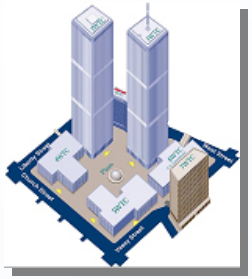

Technical Conference on the Federal Building and Fire Safety Investigation of the World Trade Center Disaster

Session VI - Structural Fire Response and Collapse Analysis

Standard Fire Test Findings

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Motivation for Conducting Standard Fire Resistance Tests of Floor Assemblies

Fireproofing of the floors in the WTC towers was an issue from the original design of the floor system and throughout the service life.

- Decision to spray trusses directly was innovative
- Need for test was expressed by Architect of Record and Engineer of Record
- Uncertainty in how SFRM thickness was specified
- LERA report reviewed fire resistance of floor system after 1975 fire
- PANYNJ's decision to upgrade fireproofing around 1995

Results From Standard Fire Tests at UL

Test	Description	Times to Reach End-Point Criteria (min)					Test Termin-ated (min)	Standard Fire Test Rating		
		Temperature on Unexposed Surface		Steel Temperatures		Failure to Support Load		ASTM E 119-61	ASTM E 119-00	
		Average (Ambient +250ºF)	Maximum (Ambient +325ºF)	Average (1100ºF)	Maxi-mum (1300ºF)			Rating (hr)	Restr-ained Ratin g (hr)	Unrestr - ained Rating (hr)
1	35 ft, restrained, ¾ in fireproofing	---	111	66	62	(3)	116(1)	1½	1½	1
2	35 ft, unrestrained, ¾ in fireproofing	---	---	76	62	(3)	146(2)	2	---	2
3	17 ft, restrained, ¾ in fireproofing	180	157	86	76	(3)	210(2)	2	2	1
4	17 ft, restrained, ½ in fireproofing	---	58	66	58	(3)	120(1)	¾	¾	¾

(1) Imminent collapse
(2) Vertical displacement exceeded capability to measure accurately
(3) Did not occur

NYC Building Code Requirement

The test assembly with ½ in. fireproofing (SFRM) thickness would not have met the 2 hour requirement of the NYC Building Code

Test	Description	Test Termin-ated	Standard Fire Test Rating (hr)		
			ASTM E 119-61	ASTM E119-00	
			Rating	**Restrained Rating**	**Unrestrained Rating**
1	35 ft, restrained, 3/4 in fireproofing	116	1 ½	1 ½	1
2	35 ft, unrestrained, 3/4 in fireproofing	146	2	---	2
3	17 ft, restrained, 3/4 in fireproofing	210	2	2	1
4	17 ft, restrained, 1/2 in fireproofing	120	¾	¾	¾

Restrained vs. Unrestrained Test Conditions

Restrained
(Test 1)


Unrestrained
(Test 2)

Restrained vs. Unrestrained Test Conditions

For the 35 ft span tests with ¾ in fireproofing, the unrestrained fire resistance rating of 2 hours determined from the unrestrained test was greater than the rating of 1 1/2 hours determined from the restrained test.

Test	Description	Test Termin-ated	Standard Fire Test Rating (hr)		
			ASTM E 119-61	ASTM E119-00	
			Rating	**Restrained Rating**	**Unrestrained Rating**
1	35 ft, restrained, 3/4 in fireproofing	116	1 ½	1 ½	1
2	35 ft, unrestrained, 3/4 in fireproofing	146	2	---	2
3	17 ft, restrained, 3/4 in fireproofing	210	2	2	1
4	17 ft, restrained, 1/2 in fireproofing	120	¾	¾	¾

Unrestrained Fire Resistance Ratings

The 35 ft span restrained test assembly with ¾ in fireproofing developed an unrestrained fire resistance rating of 1 hour while the unrestrained test assembly with ¾ in fireproofing developed an unrestrained fire resistance rating of 2 hours.

Test	Description	Test Termin-ated	Standard Fire Test Rating (hr)		
			ASTM E 119-61	ASTM E119-00	
			Rating	**Restrained Rating**	**Unrestrained Rating**
1	35 ft, restrained, 3/4 in fireproofing	116	1 ½	1 ½	1
2	35 ft, unrestrained, 3/4 in fireproofing	146	2	---	2
3	17 ft, restrained, 3/4 in fireproofing	210	2	2	1
4	17 ft, restrained, 1/2 in fireproofing	120	¾	¾	¾

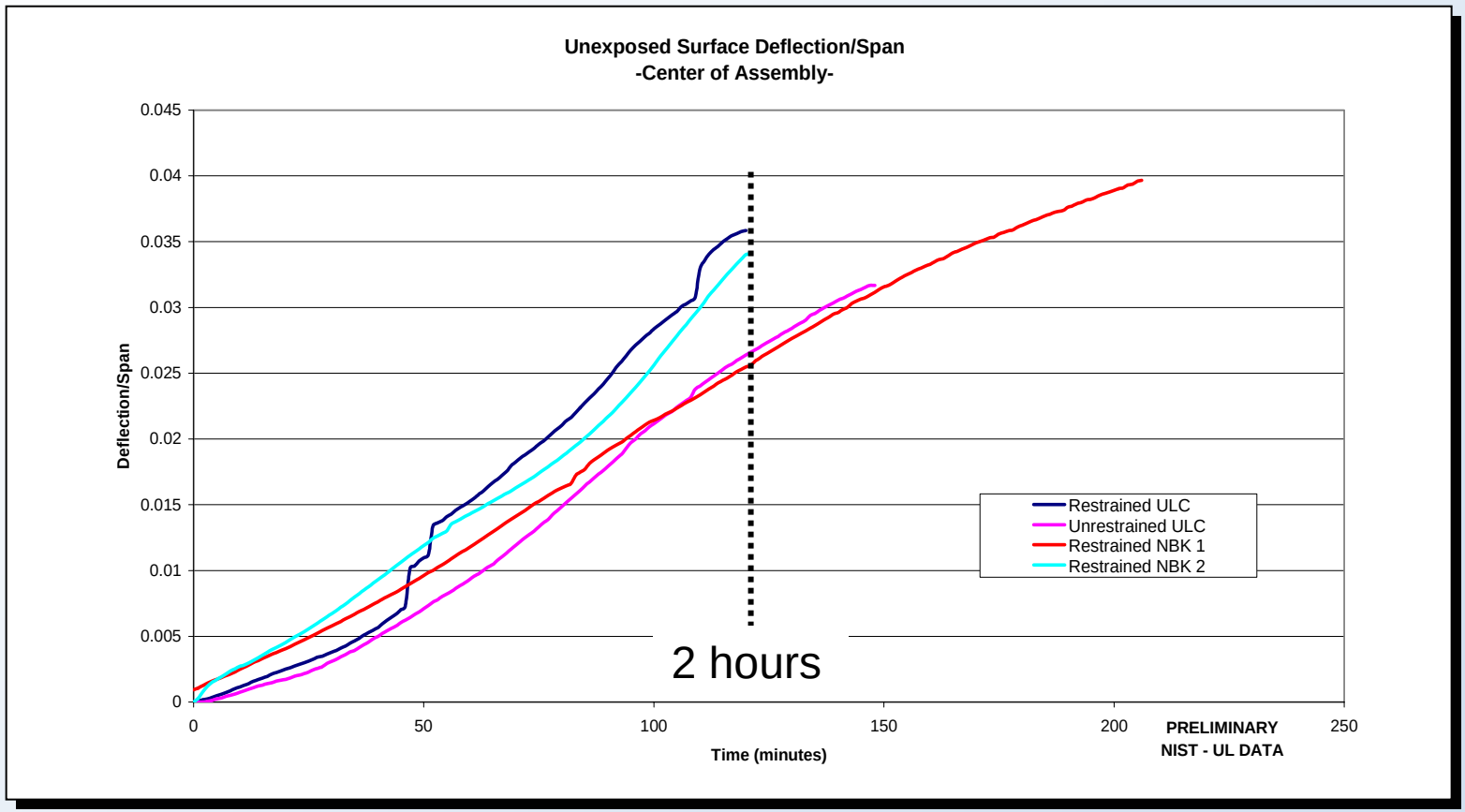
Scale of Test

For the restrained floor assemblies with ¾ in. fireproofing (SFRM) thickness, the 17 ft span assembly had a restrained rating of 2 h hours, while the 35 ft span assembly received a rating of 1 ½ hours

Test	Description	Test Termin-ated	Standard Fire Test Rating (hr)		
			ASTM E 119-61	ASTM E119-00	
			Rating	**Restrained Rating**	**Unrestrained Rating**
1	35 ft, restrained, 3/4 in fireproofing	116	1 ½	1 ½	**1**
2	35 ft, unrestrained, 3/4 in fireproofing	146	2	---	**2**
3	17 ft, restrained, 3/4 in fireproofing	210	2	2	1
4	17 ft, restrained, 1/2 in fireproofing	120	¾	¾	¾

Support of Load

Normalized Deflection of Center of Test Assembly



Support of Load

Based on four Standard Fire Resistance Tests conducted for various length scales, insulation thickness, and end restraint conditions, the floor assemblies were shown to be capable of sagging without collapsing and supported their full design load under standard fire conditions for 2 hours.