unnecessary for Recommendation No. 9 to specify that multi-compartment or multi-floor scenarios must be included as stated in Sub-item b. Standard methodologies are sufficiently addressed in Recommendation No. 9, Sub-item a.

NCSTAR 1, Table 9-1, documents that this recommendation is unrelated to the outcome of the 9/11/2001 attacks on the WTC towers.

Revision Suggestion : Delete Recommendation No. 9, Sub-item b.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 208
Paragraph : Recommendation No. 9
Comment : Delete the last sentence of Recommendation No. 9, Sub-item d.
Comment Reason : The development of new test methods or the enhancement of existing test methods to support performance-based methods for design and analysis is desirable. However, there is no technical evidence presented that would support that the development of new standard fire exposures must be developed in order to support a performance objective of burnout without collapse.

NCSTAR 1, Table 9-1, documents that this recommendation is unrelated to the outcome of the 9/11/2001 attacks on the WTC towers.

Revision Suggestion : Delete the last sentence of Recommendation No. 9, Sub-item d.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 208
Paragraph : Recommendation No. 10
Comment : Delete Recommendation No. 10
Comment Reason : The development of enhanced means of providing fire resistance properties of building materials and systems is desirable. However, there is no evidence from the WTC investigation that would support the need for development of new fire resistive coating materials, system, and technologies with significantly enhanced performance and durability to provide protection following major events based on the results of the WTC incidents. SFRM do not need to be expected to respond to highly unusual events such as aircraft impact. Rather, fire resistive coating materials, systems, and technologies should cost-effectively and risk-effectively be expected to respond to reasonably credible fire scenarios.

The performance and durability of SFRM was not a significant factor in the results of the terrorist attack on the WTC. The damage to the structural steel members and SFRM was due to incredible circumstances. The applied thickness, durability, and inspection procedures for the SFRM at the WTC were also not a significant contributor to the results of the WTC incidents.

In NCSTAR 1, Section 6.14.4 (p. 145) and Section 8.2, Objective 2, (p. 172) it is stated that □the existing condition of the insulation prior to aircraft impact, which was found to be mostly intact, and the insulation thickness on the WTC floor system did not play a significant role in initiating collapse of the towers□ and □an intense, conventional fire, in the absence of structural and insulation damage, would not have led to the collapse of a WTC tower.□ Reasonable conclusions from these statements are that the SFRM was in good condition prior to aircraft impact, was of sufficient thickness to prevent collapse of the towers from intense fires, and the towers would not have collapsed if it had not been for the extreme damage by aircraft impact. It is not reasonable to expect that SFRM in-service performance should include the ability to withstand the extreme loads imposed by aircraft impact.

The explanation of Recommendation No. 10 on p. 208 of NCSTAR 1 alludes to technical barriers to the introduction of new structural fire resistance materials, systems, and technologies. Since NCSTAR 1 does not identify any such existing technical barriers, this statement is unsupported and inappropriate.

With the exception of the WTC incidents, existing fire resistive coating systems have demonstrated a reasonable history in maintaining structural stability of buildings response to credible fires. Recommendation No. 10 is unwarranted as a direct result of the WTC incidents.

Revision Suggestion : Delete Recommendation No. 10

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 209
Paragraph : Recommendation No. 12
Comment : Delete Recommendation No. 12.
Comment Reason : The enhancement of technology related to active fire protection systems is desirable. However, the performance and redundancy of active fire protection systems were not factors in the collapse of the WTC towers. Had it not been for the severe damage created by the aircraft impact, the WTC towers would not have collapsed, even without the provision of automatic sprinklers or other active fire protection systems. It is impossible to conclude from the WTC incidents that there is a national need to enhance the performance and redundancy of active fire protection system.

There is no technical evidence presented to indicate that building heights, building populations, open spaces, compartmentation, fuel loads, or other factors have increased risks beyond those which are currently address by codes and standards. The national standards and building codes have evolved to adequately address current hazards. The statements in Recommendation No. 12 about the □greater risks□ and need for enhancement of performance and redundancy of active fire protection systems are speculative and not supported by facts.

The performance statistics related to automatic sprinkler systems and other active fire systems in response to reasonably anticipated fire scenarios are excellent. No level of enhancement of the performance or redundancy of active fire protection systems would have changed the results of the WTC attacks. The failure of the active and passive fire protection systems in the WTC towers was not a result of a single-point failure but multiple system failures due to highly unusual events. The existing levels of performance and redundancy of active fire protection systems are sufficient current for buildings subjected to credible fire scenarios.

Revision Suggestion : Delete Recommendation No. 12.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 211
Paragraph : Recommendation No. 17
Comment : Delete Recommendation No. 17.
Comment Reason : The safety of occupants due to fires or similar emergencies can be accomplished by a systematic balance of building systems and features, occupant response, and emergency response. No technical basis has been established to support the supposition that building designs should anticipate full evacuations in all cases.

Full building evacuation is one means of helping to assure the safety of occupants but it is not the only means. In many cases, full evacuation of occupants is unwarranted and could, in fact, create greater exposure to harm for building occupants. Except for extreme events, it is not necessary to design buildings for full evacuation. Building designs, building design requirements, and occupant emergency movement procedures should not require full evacuation except where indicated by credible event scenarios. It is not prudent, risk-effective, or cost-effective to design all buildings for full evacuation.

The concepts of protect in place, horizontal exits, places of refuge, and similar schemes are recognized in existing building and life safety codes have been effectively used in existing buildings. There are no technical bases presented to indicate that these concepts are inadequate for existing and new buildings, except for extreme conditions, and no basis for not recognizing these concepts in new and existing buildings. As evidenced by NFPA statistics, the historical fire and life safety record in commercial and high rise buildings is excellent with the current practices that do not require design for full building evacuation.

Revision Suggestion : Delete Recommendation No. 17.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 212
Paragraph : Recommendation No. 18
Comment : Delete Recommendation No. 18
Comment Reason : The safety of occupants due to fires or similar emergencies can be accomplished by a systematic balance of building systems and features, occupant response, and emergency response. No technical basis has been established to support the supposition that building designs should anticipate full evacuations in all cases.

Existing codes and standards provide for adequate means of egress for emergency movement of occupants in response to credible emergency scenarios if the provisions of the codes and standards are rigorously enforced.

As noted in the NIST reports, the Life Safety Code and building codes provide requirements for separation and remoteness of means of egress components. These requirements, if adopted and enforced, are adequate.

The integrity of means of egress stairwells is implicitly provided by robust constructions that must meet the requirements for fire protection rated assemblies including the hose stream test. These constructions provide for reasonable integrity of the enclosures for other reasonably anticipated loads. Aircraft impact is not a reasonably anticipated load. Although NCSTAR 1-1, Finding No. 8 suggests that concrete or reinforced concrete block walls might have provided increased integrity for the stairway enclosures, this statement is speculative. There is no evidence to suggest that such constructions would have withstood the aircraft impact. There is no evidence presented in the NIST WTC report that the stairwells existing at the time of the incident would not have maintained their integrity if exposed to accidental loads or reasonably anticipated risks that would be expected in an office tower. Further, there are no historical records that indicate that stairwells in other buildings are deficient in their ability to maintain integrity under anticipated accidental loads.

The Life Safety Code and building codes provide requirements for identification and standard signage for means of egress. These requirements, if adopted and enforced, are adequate.

Recommendation 18 is unwarranted and unnecessary. The issue of enforcement of means of egress requirements is sufficiently covered by Recommendation No. 26.

Revision Suggestion : Delete Recommendation No. 18.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 216
Paragraph : Recommendation No. 25
Comment : Delete Recommendation No. 25.
Comment Reason : There is no evidence in the NIST reports to indicate that compliance with building and fire codes was deficient such that the results of the attacks on the WTC towers would have been any different than what occurred. It is stated on p. xlvi of NCSTAR 1 that □The departures from the building codes and standards did not have a significant effect on the outcome of September 11.□

The existing codes and standards provide for third-party acceptance of building designs, independent from the building owner(s), by the Authority Having Jurisdiction. Enforcement of this requirement is sufficiently covered by Recommendation No. 26.

There is no evidence to support that yet another level of independent verification or certification is warranted or cost-effective if the Authority Having Jurisdiction exercises its responsibility for enforcement and verification.

NCSTAR 1, Table 9-1, documents that this recommendation is unrelated to the outcome of the 9/11/2001 attacks on the WTC towers.

Revision Suggestion : Delete Recommendation No. 25.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 217
Paragraph : Recommendation No. 27
Comment : The purposes of documentation retention and accessibility should be more specifically stated in Recommendation No. 27.
Comment Reason : Proper documentation of designs for all stakeholders is desirable. In addition to providing documentation for emergency responders and for post-incident evaluations, proper documentation of building design, features, and emergency systems provides all stakeholders with valuable information to maintain the building and its systems and features throughout the life of the building. The documentation provides valuable information for decision making to assure that modifications to the building to not compromise the original design intent. Information on fire safety documentation and specifications is contained in Chapter 12 of the SFPE Engineering Guide to Performance-Based Fire Protection.

Revision Suggestion : Add the following statement to Recommendation No. 27:

In addition to providing documentation for emergency responders and for post-incident evaluations, proper documentation of building design, features, and emergency systems provides all stakeholders with valuable information to maintain the building and its systems and features throughout the life of the building. The documentation provides valuable information for decision making to assure that modifications to the building to not compromise the original design intent. Information on fire safety documentation and specifications is contained in Chapter 12 of the SFPE Engineering Guide to Performance-Based Fire Protection.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 7/28/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : Various
Paragraph : Recommendation No. ALL
Comment : Each recommendation should propose specific improvements to building standards, codes, and practices based on the technical causes of the WTC Tower failures or technical aspects of evacuation and emergency response to the 9/11 WTC incidents.
Comment Reason : In order to affect changes through codes and standards making organizations, specific recommendations are necessary.

The recommendations contained in NCSTAR 1 outline general actions to be taken by others with respect to proposed changes in codes, standards, and practices. There are no specific improvements or revisions in the recommendations that can be implemented directly into codes, standards, and procedures.

Public Law 107-231, National Construction Team Act, establishes National Construction Safety Teams whose duties include to □recommend, as necessary, specific improvements to building standards, codes, and practices based on findings&□ In the preface to NCSTAR 1, it is stated that a specific objective of the NIST WTC Investigation is to □identify, as specifically as possible, areas in current building and fire codes, standards, and practices that warrant revision.□

While the wording in the duties and objectives of Public Law 107-231 and NCSTAR 1, respectively, differ slightly, each identifies the need to be specific in recommended improvements or revisions to codes and standards. In compliance with the Act and so that the organizations responsible for implementing changes in codes and standards can take appropriate actions to make specific changes in codes and standards deemed appropriate by the National Construction Safety Team, each of the recommendations should contain specific recommendations for proposed changes in codes and standards.

Revision Suggestion : Revise each recommendation to make specific recommendations for specific improvements to building codes, standards, and practices.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR1-6B
Page Number : 2
Paragraph : Section 1.3 Test Variables
Comment : There is a need to identify an important test variable, test furnace heating conditions, which is not identified in this section.
Comment Reason : In this section, NIST implies that it has identified the important test variables and those are (1) fireproofing thickness, (2) constraint conditions, and (3) scale of the test. What NIST has totally missed is the most important variable in fire resistance testing, that being the difference in heating conditions. While ASTM E-119 specifies a standard temperature versus time profile, ASTM E-119 does not specify a standard heating profile. While the temperature indicates a potential for heating of test specimen, it does not define the heat exposure to the specimen. Heating conditions can vary significantly from test to test within a particular test furnace (repeatability) and even more significantly from furnace to furnace (reproducibility). Tests performed on the larger ULC furnace might not be comparable to a similar test on the smaller UL furnace even though the same temperature versus time profile is reproduced.

The measured temperature within a furnace is not a reliable measurement of the heat flux produced in the furnace. Heat flux drives the response of the specimen being tested. The size and geometry of the furnace, the thermal inertia of the furnace lining, and the emissivity of the furnace gases will greatly influence the heat flux that is experienced by the specimen.

Kanury and Holve concluded (Kanury A. M., and Holve, D. J, A Theoretical Analysis of the ASTM E-119 Standard Fire Test of Building Construction and Materials, Menlo Park, CA, Stanford Research Institute, 1975):

□Radiant heat transfer is the dominant heat transfer mode. Reradiation properties of the exposed material have an influence on the fire resistance time. Thus, the true measure of fire severity is given by the heat flux to the specimen, a function of both the furnace temperature and emissivity.

The exact temporal distribution of temperature exposure has little effect on the fire endurance time as compared to the standard ASTM E-119 T(t) curve. Future improvements of the ASTM E-119 test should focus more on the control, measurement, and specification of the heat flux exposure condition rather than the furnace temperature history.

Furnace emissivity has appreciable effect on endurance time, even though the relation is less than linear. An increase in emissivity from 0.2 to 0.6 increases the net flux by 80% and decreases the fire endurance time by 30%□

In Section 4.5, Instrumentation, the report describes radiometers used to measure and characterize the furnace environment during the tests. It states that the location of the radiometers is given in Appendices D and F. However, the location of the radiometers is not clearly indicated in those Appendices.

In Section 6.1, Comparison of Results, the average furnace temperatures, as measured by the ASTM E-119 standard thermocouples, is shown. While this demonstrates that the furnace temperatures measured in the four tests were comparable, it does not demonstrate that the heating conditions were similar.

Section 6.1.2, Furnace Temperature Environment, indicates that additional instrumentation was included to □further characterize the thermal environment of the exposing fire.□ While the measurements from the thermocouples reflect the temperature conditions in the furnace, the true thermal environment can only be assessed with the reporting of the heat fluxes measured by the radiometers. NIST failed to report the radiometer measurements in this section. Complete data from the radiometers should be reported in this section.

Some, very limited information about furnace heat fluxes is reported, in part, in Chapter 5, Test Results. This information can be found only in Figures Nos. 5-11, 5-12, 5-48, 5-49, 5-64, and 5-65. This information is summarized below:

Test 1 ULC, 35 ft., Restrained
West Radiometer
Heat Flux Range: 10-50 kw/m2
Mean Flux: 20 kw/m2 (estimated)
East Radiometer
Heat Flux Range: 10-60+kw/m2
Mean Flux: 40 kw/m2 (estimated)

Test 2 ULC, 35 ft., Unrestrained
No radiation data reported

Test 3 UL, 17 ft., Restrained
South Radiometer
Heat Flux Range: 20-135 kw/m2
Mean Flux: 90 kw/m2 (estimated)

North Radiometer
Heat Flux Range: 20-110 kw/m2
Mean Flux: 70 kw/m2 (estimated)

Test 4 UL, 17 ft., Unrestrained
South Radiometer
Heat Flux Range: 5-40 kw/m2 (prior to failure)
Mean Flux: 25 kw/m2 (estimated)

North Radiometer
Heat Flux Range: 20-100+ kw/m2
Mean Flux: 95 kw/m2 (estimated)

Figure 6-2 implies that the heating conditions between the two furnaces were similar. The data for two plate thermocouples were plotted only for Tests Nos. 2 and 4. Similar data for Tests Nos. 1 and 3 were not given or plotted to show correlation. Figure 6-3 clearly shows a significant difference in recorded temperatures for the south plate thermocouple in the range beyond 50 minutes. Thus, there are only three sets of date, total, for the four tests, from which it was concluded that the fire exposures for both furnaces were equivalent. The lack of correlation among all of the plate thermocouples and the radiometers in the four tests on two different furnaces is unexplained and unresolved. The limited data based on three thermocouples, ignoring the non-corroborative data of one thermocouple and the wide variation in readings from the radiometers, does not support the conclusion in Section 6.1.2 that "The ASTM E-119 fire exposures for both furnaces used in this study were essentially equivalent." There is an attempt to imply that the heating exposures in the two furnaces were identical based on incomplete data and without mention or explanation of the variation in radiometer data. Based on the radiometer data, one cannot reasonably conclude that the heating conditions were identical even though the temperature profiles for two of the plate thermocouples are similar. NCSTAR 1-6B should provide some rational explanation for the discrepancies in data between the two furnaces or revise the statements about similar heating conditions in the two furnaces.

There is clearly a significant difference in heating conditions between the ULC and UL furnaces despite the fact the both furnaces followed the same temperature versus time curve. Such a large difference in heating conditions would have a considerable effect on the response of the tested specimen.

There is a large difference in the thermal exposures between the large scale ULC tests and the smaller scale UL tests. The results of the tests on the two furnaces are not directly comparable. The NIST report fails to recognize or report on the difference in test conditions.

NIST missed an important opportunity to make a specific recommendation for improvement of fire resistance test methods. To be comparable between tests (repeatability) and comparable among all tests (reproducibility), and to provide data for analytical methods, fire resistance test methods should include a requirement for specification, measurement, and reporting of furnace heat flux. Heat flux measurements are required in ASTM E-1529 but not in ASTM E-119 and standards similar to ASTM E-119.

Revision Suggestion : Section 1.3, Test Variables, should be revised by NIST to indicate that all test variables have not been identified and isolated. The most significant variable in fire resistance testing is the heat flux in the furnace. The different heating conditions between the two test furnaces used in this evaluation have not been identified or analyzed.

The NIST report should clearly indicate the difference in heating conditions among the tests and comment on the lack of correlation between the ULC and UL tests. Comment on the fact that the specific, single tests performed for this investigation are neither repeatable nor reproducible would be appropriate.

NCSTAR 1-6B should provide some rational explanation for the discrepancies in data between the two furnaces or revise the statements about similar heating conditions in the two furnaces.

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR1-6B
Page Number : 47
Paragraph : Chapter 5 Test Results
Comment : Numerical data output from all instrumentation including shielded thermocouples, plate thermocouples, aspirated thermocouples, and radiometers should be included in Chapter 5, Test Results.
Comment Reason : Some, very limited information about furnace heat fluxes is reported, in part, in Chapter 5, Test Results. This information can be found only in Figures Nos. 5-11, 5-12, 5-48, 5-49, 5-64, and 5-65. This information is summarized below:

Test 1 ULC, 35 ft., Restrained
West Radiometer
Heat Flux Range: 10-50 kw/m2
Mean Flux: 20 kw/m2 (estimated)

East Radiometer
Heat Flux Range: 10-60+kw/m2
Mean Flux: 40 kw/m2 (estimated)

Test 2 ULC, 35 ft., Unrestrained
No radiation data reported

Test 3 UL, 17 ft., Restrained
South Radiometer
Heat Flux Range: 20-135 kw/m2
Mean Flux: 90 kw/m2 (estimated)

North Radiometer
Heat Flux Range: 20-110 kw/m2
Mean Flux: 70 kw/m2 (estimated)

Test 4 UL, 17 ft., Unrestrained
South Radiometer
Heat Flux Range: 5-40 kw/m2 (prior to failure)
Mean Flux: 25 kw/m2 (estimated)

North Radiometer
Heat Flux Range: 20-100+ kw/m2
Mean Flux: 9 5 kw/m2 (estimated)

Figure 6-2 implies that the heating conditions between the two furnaces were similar. The data for two plate thermocouples were plotted only for Tests Nos. 2 and 4. Similar data for Tests Nos. 1 and 3 were not given or plotted to show correlation. Figure 6-3 clearly shows a significant difference in recorded temperatures for the south plate thermocouple in the range beyond 50 minutes. Thus, there are only three sets of date, total, for the four tests, from which it was concluded that the fire exposures for both furnaces were equivalent. The lack of correlation among all of the plate thermocouples and the radiometers in the four tests on two different furnaces is unexplained and unresolved. The limited data based on three thermocouples, ignoring the non-corroborative data of one thermocouple and the wide variation in readings from the radiometers, does not support the conclusion in Section 6.1.2 that "The ASTM E-119 fire exposures for both furnaces used in this study were essentially equivalent." There is an attempt to imply that the heating exposures in the two furnaces were identical based on incomplete data and without mention or explanation of the variation in radiometer data. Based on the radiometer data, one cannot reasonably conclude that the heating conditions were identical even though the temperature profiles for two of the plate thermocouples are similar. NCSTAR 1-6B should provide some rational explanation for the discrepancies in data between the two furnaces or revise the statements about similar heating conditions in the two furnaces.

There is clearly a significant difference in heating conditions between the ULC and UL furnaces despite the fact the both furnaces followed the same temperature versus time curve. Such a large difference in heating conditions would have a considerable effect on the response of the tested specimen.

There is a large difference in the thermal exposures between the large scale ULC tests and the smaller scale UL tests. The results of the tests on the two furnaces are not directly comparable. The NIST report fails to recognize or report on the difference in test conditions.

Complete numerical data is needed and should be reported for informed analysis of test results.

Revision Suggestion : Add to Chapter 5, Test Results:

□Numerical data output from all instrumentation including shielded thermocouples, plate thermocouples, aspirated thermocouples, and radiometers are reported in Chapter 5, Test Results.□

(Include tables of all numerical data output)

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Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR1-6B

Information Submitted on: 8/3/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR1-6B
Page Number : 96
Paragraph : Section 6.1.2 Furnace Temperature Environment
Comment : While the measured temperatures in the two furnaces were similar, the heating environments, as evidenced by the radiometer data, were not equivalent.
Comment Reason : Some, very limited information about furnace heat fluxes is reported, in part, in Chapter 5, Test Results. This information can be found only in Figures Nos. 5-11, 5-12, 5-48, 5-49, 5-64, and 5-65. This information is summarized below:

Test 1 ULC, 35 ft., Restrained
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Heat Flux Range: 10-50 kw/m2
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No radiation data reported

Test 3 UL, 17 ft., Restrained
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North Radiometer
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Mean Flux: 25 kw/m2 (estimated)

North Radiometer
Heat Flux Range: 20-100+ kw/m2
Mean Flux: 95 kw/m2 (estimated)

Figure 6-2 implies that the heating conditions between the two furnaces were similar. The data for two plate thermocouples were plotted only for Tests Nos. 2 and 4. Similar data for Tests Nos. 1 and 3 were not given or plotted to show correlation. Figure 6-3 clearly shows a significant difference in recorded temperatures for the south plate thermocouple in the range beyond 50 minutes. Thus, there are only three sets of date, total, for the four tests, from which it was concluded that the fire exposures for both furnaces were equivalent. The lack of correlation among all of the plate thermocouples and the radiometers in the four tests on two different furnaces is unexplained and unresolved. The limited data based on three thermocouples, ignoring the non-corroborative data of one thermocouple and the wide variation in readings from the radiometers, does not support the conclusion in Section 6.1.2 that "The ASTM E-119 fire exposures for both furnaces used in this study were essentially equivalent." There is an attempt to imply that the heating exposures in the two furnaces were identical based on incomplete data and without mention or explanation of the variation in radiometer data. Based on the radiometer data, one cannot reasonably conclude that the heating conditions were identical even though the temperature profiles for two of the plate thermocouples are similar. NCSTAR 1-6B should provide some rational explanation for the discrepancies in data between the two furnaces or revise the statements about similar heating conditions in the two furnaces.

There is clearly a significant difference in heating conditions between the ULC and UL furnaces despite the fact the both furnaces followed the same temperature versus time curve. Such a large difference in heating conditions would have a considerable effect on the response of the tested specimen.

There is a large difference in the thermal exposures between the large scale ULC tests and the smaller scale UL tests. The results of the tests on the two furnaces are not directly comparable. The NIST report fails to recognize or report on the difference in test conditions.

Complete numerical data is needed and should be reported for informed analysis of test results.

Revision Suggestion : The statement on p. 96 under □Plate Thermocouple Measurements□ that states, □Thus, the ASTM E 119 fire exposure for both furnaces used in this study were essentially equivalent□ should be changed to □The measured furnace temperatures, as indicated by the plate thermocouples, for the two furnaces followed the temperature vs. time curve specified by ASTM E 119. However, the radiometer data indicated that the heating conditions in the two furnaces were not the same. The temperatures recorded by the shielded thermocouples for furnace temperature control as specified by ASTM E-119 are not those that are plotted in Figures 6-2 and 6-3.□

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

From: Wayne.D.Holmes, P.E., FSFPE <Wayne_Holmes@hsb.com>
To: wtc@nist.gov
Cc: dlowe@nist.gov
Subject: WTC Draft Final Report Comment Form for Report: NCSTAR 1

Information Submitted on: 8/3/2005.

Name : Wayne D. Holmes, P.E., FSFPE
Affiliation :
Email Address : Wayne_Holmes@hsb.com
Phone : 860-722-5621
Report Number : NCSTAR 1
Page Number : 205
Paragraph : Recommendation 5
Comment : Recommendation 5 is a very general and vague statement about improvement to the standard fire resistance test method. A specific recommendation should be made that ASTM E-119 and similar test methods should be improved to require a specific heating profile based on heat flux in the furnace.
Comment Reason : NIST missed an important opportunity to make a specific recommendation for improvement of fire resistance test methods. To be comparable between tests (repeatability) and comparable among all tests (reproducibility), and to provide data for analytical methods, fire resistance test methods should include a requirement for specification, measurement, and reporting of furnace heat flux. Heat flux measurements are required in ASTM E-1529 but not in ASTM E-119 and standards similar to ASTM E-119.

It is generally recognized in the fire protection profession that ASTM E-119 tests, based on a temperature vs. time profile, are not repeatable or reproducible. This is addressed, in part, in NCSTAR 1, Recommendation 5. Successful tests are often reported on the basis of passing a single test which might not be repeated on the same test furnace or reproduced on another test furnace. The ASTM E-119 standard contains the warning that □no comprehensive test program has been conducted to develop data on which to derive statistical measures of repeatability (within-laboratory variability) and reproducibility (among-laboratory variability).

While ASTM E-119 specifies a standard temperature versus time profile, ASTM E-119 does not specify a standard heating profile. While the temperature indicates a potential for heating of test specimen, it does not define the heat exposure to the specimen. Heating conditions can vary significantly from test to test within a particular test furnace (repeatability) and even more significantly from furnace to furnace (reproducibility). Tests performed on the larger ULC furnace might not be comparable to a similar test on the smaller UL furnace even though the same temperature versus time profile is reproduced.

The measured temperature within a furnace is not a reliable measurement of the heat flux produced in the furnace. Heat flux drives the response of the specimen being tested. The size and geometry of the furnace, the thermal inertia of the furnace lining, and the emissivity of the furnace gases will greatly influence the heat flux that is experienced by the specimen.

Kanury and Holve concluded (Kanury A. M., and Holve, D. J, A Theoretical Analysis of the ASTM E-119 Standard Fire Test of Building Construction and Materials, Menlo Park, CA, Stanford Research Institute, 1975):

□Radiant heat transfer is the dominant heat transfer mode. Reradiation properties of the exposed material have an influence on the fire resistance time. Thus, the true measure of fire severity is given by the heat flux to the specimen, a function of both the furnace temperature and emissivity.

The exact temporal distribution of temperature exposure has little effect on the fire endurance time as compared to the standard ASTM E-119 T(t) curve. Future improvements of the ASTM E-119 test should focus more on the control, measurement, and specification of the heat flux exposure condition rather than the furnace temperature history.

Furnace emissivity has appreciable effect on endurance time, even though the relation is less than linear. An increase in emissivity from 0.2 to 0.6 increases the net flux by 80% and decreases the fire endurance time by 30%□

In Section 4.5 of NCSTAR 1-6B, Instrumentation, the report describes radiometers used to measure and characterize the furnace environment during the tests.

In Section 6.1 of NCSTAR 1-6B, Comparison of Results, the average furnace temperatures, as measured by the ASTM E-119 standard thermocouples, is shown. While this demonstrates that the furnace temperatures measured in the four tests were comparable, it does not demonstrate that the heating conditions were similar.

Section 6.1.2 of NCSTAR 1-6B, Furnace Temperature Environment, indicates that additional instrumentation was included to □further characterize the thermal environment of the exposing fire.□ While the measurements from the thermocouples reflect the temperature conditions in the furnace, the true thermal environment can only be assessed with the reporting of the heat fluxes measured by the radiometers. NIST failed to report the radiometer measurements in this section. ASTM E-119 does not require measurement of, reporting of, or control of heat flux within the test furnace.

Some, very limited information about furnace heat fluxes is reported, in part, in Chapter 5 of NCSTAR 1-6B, Test Results. This information can be found only in Figures Nos. 5-11, 5-12, 5-48, 5-49, 5-64, and 5-65. This information is summarized below:

Test 1 ULC, 35 ft., Restrained
West Radiometer
Heat Flux Range: 10-50 kw/m2
Mean Flux: 20 kw/m2 (estimated)

East Radiometer
Heat Flux Range: 10-60+kw/m2

Mean Flux: 40 kw/m2 (estimated)

Test 2 ULC, 35 ft., Unrestrained
No radiation data reported

Test 3 UL, 17 ft., Restrained
South Radiometer
Heat Flux Range: 20-135 kw/m2
Mean Flux: 90 kw/m2 (estimated)

North Radiometer
Heat Flux Range: 20-110 kw/m2
Mean Flux: 70 kw/m2 (estimated)

Test 4 UL, 17 ft., Unrestrained
South Radiometer
Heat Flux Range: 5-40 kw/m2 (prior to failure)
Mean Flux: 25 kw/m2 (estimated)

North Radiometer
Heat Flux Range: 20-100+ kw/m2
Mean Flux: 95 kw/m2 (estimated)

Figure 6-2 of NCSTAR 1-6B implies that the heating conditions between the two furnaces were similar. The data for two plate thermocouples were plotted only for Tests Nos. 2 and 4. Similar data for Tests Nos. 1 and 3 were not given or plotted to show correlation. Figure 6-3 clearly shows a significant difference in recorded temperatures for the south plate thermocouple in the range beyond 50 minutes. Thus, there are only three sets of date, total, for the four tests, from which it was concluded that the fire exposures for both furnaces were equivalent. The lack of correlation among all of the plate thermocouples and the radiometers in the four tests on two different furnaces is unexplained and unresolved. The limited data based on three thermocouples, ignoring the non-corroborative data of one thermocouple and the wide variation in readings from the radiometers, does not support the conclusion in Section 6.1.2 of NCSTAR 1-6B that "The ASTM E-119 fire exposures for both furnaces used in this study were essentially equivalent." There is an attempt to imply that the heating exposures in the two furnaces were identical based on incomplete data and without mention or explanation of the variation in radiometer data. Based on the radiometer data, one cannot reasonably conclude that the heating conditions were identical even though the temperature profiles for two of the plate thermocouples are similar. NCSTAR 1-6B should provide some rational explanation for the discrepancies in data between the two furnaces or revise the statements about similar heating conditions in the two furnaces.

There is clearly a significant difference in heating conditions between the ULC and UL furnaces despite the fact the both furnaces followed the same temperature versus time curve. Such a large difference in heating conditions would have a considerable effect on the response of the tested specimen.

There is a large difference in the thermal exposures between the large scale

ULC tests and the smaller scale UL tests. The results of the tests on the two furnaces are not directly comparable. The NIST report fails to recognize or report on the difference in test conditions.

Public Law 107-231, National Construction Team Act, establishes National Construction Safety Teams whose duties include to □recommend, as necessary, specific improvements to building standards, codes, and practices based on findings&□ In the preface to NCSTAR 1, it is stated that a specific objective of the NIST WTC Investigation is to □identify, as specifically as possible, areas in current building and fire codes, standards, and practices that warrant revision.□

While the wording in the duties and objectives of Public Law 107-231 and NCSTAR 1, respectively, differ slightly, each identifies the need to be specific in recommended improvements or revisions to codes and standards. In compliance with the Act and so that the organizations responsible for implementing changes in codes and standards can take appropriate actions to make specific changes in codes and standards deemed appropriate by the National Construction Safety Team, each of the recommendations should contain specific recommendations for proposed changes in codes and standards.

NIST has the opportunity, if not the obligation, to make specific recommendations for improvement in the standard test method for fire resistance tested of building construction and materials. A specific recommendation should be made that ASTM E-119 and similar test methods should be improved to require a specific heating profile based on heat flux in the furnace.

Revision Suggestion : Add an additional recommendation following Recommendation 5 (or amend Recommendation 5) as follows:

□To more effectively represent heating conditions, to improve repeatability and reproducibility of test results, and to facilitate analysis and extrapolation of fire resistance test results, standard fire resistance test methods should specify a standard heating profile based on heat flux in the test furnace.□

2005 WTC Report Comment Application 1.0, dlowe@nist.gov, rev. 6/21/2005

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Subj: WTC Twin Towers Collapse

Please see enclosed a review of NIST Study on Twin Towers requested by Eric Douglas, IPRC, Independent Peer Review Council.
Dr.P.Jayachandran, WPI
Worcester, Mass, 01609

NISTsudy.doc

Collapse of the Twin Towers of World Trade Center

National Institute of Standards and Technology, BFRL Study

Gaithersburg, MD, 20303

Review by

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Introduction

The collapse of the twin towers of the world trade center, New York, NY, on September 11, 2001, was a tragic event in the history of US practice of structural engineering and design. It also resulted in loss of life for over 3068 people, and severe damage to infrastructure and financial losses in New York. NIST study on the probable causes of collapse of the twin towers was sanctioned by Congress, and was conducted at BFRL, Building and Fire Research Laboratory. This is a review of this study, undertaken at the request of IPRC, Independent Peer Review Council, headed by Eric Douglas, Architects and Engineers. The families of these victims have requested this study.

The twin towers were designed as framed-tube tall buildings, where all lateral loadings were carried by framed-tube at the periphery of each tower. The interior core, consisting of braced frames, carried mainly gravity loads. Framed-tube systems were developed by Dr. Fazlur R. Khan, of Skidmore, Owings and Merrill, Architects and Engineers, Chicago, IL. Well known buildings designed by him and his associates are, Sears Tower and John Hancock Center, Chicago, 110 and 100 story buildings. Sears is a bundled tube, while John Hancock is a diagonal-trussed tube system. They are very stiff, by virtue of their internal cells and exterior diagonal braces. The twin towers did not have these systems, except a single framed-tube at the periphery. The frequencies of these buildings are as follows-0.1282 Hertz, 0.125 Hertz and 0.0911 Hertz. Clearly, the twin towers were more flexible. The twin towers also had a framed-tube made up of box columns with flat plate spandrels, all 14 inches deep, to make uniform sizes, easy for fabrication. The thickness of these elements gradually increased at bottom to resist largest wind moments and shears at bottom. The steel yield strength was varied from A36 at top to 100 ksi steel at bottom. Sears uses only A36 and A572-50 ksi steel. John Hancock uses only A36 steel. The twin towers design was inspired by aircraft design, with stringer-shear panel theory, common in aeronautics. The Sears and John Hancock use traditional wide flange shapes for columns and spandrel girders, as in other tall buildings.

The NIST study is quite comprehensive in its objectives. Elastic, inelastic and nonlinear analyses were made and experiments conducted using substructures, for structural and fire resistance and collapse, due to simulated impact loadings by aircrafts. Probable causes of collapse are given. Design recommendations are made for future design of tall framed-tube buildings. This review examines its methodology and results of the failure analysis.

The Probable Causes of Collapse of Twin Towers

The NIST study outlines some probable causes of collapse of the two towers. The extensive finite element analysis and experimental model studies of typical elements and substructures have been used to suggest possible modes of failure. This is also supported by video, photographs and media reports on the sequence of collapse of towers 1 and 2.

The events listed are essentially due to aircraft impact damage, the role of the hat truss, interior core and framed-tube to redistribute the loads, once key columns and spandrels were damaged in the walls, where the aircrafts impacted. Redistribution of loads around the severed columns is examined. The role of the hat truss is also studied for its role in redistribution. The loss of fire proofing on key structural elements and subsequent fires at several floors, due to contents burning, are also studied.

The thermal plastic and creep strains in the core, floor system and the framed-tube are examined under impact and thermal loads. The weakening of the structural system due to these extreme strains is assessed, and failure mechanisms are suggested for the initiation of collapse. Local buckling of the framed-tube and the overall buckling of the entire building are deduced from this.

The probable causes of collapse are suggested. The change in potential energy due to the downward movement of several floors, above the already buckled columns in and around the framed-tube walls, was greater than the strain energy, which could be absorbed by floors at lower levels, is suggested to be a probable cause of collapse. The effects of collapsed floors, which consisted of open web trusses, with bent up bars as shear connectors, is not very clearly established. Membrane strength of diaphragms in tall framed –tube, is assured by floor systems, made up of composite steel-concrete construction, with wide flange beams. John Hancock Center, Chicago, has these systems for its floors. Sears has a truss floor system, but it is made up of structural steel angles, for its web and flanges, and stud shear connectors. Twin towers had truss-joists only. This is more flexible than the former.

The floor trusses collapsed first, resulting in the loss of diaphragm stiffness for the framed-tube. Of course, framed-tube walls, where the aircrafts impacted, caused their columns to buckle first, at these locations. Framed-tube could go into a breathing type mode of failure, if its internal diaphragms collapsed first. Dynamic analysis would have predicted this mode. Floor trusses also lost their protective fire proofing, during the explosion due to aircraft fuel, and consequent fire. This has implications for future tall framed-tube building design. NIST report does not discuss this much, except the collapse of floor trusses under fire. Progressive collapse of the tube was probably initiated by the collapse of successive floors.

The effects of several floors falling on to floors below, as impact loads, and an assessment of a dynamic load factor due to these impact loads, are not determined. The dynamic load factors suggested by approximate methods (Bazant, 2002), are not examined. Bazant suggested that it would be of the order of 15 to 20. Most buildings are not designed for such dynamic load factors. Gust effect factors often used in tall building design for wind are of the order of 3 to 4 (Davenport, 1967). Wind tunnel studies reported by the project structural engineers, suggest these values.

Dynamic analysis of the framed-tube building, with diaphragms included for floors, may have been done, by NIST, but not included in the report. This would have explained the dynamic collapse of the twin towers. The overall collapse of the towers is essentially deduced from the elastic, inelastic and nonlinear analyses. Substructures are used for nonlinear and fire response studies. However, a dynamic analysis of the core and the framed-tube are not reported.

The experimental model studies are quite extensive to establish the failure of floor system and its components. However, this is not fully integrated in to an overall collapse of the entire building, made of interior braced-core and exterior framed-tube, and an assessment of a collapse load, is not reported.

Summary and Conclusions

The NIST study is quite comprehensive in its objectives. It has detailed elastic, inelastic and nonlinear analyses to assess stresses and displacements to suggest possible causes of collapse. However, a dynamic analysis based assessment of collapse loads and mechanisms seem to be not reported. NIST may have carried out such analyses. It may be included in its final reports. Design recommendations should include results of such studies. Virtual work principles could be used to assess effects of overloads, fire and dynamic impact loadings. This would make NIST study more complete and helpful in future design of tall framed-tube buildings. NIST recommendations for fire resistant design and HVAC systems are quite comprehensive. The fire evacuation methods suggested, are also quite detailed, and will be useful for architects, construction engineers and management professionals. Clients and public will be benefited from such recommendations. NIST should also be funded for future research on the design of framed-tube tall buildings, to develop a design methodology, for wind, earthquake, fire and blast loadings. Research proposals could be written at NIST, seeking such funds, in collaboration with universities and consulting firms. NSF does not fund this type of research at present, due to its emphasis on infrastructure and its rehabilitation.

References

1. Bazant, Z., et.al., " Why did the Trade center Collapse ? - A Simple Analysis", Journal of the Engineering Mechanics, Proc., ASCE, Vol. 128, No. 2, 2002. pp. 245-267.
2. Jayachandran, P., "Tall Buildings-Design and Behavior of Framed-Tube Systems", Paper to be presented at 4th International Conference on Computational Structures Technology, La Palma, Spain, and February 2006. (available at author's web page in www.wpi.edu, Civil and Environmental Engineering, WPI)
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4. Khan, Y.S., "The Trussed Tube-John Hancock Center". Journal of Civil Engineering Practice, Proc., BSCE, Vol.19, No.2, December, 2004., pp.7-29.

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X-MailScanner-From: sunder@nist.gov

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Date: 7/21/05 7:53 am
To: sunder@nist.gov, simiu@nist.gov
Cc: rangish@hotmail.com, babaiks@yahoo.co.uk
Subj: WTC Twin Towers Collapse

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Dr.P.Jayachandran, WPI
Worcester, Mass, 01609
NISTsudy.doc

Collapse of the Twin Towers of World Trade Center

National Institute of Standards and Technology, BFRL Study

Gaithersburg, MD, 20303

Review by

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Introduction

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3. Davenport, A.G., "Gust Loading Factors", Journal of the Structural Division, Proc.ASCE, Vol.93, No.ST3, June 1967. pp. 11-35.
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