HTS
8/16 11 am

Glanda Thomas

From: Bhol, Saroj [sbhol@panynj.gov]
Sent: Wednesday, July 27, 2011 3:44 PM
To: Thomas Fariello
Cc: Glanda Thomas; Keith Wen; Lin, C. John
Subject: RE: WTC-Fire proofing of Oculus frame
Attachments: Whitepaper on Fire Resistance of Above Grade Oculus Steel Rev 00- 6 22 11.pdf; attachment 1.pdf; Attachment 2.pdf

I am forwarding the A/E of Record's Analysis for some background on this.

Thanks

Saroj

<<Whitepaper on Fire Resistance of Above Grade Oculus Steel Rev 00- 6 22 11.pdf>> <<attachment 1.pdf>> <<Attachment 2.pdf>>

From: Bhol, Saroj
Sent: Friday, July 15, 2011 3:40 PM
To: Thomas Fariello (tfariello@buildings.nyc.gov)
Cc: GlandaT@buildings.nyc.gov; kwen@buildings.nyc.gov; Lin, C. John
Subject: WTC-Fire proofing of Oculus frame

Tom,

There is a fireproofing issue for the WTC Transportation HUB oculus structure that I would like to present to you and seek your opinion/concurrence.

The oculus at the WTC Transportation Hub is an unique structure comprising portal frames which rise more than 160 feet above the plaza level (See attachment for cross section). It functions as the weather enclosure to the main entrance from the street level to the transportation concourses below. The WTC transportation Hub is designed as Construction Class 1-C per the 1968 code. For 1-C construction, columns, girders, trusses(other than roof trusses) require 1-1/2 hr fireproofing , as per Table 3-4. The issue is whether the oculus structure needs fire proofing similar to that required for columns.

The A/E of record has performed a structural Fire Engineering Analysis and demonstrated that due to the high volume of the space and robustness of the structure, the maximum temperature of the steel, without any fire resistive coating, will never exceed 105 degree F under all possible fire scenarios, Since Steel strength begins to deteriorate at 400 degrees F, it can be concluded that the structure, without any fireproofing provides an inherent equivalent fire rating of more than 1-1/2 hour that the code requires for columns, girders trusses and framing.

Keith participated in some discussion on this in last December. I will call Glanda to set up a meeting towards the end of July, your calendar permitting.

I will see you on the 19th for Delta project at JFK.

Have a nice weekend.

Thanks

Saroj

Thanks

Saroj

<< File: oculus.pdf >>

Whitepaper on Fire Resistance of Above Grade Oculus Steel

Purpose:

Section 27-271 and Table 3-4 of the 1968 NYC Building Code specify a 1-1/2 hour fire resistance rating for columns, girders, trusses and framing supporting one floor in Class 1-C Construction. The Upper Portal Frames, of the above grade portion of the Oculus structure, have been classified as columns and therefore must achieve a 1-1/2 hour fire resistance. This whitepaper presents an alternative engineering approach to demonstrate an equivalency to the 1-1/2 hour fire resistance requirement for the Upper Portal Frame of the Oculus structure.

TABLE 3-4

TABLE 3-4 CONSTRUCTION CLASSIFICATIONS	CONSTRUCTION ELEMENT		CLASS I-A		CLASS I-B		CLASS I-C		CLASS I-D		CLASS I-E	
			Rating in Hrs.	Ext.[a,b] Open'g	Rating in Hrs.	Ext.[a,b] Open'g	Rating in Hrs.	Ext.[a,b] Open'g	Rating in Hrs.	Ext.[a,b] Open'g	Rating in Hrs.	Ext.[a,b] Open'g
CONSTRUCTION GROUP 1 NONCOMBUSTIBLE	Exterior Walls with an Exterior Separation of: 3'-0" or less	Bearing	4	N.P.	3	N.P.	2	N.P.	2	N.P.	2	N.P.
		Non-bearing[c]	2		2		2		2		1	
	More than 3'-0" but less than 15'-0"	Bearing	4	3 1/3 %	3	3 1/3 %	2	3 1/3 %	2	3 1/3 %	2	6 2/3 %
		Non-bearing[c]	2	protected	2	protected	2	protected	2	protected	1	protected
	15'-0" or more but less than 30'-0"	Bearing	4	3 1/3 %	3	3 1/3 %	2	3 1/3 %	1	3 1/3 %	0	N.L.
		Non-bearing[c]	1½		1½		1		1		0	
	30'-0" or more	Bearing	4	N.L.	3	N.L.	2	N.L.	1	N.L.	0	
		Non-bearing[c]	0		0		0		0		0	
Required fire-resistance ratings of construction elements in hours, based on the test procedures of reference standard RS 3-1.	Interior bearing walls and bearing partitions.		4		3		2		1		0[d]	
	[e]Enclosure of vertical exits[f], and passageways, horizways [g] and shafts.		2		2		1		1		1	
	Fire divisions and fire separations.		See Article 5									
	Columns[h], girders, trusses (other than roof trusses) and framing.	Supporting one floor	3		2		1½		1		0[d]	
		Supporting more than one floor[i]	4		3		2		1		0[d]	
	Structural members supporting a wall.		Same as required fire resistance of wall supported, but not less than rating required for member by the class of construction.									
	Floor construction including beams.		3		2		1½		1		0[d]	
	Roof construction, including beams, trusses and framing, including arches, domes, shells, cable supported roofs and roof decks[j].	15'-0" or less in ht. above floor to lowest member	2		1½		1[k]		1[k]		0[d]	
		15'-0" to 20'-0" in ht. above floor to lowest member	2[k] or 1[d]		1½[k] or 1[d]		1[k]		1[k]		0[d]	
		20'-0" or more in ht. above floor to lowest member	2[k] or 0[d,k]		1½[k] or 0[d,k]		1[k] or 0[d,k]		1[k] or 0[d,k]		0[d]	

Key:

N.P.—Not permitted
N.L.—No limit

Noncombustible Materials

This approach is based upon AISC's "Specification for Structural Steel Buildings, Appendix 4: Structural Design for Fire Conditions, 2010" (Attachment 2). Following are two excerpts from that document;

- *"Structural components, members and building frame systems shall be designed so as to maintain their load-bearing function during the design-basis fire and to satisfy other performance requirements specified for the building occupancy."*
- *"The analysis methods in Section 4.2 are permitted to be used to demonstrate an equivalency for an alternative material or method, as permitted by the applicable building code."*

A recent article by ARUP, "Structural Design for Fire Conditions", Modern Steel Construction, April 2010, (Attachment 3), provides an overview and case studies of the alternative engineering approach.

The Project is designed to be in conformance with the New York City Building Code (NYCBC) of 1968 as amended through 2003 and this alternative approach is being presented in accord with the following provisions of that code;

- "27-104 Interpretation. – This code shall be liberally interpreted to secure the beneficial purposes thereof. ..... "
- "27-107 Variations. – The requirements and standards prescribed in this code shall be subject to variation in specific cases by the commissioner, or by the board of standards and appeals,...."

The current NYCBC (2008) is more specific regarding alternative approaches to fire resistance:

"703.3 Alternative methods for determining fire resistance.
The application of any of the alternative methods listed in this section shall be based on the fire exposure and acceptance criteria in ASTM E 119. The required fire resistance of a building element shall be permitted to be established by any of the following methods or procedures:

1. Fire-resistance designs documented in approved sources.
2. Prescriptive designs of fire-resistance-rated building elements as prescribed in Section 720.
3. Calculations in accordance with Section 721.
4. Engineering analysis based on a comparison of building element designs having fire-resistance ratings as determined by the test procedures set forth in ASTM E 119.
5. Alternative protection methods as allowed by Section 104.1."

Project Description and Design Criteria:

Design-Basis Fire Sizes per the Project's Basis of Design Report (BDR) Revision 5, September 14, 2009, are as follows;

- Platform Level Train Fire: 10MW.
- PATH Hall Fire: 2 MW.
- West St. Concourse fire: 2 MW.
- Transit Hall Level Fire: 2 MW.
- Upper Transit Hall Level Fire: 2 MW.
- Concourses Fire: 2 MW.

The Upper Portal Frames are part of the structure of the Transit Hall. The design-basis fire for use in analysis is therefore 2 MW, equivalent to a non-sprinklered kiosk of no more than 30 square feet area. The Transit Hall is the HUB's principal public circulation space within the east 'bathtub' and the two principal floor levels are equipped with a ring of sprinklers separating the high bay portion of the Hall from the adjacent retail use at

those levels. The design-basis fire has been utilized throughout the project's development in analysis of life safety systems, including CFD studies of smoke and heat generation within the Transit Hall.

The Transit Hall's above grade structure also includes purlins, rafters, rafter/portal transition elements and arches (see sketches), which are non-combustible and do not require a fire resistance rating in accordance with NYCBC 1968, Table 3-4, for Construction Group 1-C, being components of Roof Construction 20 feet or more above the floor to lowest member or non-bearing exterior wall construction. The Lower Portal Frames (that portion of the Portal Frame below the elevation of the plaza) are fire resistance rated with an intumescent fire protective coating.

All other structural steel below plaza level is specified to be fire proofed in accordance with NYCBC Table 3-4, see Attachment 4.

The Transit Hall structure also meets the Project's Security Performance Criteria (SPC) for limiting damage to the structure and preventing progressive collapse. Extensive analysis of the SPC specified threats on the behavior and performance of the structure has been performed. The resultant structural design therefore exceeds the requirements of the normal applied structural loads for wind, live, snow, etc and is "robust".

Status: ARUP as consultant to DDP performed CFD analyses of the design basis fire in the Transit Hall, for the purposes of smoke exhaust system design. A product of those analyses has been determination of the temperature gradient resultant in the Transit Hall due to a single 2MW fire occurring at various locations. Additional analysis of the Upper Portal Frame, when subject to the design basis fire size was performed, to determine, per AISC Appendix 4, if a fire protective coating of the Upper Portal Frame is required.

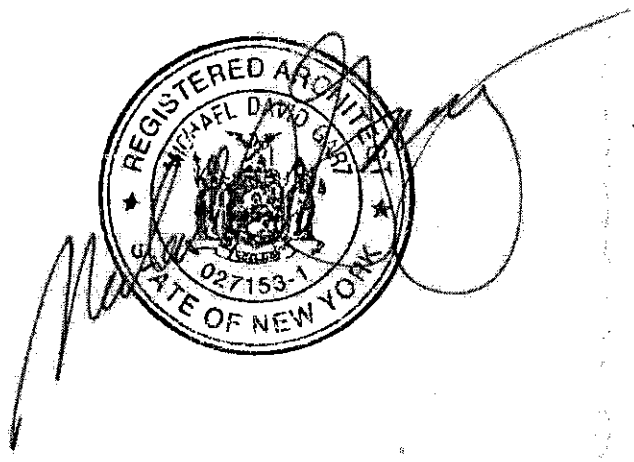
Analysis Findings:

> *"....the strength of the steel portal frame members is not expected to be reduced as a result of the calculated fire exposures. For all fire scenarios considered, the average temperature of the steel will never exceed 105 °C, as demonstrated by CFD analysis. Therefore[1], a factor of safety of at least 3.8 is maintained relative to the point at which steel strength begins to deteriorate (400* C). When compared to ASTM failure criteria (538*C), a factor of safety of at least 5.1 is provided. The analysis, therefore, justifies the omission of applied fire protective coatings on the portions of the steel portal frames more than 33' to 47' above the Transit Hall elevation of 274'."*
>
> [1] *Inserted*

See Attachment 1 for ARUP's "Structural Fire Engineering Analysis", dated February 25, 2011.

Conclusion: The inherent fire resistance of the steel assembly comprising the Upper Portal Frame provides equivalency to the NYCBC specified 1-1/2 hour fire resistance without addition of a fire protective coating for the Project's established fire conditions.

Prepared by: M. Garz
Reviewed by: S McIntyre



Attachment 1
"World Trade Center Transportation HUB
Structural Fire Engineering Analysis"
ARUP, February 25, 2011

Attachment 2
AISC "Specification for Structural Steel Buildings, June 22, 2010
Appendix 4 Structural Design for Fire Conditions"

Attachment 3
"Structural Design for Fire Conditions"
Modern Steel Construction, April 2010

Attachment 4
World Transportation Hub
Oculus Steel
Fire Protection Diagrams