

**Federal Building and Fire Safety Investigation  
of the World Trade Center Disaster**

**National Construction Safety Team  
Advisory Committee Meeting**

**Project 6 – Standard Fire Tests of  
WTC Tower Typical Floor Construction**

June 22, 2004

John L. Gross, Ph.D., P.E.

**Building and Fire Research Laboratory**

**National Institute of Standards and Technology**

**U.S. Department of Commerce**

**[John.Gross@nist.gov](mailto:John.Gross@nist.gov)**

## May 2003 Progress Report: Fire Protection\*

In October 1969, ... , the Port Authority stated, in a letter to the fireproofing contractor, that

- ❑ “All Tower beams, spandrels, and bar joists requiring spray-on fireproofing are to have a ½” covering of Cafco.”
- ❑ “The above requirements must be adhered to in order to maintain the Class 1-A Fire Rating of the New York City Building Code.”[1]

[1] Letter dated October 30, 1969 from Robert J. Linn (Manager, Project Planning, The World Trade Center) to Mr. Louis DiBono (Mario & DiBono)

\* Interim Report on Procedures and Practices Used for Passive Fire Protection of the Floor System of the World Trade Center Tower Structures

# WTC Tower Floor Truss Fireproofing



Reproduced with permission of U.S. Mineral Products Company dba  
Isolatek International and Morse Zehnter Associates



Reproduced with permission of U.S. Mineral Products Company dba  
Isolatek International and Morse Zehnter Associates

# ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials

ASTM E119 prescribes a standard exposing fire of controlled extent and severity

Performance is defined as the period of resistance to standard exposure before the first critical point in behavior (conditions of acceptance or end point conditions) is observed.

Conditions of acceptance include (for floor systems):

- Sustained applied load during classification period;
- Maximum temperature on unexposed side of the specimen;  
and
- Maximum and average temperatures of the steel joists.

# Standard Fire Tests\* of WTC Tower Floor Construction

Test plan includes:

- “As-specified” fireproofing conditions;
- “As-installed” fireproofing conditions;
- U.S. practice for establishing a fire endurance rating of a building construction;
- Full-scale testing; and
- Comparison of thermal restraint conditions.

\* ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials

# Original (or “as built”) Conditions...

## Duplication of original conditions

- Geometry (including camber)
- Steel ASTM A242
- Welding
- Metal deck
- Primer paint
- Lightweight concrete
- Welded wire fabric
- SFRM material – Cafco DC/F

# SFRM Thickness

Thicknesses of SFRM as originally installed:

❑ “As Specified” = 0.5 in

- Letter dated October 30, 1969 from Robert J. Linn (Manager, Project Planning, The World Trade Center) to Mr. Louis DiBono (Mario & DiBono)

❑ “As applied” = 0.75 in

- Determined from thickness measurements of the existing fireproofing on floors 23 and 24 of WTC 1 - performed by the Port Authority in 1994

Thickness of SFRM as “upgraded” (since 1995)

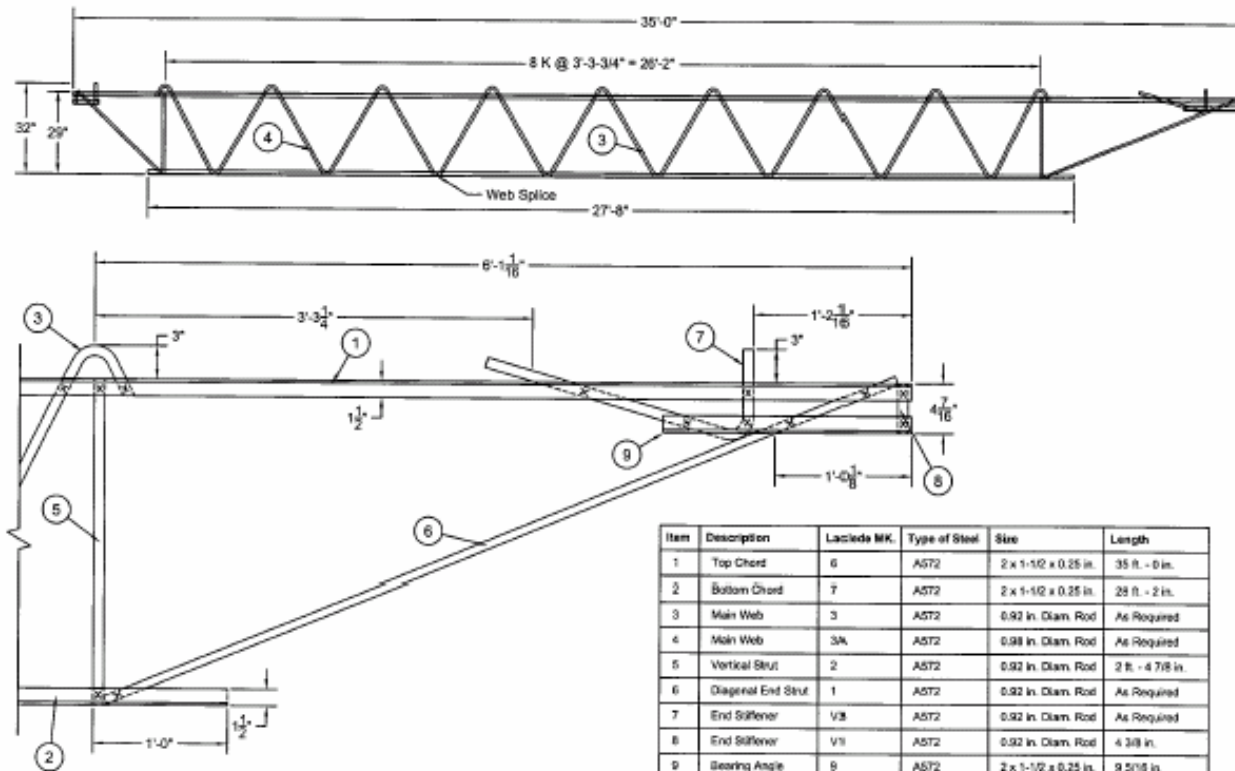
❑ “As specified” = 1.5 in

- PANYNJ white paper titled “Fireproofing Requirements for World Trade Center Tenant Floor Joist Construction that Requires Installation Due to Asbestos Removal or Local Removal to Facilitate Construction,” August, 1995.

❑ “As applied” = 2.5 in

- Determined from thickness measurements – PANYNJ Construction Audit Reports for floors affected by fire

# Geometry of 35 ft Steel Truss



Item	Description	Labeled MK.	Type of Steel	Size	Length
1	Top Chord	6	A572	2 x 1-1/2 x 0.25 in.	35 ft. - 0 in.
2	Bottom Chord	7	A572	2 x 1-1/2 x 0.25 in.	28 ft. - 2 in.
3	Main Web	3	A572	0.92 in. Diam. Rod	As Required
4	Main Web	3A	A572	0.98 in. Diam. Rod	As Required
5	Vertical Strut	2	A572	0.92 in. Diam. Rod	2 ft. - 4 7/8 in.
6	Diagonal End Strut	1	A572	0.92 in. Diam. Rod	As Required
7	End Stiffener	V3	A572	0.92 in. Diam. Rod	As Required
8	End Stiffener	V1	A572	0.92 in. Diam. Rod	4 3/8 in.
9	Gearing Angle	9	A572	2 x 1-1/2 x 0.25 in.	9 5/16 in.
10	Vertical Strut Core Side	5	A572	0.98 in. Diam. Rod	As Required
11	Diagonal Strut	10	A572	0.98 in. Diam. Rod	As Required
12	End Stiffener	V2	A572	0.98 in. Diam. Rod	7 3/8 in.
13	End Stiffener	V1	A572	0.98 in. Diam. Rod	As Required

35'-0" Main Truss Column End Detail

CONFIDENTIAL-  
DRAWN FROM INFORMATION  
PROVIDED BY NIST

**REVISED**  
**SEP 25 2003**  
**UNDERWRITERS**  
**LABORATORIES INC.**

MAINTRUSS35LSHOP.DWG



# Standard Fire Tests of WTC Tower Floor Construction

Test	Span	Thermal Restraint	SFRM Thickness
1	17 ft.	Restrained	0.5 in.
2	17 ft.	Restrained	0.75 in.

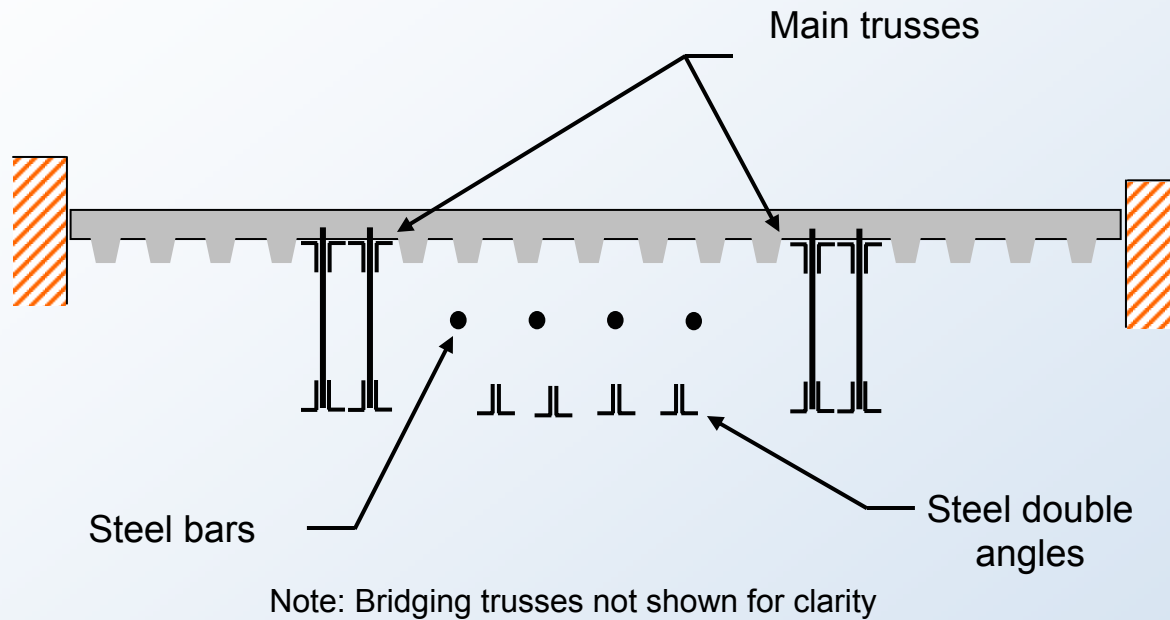
- ❑ Represents current U.S. practice for establishing a fire endurance rating of a building construction.
- ❑ Typical of the floor assembly test furnaces used by the U.S. testing laboratories that routinely conduct the ASTM E119 test.

# Standard Fire Tests of WTC Tower Floor Construction

Test	Span	Thermal Restraint	SFRM Thickness
3	35 ft.	Restrained	0.75 in.
4	35 ft.	Unrestrained	0.75 in.

- Allows direct comparison of the effect of thermal restraint on fire endurance rating.
- Will bound behavior of a floor system that is indeterminately restrained
- Twice the scale of the first test. Represents a full-scale assembly of a 35 ft floor panel.
- Allows direct comparison to Test 1 of the effect of test scale on fire endurance rating

# Additional Steel Members



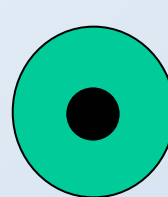
SFRM on Steel Bars:



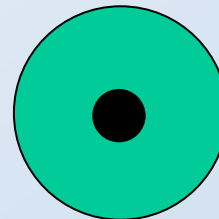
0.5 in



0.75 in



1.5 in



2.5 in

# On-site Monitoring and Inspection

NIST has overseen

- Design and fabrication of test specimens
- Casting of concrete slab and test cylinders
- Curing and drying of concrete
- Instrumentation
- Application of SFRM

NIST will continue to monitor closely

- Instrumentation
- Specimen loading
- Conduct of tests

# Instrumentation

## Temperature Measurements (exceed ASTM E119 requirements)

- Measurement of the temperature of the steel along the length of the members
- Measurement of the temperature of the unexposed surface (top) of the concrete slab
- Measurement of the temperature of the bottom of the concrete slab (steel deck)

## Deflection (not required by ASTM E119)

- Deflection measurements will be made at 9 locations on the unexposed side of the specimen as well as 3 locations on the bottom chord of both main trusses

# Instrumentation

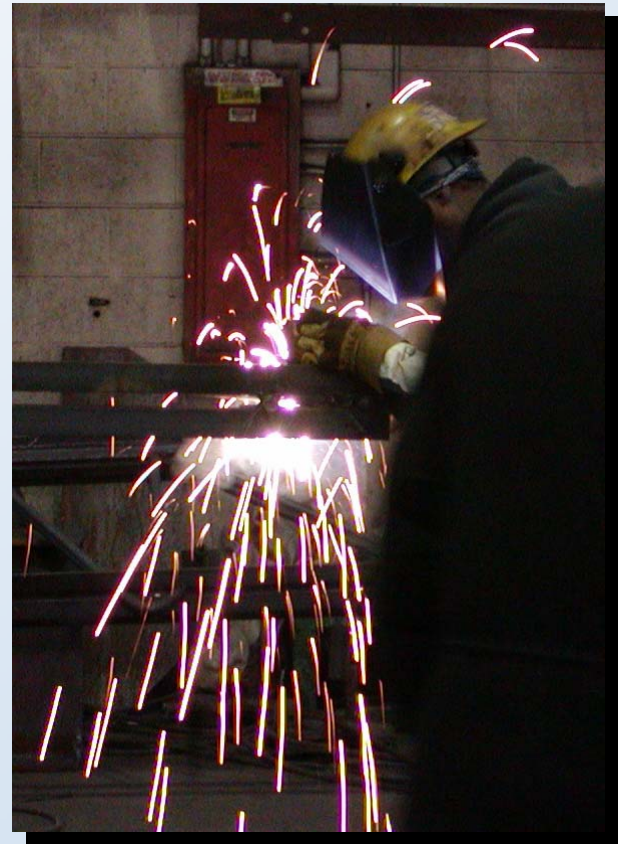
## **Gas Temperatures** (not required by ASTM E119)

- ❑ Gas temperatures will be continuously recorded at three locations using plate thermometer and aspiration thermocouples

## **Heat Flux** (not required by ASTM E119)

- ❑ Radiative heat flux will be measured at lower surface of metal deck and to the bottom flange of the main trusses using wide-angle radiometers

# Fabrication of Steel Joists



## Steel Joists Ready for Welding





## Assembly in UL's Toronto Test Facility



# Casting Concrete in UL's Toronto Test Facility



## Instrumentation of Test Assembly



## Spray-Application of Fireproofing Material



## Schedule for Testing

- Design of tests completed
- Fabrication of steel trusses completed
- Assembly of all four test specimens completed
- Curing of concrete to 28-day strength completed
- Drying of specimens to specified moisture equilibrium completed
- Shop primer paint applied on all specimens
- Instrumentation installed on all specimens
- Fireproofing applied to two specimens – all work to be completed by First week of July
- Testing to begin in late July – early August
- Results – will be available shortly after test completion