**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 96$^{th}$ 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.