



**THE PORT AUTHORITY OF NY & NJ**

*Engineering Department*

October 4, 2006

Hon. Fatma M. Amer, P. E.  
Deputy Commissioner, Technical Affairs  
NYC Department of Buildings  
280 Broadway, 7<sup>th</sup> Floor  
New York, NY 10007

Re: World Trade Center Memorial and Museum

Dear Commissioner Amer:

Thank you for meeting with the Port Authority representatives and the Lower Manhattan Development Corporation's (LMDC) design team on August 4, 2006 to discuss the revised design and the exit facilities of the World Trade Center Memorial and Museum. The original design presented to you and discussed with you on March 6, April 6, and May 5, 2006. An overview of the revised design and the exit facilities, as discussed at the August 4<sup>th</sup> meeting, is presented below:

Overview of the design features

- The Memorial comprises two open reflecting pools on the footprints of the original towers, to be viewed by the public only from the open plaza at the street level. The below grade viewing galleries around the memorial and the open ramps leading to and from those galleries, which were part of the original design, have been eliminated in the revised design.
- The revised design of the Museum consists of the Hall of Memory, located one level below grade at El. 285'-11", the main exhibition space at the bedrock level at EL 242', and a single ramped floor that connects these spaces. Most of the ramp will be sloped at 1:20. The Hall of Memory and the ramp is open to the main exhibition space below.
- The Museum will be classified as F-3 assembly occupancy and the construction classification of the Museum will be Type 1C, fully sprinklered. Due to its design with open (unenclosed) ramps between the two levels that provides continuous view of the main exhibition space, it will be considered as a single story space of unlimited area.

Hon. Fatma Amer, P.E.

October 4, 2006

- Entrance to the Museum will be from the plaza level (El. 313'-0") security area within the Visitor Orientation and Education Center (VOEC), which will be designed by a separate architect and is anticipated to have three or more stories above grade.
- Access to the Hall of Memory (at EL. 285'-11") from the VOEC security area will be through unenclosed escalators. The unenclosed escalator opening will be a high story space that will connect to several floors of the VOEC, and it will be considered similar to an atrium with the two lowest levels being at El. 285'-11" and at the Grade Level at EL. 313'. These two levels in the atrium will be separated from the adjoining spaces by draft curtain and sprinklers spaced at 6 feet on centers. All other levels within the VOEC building above grade will be separated from the atrium with 2-hour fire-rated construction or by glass with sprinklers on the occupied side at 6'-0" on centers.
- The atrium will be provided with a smoke control system, as required by the building code.
- The exit facilities from the Museum will be provided by exit stairs and/or fire rated and pressurized exit passageways that lead to the exit stairs.
- The actual number of occupants in the Museum, which will be controlled through time ticketing at 5 minute intervals and monitoring the entrance and departure of visitors, will be significantly lower than that based on occupant-area ratio in code table 6-2. The exit capacities are based on the actual occupant load of the Museum, as per code section 27-358(b). The procedure for controlling and monitoring will be properly documented.

#### Specific Details of Exit facilities in the Museum

- The exit passageways from the Memorial and the Museum are minimum 8 feet wide, generally, with a few exceptions. The exit passageways that are 8 feet or wider are separated from the stairs by doors and serve as "safe areas" as per code section 27-535. The exit passageways that are less than 8 feet wide are designed as horizontal extension of stairs, as per code section 27-370.
- The enclosing walls of the exit passageways, and stairs that require 2-hr fire rating are constructed of concrete to provide additional blast protection. The scissor stairs (stairs A.1 and A.2) are also separated by 1'-0" thick concrete walls.
- The exit passageways and stairs will be pressurized to prevent smoke infiltration.

Hon. Fatma M. Amer, P.E.

October 4, 2006

- Although not required by code, enhanced exit signage, including photo-luminescent markings, will be provided in the exit passageways and stairs.
- Proper evacuation plans and procedures for the Museum will be established with the Fire Department.
- The exit stairs that are open at the top (subway type) at the plaza level shall be provided with snow melting devices.
- The design professionals responsible for the design has evaluated the effectiveness of the exit facilities with a performance based study using extensive time motion analysis and computational fire dynamics analysis (Recommendation number 30 in NIST's WTC Investigation Report).

The following drawings and line diagrams were presented during discussions at the meetings, copies (as presented at the 5/5/06 meeting) of which are enclosed.

- |                             |                                       |               |
|-----------------------------|---------------------------------------|---------------|
| ▪ Drawings                  |                                       |               |
| A-011                       | Life safety/Fire Egress-El. +242'-0"  | Dated 8/04/06 |
| A-012                       | Life safety/Fire Egress EL. +264'-0"  | 8/04/06       |
| A-013                       | Life safety/Fire Egress EL. +285'-11" | 8/04/06       |
| A-014                       | Life safety/Fire Egress EL. +313'-0"  | 8/04/06       |
| ▪ Line Diagrams             |                                       |               |
| ASK.060403.01<br>(2 sheets) | Egress @ @ 279' & 285'-11"            | 8/04/06       |

Also, enclosed are the following documents:

- Letter from Code consultants to Davis Brody Bond, the Architect of Record, dated September 29, 2006, regarding design concepts.
- Memorandum from Management Resources, dated September 19, 2006, on Museum Occupancy by Level.
- Memorandum from Management Resources, dated September 8, 2006, on the Guest Flow Control and Monitoring Systems that will be used for controlling the number of occupants through time ticketing and visitor counting.



**THE PORT AUTHORITY** OF NY & NJ

Hon. Fatma M. Amer, P.E.

October 4, 2006

Based on the review of the egress drawings, the related documents, and the discussions at the meetings with you, the Port Authority is of the opinion that the design of the Memorial and the Museum, and their exit facilities meet the requirements of the New York City building Code.

If you find the above to be a fair and accurate summary of our meetings and concur that the design meets the code requirements, I would appreciate your signing and returning a copy of this letter to me.

Very truly yours,

Saroj Bhol, P. E.  
Manager, Design Standards

Concurred:

Fatma M. Amer, P. E.  
Deputy Commissioner  
Technical Affairs



September 29, 2006



CODE CONSULTANTS  
PROFESSIONAL ENGINEERS, PC

330 West 38th Street  
Suite 905  
New York, NY 10018  
212-216-9596 phone  
212-216-9619 fax

The Fire Protection and  
Life Safety Experts

- Code Consultation
- Alarm Systems Design
- Fire Sprinkler Design

Mr. Carl Krebs  
Davis Brody Bond, LLP  
315 Hudson Street  
New York, NY 10013

RE: WORLD TRADE CENTER MEMORIAL  
CONCEPT NARRATIVE  
PROJECT NO. XX-07383-10

Dear Carl:

Due to the overall size and complexity of the revised World Trade Center Memorial and Museum complex, the egress and construction concepts for the facility must be clarified to confirm compliance with the Building Code of the City of New York. This letter is intended to address two specific design concepts and the compliance of these concepts with the Building Code. The two concepts are as follows:

1. Posted Occupant Load
2. Memorial/Museum Classification

#### Occupant Load

Section 27-358 of the Building Code requires that the number of occupants for whom exit facilities must be provided shall be established either (1) by the actual number of occupants for whom the room or space is designed, or (2) by using the appropriate occupant-area ratios from Table 6-2, whichever is greater. However, Sub-Section (b) of Section 27-358 permits the Commissioner to establish an alternative basis for the determination of the occupant load when the actual occupant load of any space will be significantly lower than that listed in Table 6-2.

Table 6-2 specifies an occupant-area ratio of 10 net square feet per person for exhibition spaces. This occupant-area ratio for both the Memorial/Museum results in an occupant load that is significantly greater than the actual number of occupants that will be permitted within these spaces.

The Memorial/Museum has a net occupiable area for visitor circulation and viewing of approximately 81,000 square feet which results in a calculated occupant load of 8,100 persons. The net occupiable area is based on assumptions about the size and location of exhibits developed by the operations consultant, Management Resources.

The current studies by Management Resources have determined the maximum number of occupants that may theoretically occupy the facility and have the intended experience within the space (see attached Memoranda from Management Resources). The calculated and actual numbers for the Memorial/Museum are summarized in the table below.

	Calculated Occupant Load	Actual Occupant Load
Memorial / Museum	8,100	2,250

The studies by Management Resources have also determined the maximum peak occupant load for any given level based on the overall occupant load that is admitted to the Museum at a single time. Based on studies utilizing time ticketing and a ninety (90) minute occupant experience, the distribution of the 2,250 occupants within the Museum, the calculated occupant load for the public museum area of each level, and the available exit capacity, is as follows:

	Calculated Occupant Load	Actual Occupant Load	Exit Capacity
Museum – 242' Level	5,132	1,625	1,760
Museum – 264' Level	496	250	480
Museum – 285' Level	2,472	375	800

Due to the significant difference that exists between the calculated occupant load and the actual occupant load of Memorial/Museum spaces, we recommend providing exit facilities for the actual occupant load intended for the spaces as permitted by Section 27-358(b) of the Building Code. As part of the approval for the use of the actual occupant load to determine exit requirements, the following will be provided:

1. The actual occupant load for each space will be posted in a location that is conspicuously visible to a person entering the facility in accordance with Section 27-527 of the Building Code.
2. The occupant load entering and leaving the Memorial/Museum will be monitored to assure that the occupant load does not exceed the posted occupant load. The occupant load will be monitored by the use of time entry ticket media and visitor counting technology (see attached Memoranda from Management Resources).
3. Facility personnel will staff the Memorial/Museum and will be trained to prevent overcrowding of spaces.
4. A time-based egress study will be performed for the Memorial/Museum that will evaluate the efficiency of the current egress design when compared to typical egress times for other buildings.
5. Studies by Management Resources, specializing in the analysis of crowd movement in public assembly spaces, will establish that the proposed actual occupant load is the realistic maximum instantaneous occupant load for the spaces. It is expected that the typical occupant load within the spaces will be less.
6. Fire protection and life safety features, such as automatic sprinkler systems, standpipe coverage, smoke control systems and occupant notification systems, will be provided throughout the facilities.

#### **Memorial/Museum Classification**

The World Trade Center Memorial/Museum consists of the Hall of Memory (located one level below grade (EL 285')), the main exhibition space located at the Bedrock Level (EL 242'), and a single sloping/ramped floor that connects these two spaces. The sloping/ramped floor is intended to provide a continuous exhibit experience that begins in the Hall of Memory and continues to the lowest level of the space. Exhibits will be provided along the continuous ramping levels for occupant viewing.

The Hall of Memory and the sloping floors/ramps connecting the Hall of Memory to the EL 242' Level are open (unenclosed) to the EL 242' Level to provide continuous views of the excavated site below. The sloping floors/ramps will be sloped at less than 1:12 and in most cases will be sloped at 1:20. Entrance to the Memorial/Museum will be from the Grade Level (EL 313') security area of the Visitor Orientation and Education Center (VOEC).

#### Unlimited Area Single Floor

The Memorial/Museum complex will be constructed in accordance with a Type IC construction classification. Type IC construction permits the F-3 Memorial/Museum complex to be of unlimited area for a fully sprinklered building. Therefore, because the Memorial/Museum complex is a single volume space with sloping/ramped floors, the complex is considered a single-story space of unlimited area.

Although not classified as an atrium, the following systems will be provided similar to those requirements specified for an atrium:

1. A smoke control system that will be designed and analyzed using Computational Fluid Dynamics (CFD) for the entire volume of the space.
2. Egress systems that will be analyzed with computer-based models to determine the efficiency of the system based on the proposed occupant loads and a series of evacuation scenarios.
3. Exit stairs and passageways that will be pressurized during emergency evacuation and will have means for mechanical exhaust. The exit systems will be enclosed in 2-hour fire resistant construction that is hardened to protect against damage due to explosions.
4. Fire protection and life safety features, including automatic sprinkler systems, standpipe coverage, occupant notification and communication systems, emergency lighting, and exit markings/signage
5. Emergency power for life safety systems, including the smoke control system, occupant notification systems, elevators and all emergency/exit lights.

#### Entrance Atrium

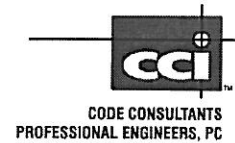
The entrance to the Memorial/Museum complex is through the Grade Level (EL 313') security area of the Visitor Orientation and Education Center (VOEC). The first level of the Memorial/Museum is one level below grade (EL 285') and is connected to the VOEC building above by unenclosed escalators. The unenclosed escalator opening will be a high-story space that will connect to several floors of the VOEC, in addition to the Grade Level. Although not yet designed, the VOEC building above is anticipated to have three or four stories above grade.

As defined by the Building Code, an atrium is "A vertical opening or series of openings within a building connecting three or more floors, which may be covered at the top, and which is used for purposes other than an enclosed stairway, elevator hoistway or utility shaft." The opening that connects the EL 285' Level of the Memorial/Museum to the VOEC Building will be classified as an atrium.

In accordance with Section 27-521 of the Building Code, an atrium must be fully enclosed. However, openings of any size into the two lowest levels of the atrium are permitted when such openings are provided with opening protectives having a fire resistance rating of 1-1/2 hours or the openings are protected with sprinklers spaced not more than 6 feet on center. All other levels of the atrium must be enclosed by 2-hour fire resistant rated construction or glass that is wired, laminated or tempered and protected with sprinklers on the occupied side that are spaced not more than 6 feet on center.

The two lowest levels of the atrium are the EL 285' Level and Grade Level (EL 313'). These two levels will be separated from the atrium by 2-hour fire resistance rated construction or by sprinklers spaced 6' on center at the openings. The line of sprinklers at the openings define the extent of the atrium and separate the remainder of these levels (and the remainder of the Memorial/Museum and VOEC) from the atrium. All levels within the VOEC building above Grade Level will be separated from the atrium by 2-hour fire resistance rated construction or by glass that is protected by sprinklers 6 feet on center.

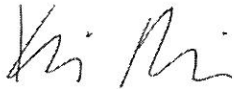
Mr. Carl Krebs  
September 29, 2006  
Page 4



The atrium will be designed in accordance with Article 21 of Sub Chapter 7 of the Building Code. Occupants will not be required to egress through the atrium to exit. In addition, active and passive smoke exhaust systems will be provided within the atrium as required by the Building Code.

The concepts outlined above are intended to comply with the requirements of the Building Code of the City of New York.

Sincerely,



Kevin Morin, PE  
Project Manager



John McCormick, PE, FSFPE  
Principal

Attachments