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The Fire Protection and Life Safety Experts
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September 16, 2014

Mr. Joaquin Stearns
Broadway Trio LLC c/o
Extell Development Company
805 Third Avenue, 7th Floor
New York, NY 10022

**RE: 217 WEST 57TH STREET RESIDENTIAL TOWER
FIRE & SMOKE MODELING
PROJECT NO. 130866.54.000**

Dear Joaquin:

A new 217 West 57th Street Residential Tower is proposed to be built in New York City. The proposed high-rise building will include a portion of the building that cantilevers over an adjacent building. This letter serves as documentation of the fire engineering analysis required for buildings that cantilever over an adjacent building by Section 705.12 of the 2014 NYCBC.

Applicable Codes

It will be necessary for the 217 West 57th Residential Tower to be designed in accordance with the codes adopted by the City of New York and as listed below:

- 2008 New York City Building Code (NYCBC)
- 2008 New York City Fire Code

The project will be permitted in accordance with the 2008 NYCBC which does not specifically address cantilever conditions. However, the most recent edition (2014 NYCBC) of the New York City Building Code includes specific requirements to protect portions of buildings that cantilever over existing buildings. It is anticipated that the DOB will require compliance with these provisions through the variance process.

Code Requirement

Section 705.12 of the 2014 NYCBC states "...cantilevered portions [of a building] shall be protected with construction that conforms to a fire engineering analysis acceptable to the commissioner..." The Computational Fluid Dynamics (CFD) model created for this analysis is intended to address the following criteria set forth in Section 705.12.1.1 of the 2014 NYCBC, which requires:

1. The simulated fire scenario shall run until burn-out with no intervention of the fire department or any fire suppression systems
2. All interior vertical compartmentation, including the entrances to stairways, are removed from the CFD model,
3. The fuel loading exceeds what is expected for the current occupancy by a factor of safety approved by the commissioner

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Section 705.12.1 of the 2014 NYCBC requires analysis of the following cantilever building elements; frame, structural supports, underside of projecting assemblies, and all exterior walls and openings on all sides. Additionally, the cantilever must adhere with applicable provisions of the NYC Fire Code with respect to access to the building and its roof.

Analysis

The requirements for a fire engineering analysis for cantilevered portions of a building are specified in the 2014 NYCBC. The effects of a potential catastrophic fire on the cantilever from the buildings below were modeled using the computer fire model Fire Dynamics Simulator (FDS) that was developed by the Building and Fire Research Laboratory at the National Institute of Standards and Technology (NIST). FDS is a CFD model specifically developed for fire applications.

FDS solves a form of the fundamental equations of fluid motion (the Navier-Stokes equations) to calculate conditions in a space due to a fire. This requires the creation of a 3-dimensional computer model of the building. A CFD model works by dividing the space into multiple regions or cells. The equations describing the motion of fire gases are solved for each cell and the combination of the results for all of the cells in the model creates a solution that describes the motion of fire gases around the building. CFD models, such as FDS, require extensive computer resources and must be run on multiple high-powered computer workstations.

Figures 1 below shows the 3-dimensional computer model created for the code permitted scenario and the proposed scenario, respectively. The light blue portion represents the cantilevered portion of the 217 West 57th building (light brown building). The yellow building represents the adjacent building.

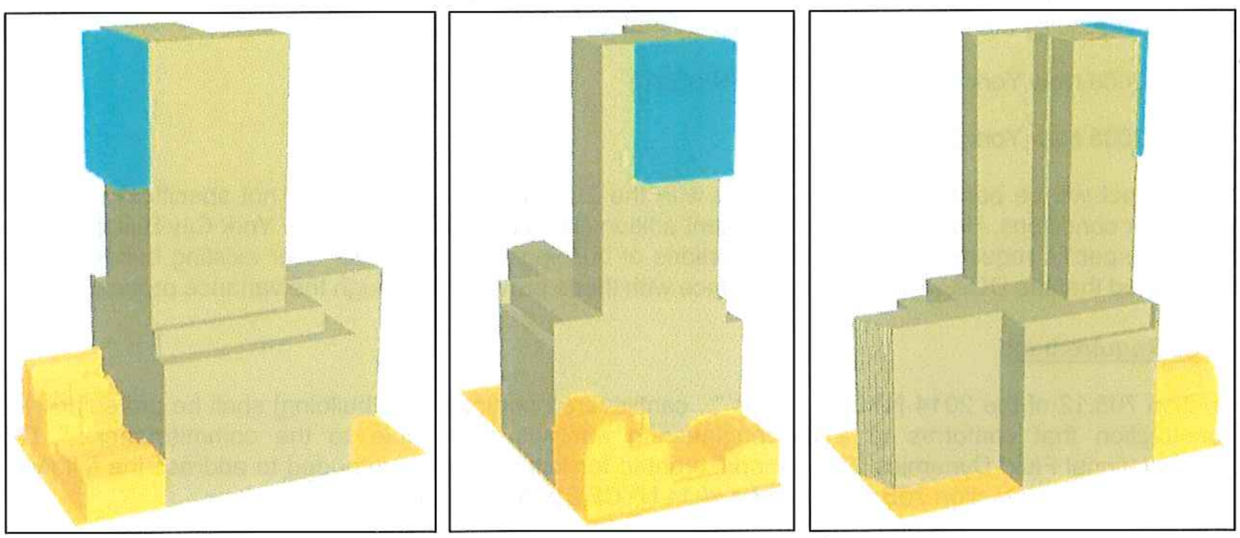

Figure 1. Three Views of FDS Model

The adjacent building is an art institute. The expected fuel loads include paper, canvas, paints, and some furniture. The design fire used in the analysis is based on a fuel load density of 661 MJ/m^2, taken from *"Characterizing of Design Fires for Clothing Stores",* Zalok, E. et al., which is based on fuel loading for a clothing store. This is conservative as the fuel load in a clothing store is much denser than would be expected in the art institute building adjacent to the 217 West 57th building. Using this value, and an expected fire burn out time of 30 minutes, a heat release rate per unit area of 367 kW/m^2 is calculated. For this analysis, the short anticipated burn out time is conservative because it increases the heat release rate for

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the same amount of fuel. The heat release rate per unit area was further increased by a safety factor of 20% to 450 kW/m^2. This results in a design fire size of about 557 MW. The design fire scenario assumes no intervention by building fire sprinkler systems or fire department operations, is modeled as a steady state scenario, with no growth phase or decay phase, and is allowed to continue until steady state conditions are reached. This is conservative and consistent with the requirements of Section 705.12.1.1 of the 2014 NYCBC.

Pass/Fail Criteria

The NYCBC does not provide pass/fail criteria for the evaluation of cantilevered buildings. However, Section 703.2 requires a fire-resistance rated assembly be tested in accordance with ASTM E-119.

ASTM E-119 tests the performance of fire-rated construction by exposing the protected steel member to a a standard time-temperature curve. The standard states that the temperature of the steel member cannot exceed 538°C (1000°F) at any point during the test, over a time equal to the classification. For a 2-hour fire resistance rated structural steel member, such as those required for the 217 West 57th building, the temperature of the steel cannot exceed 538°C for two hours. It should be noted, however, that the simulations were run until steady state conditions were reached, which was less than 2 hours.

In addition, a heat flux of 10 kW/m^2 will be used to determine if a design fire has the potential to ignite adjacent combustibles A heat flux of 10 kW/m^2 is identified by NFPA 92 as a conservative threshold for the ignition of combustibles.

Results

The images below show the heat flux on the cantilevered section of the 217 West 57th building. Each snapshot is at the time of greatest heat flux for the specific location indicated in the Figure description. Figure 2 shows the maximum heat flux on the underside of the cantilever, and Figure 3 shows the maximum heat flux on the other exterior walls.

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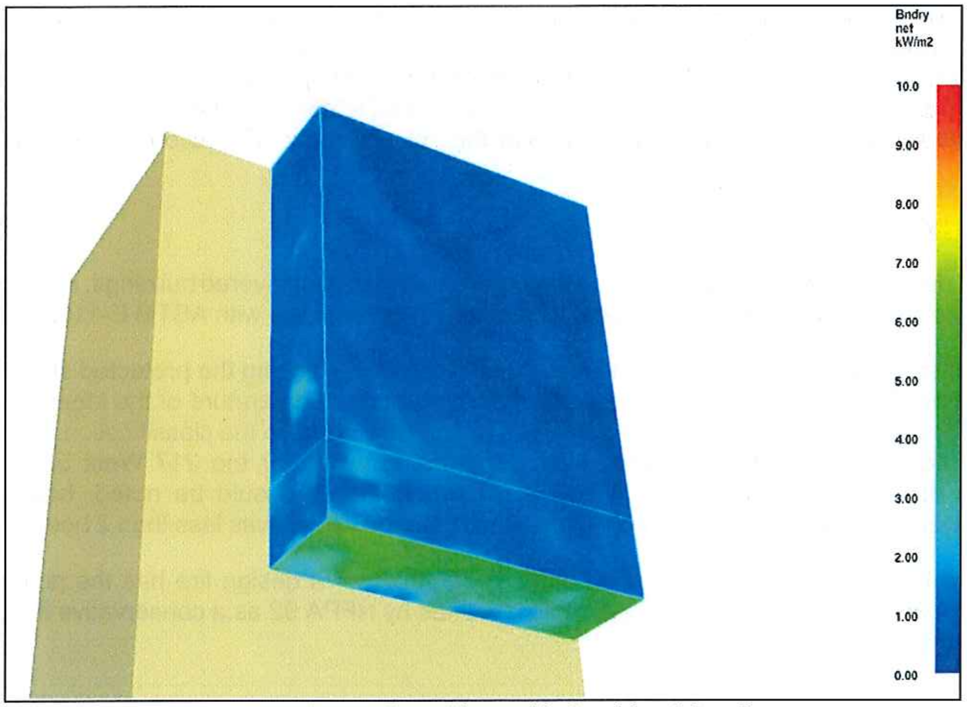

Figure 2. Maximum Heat Flux at Underside of Cantilever

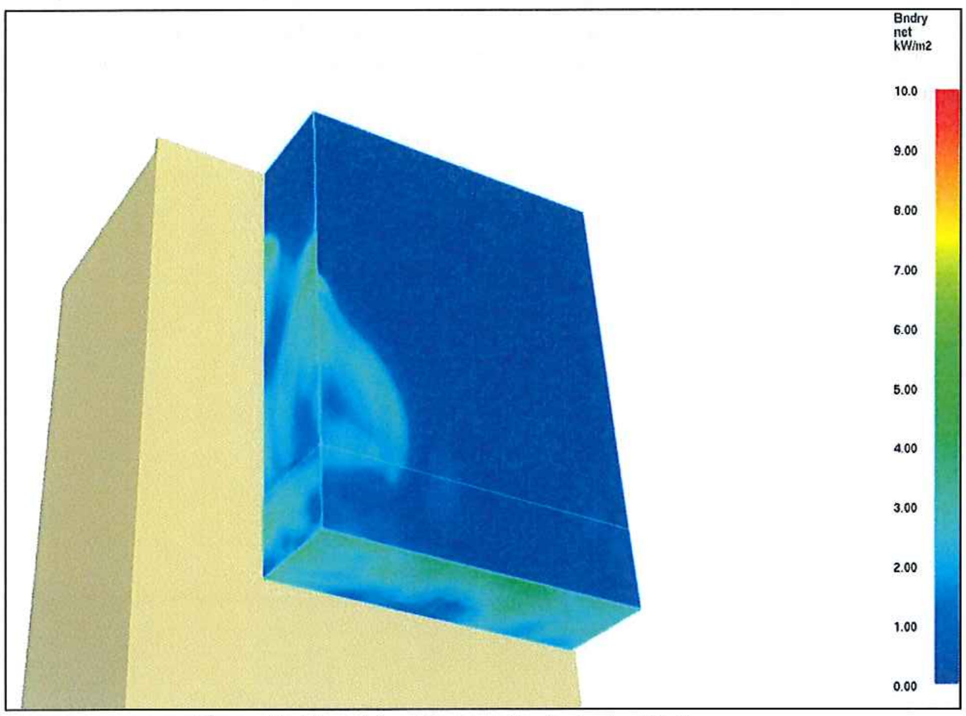

Figure 3. Heat Flux Scaled for Exterior Walls

As shown in Figure 2, the heat flux on the underside of the cantilever approaches a peak value of 6 kW/m^2.

The remaining sides of the cantilever, seen in Figure 3, show a heat flux nearing 4.3 kW/m^2. Figure 4 below shows the surface temperature of the cantilever.

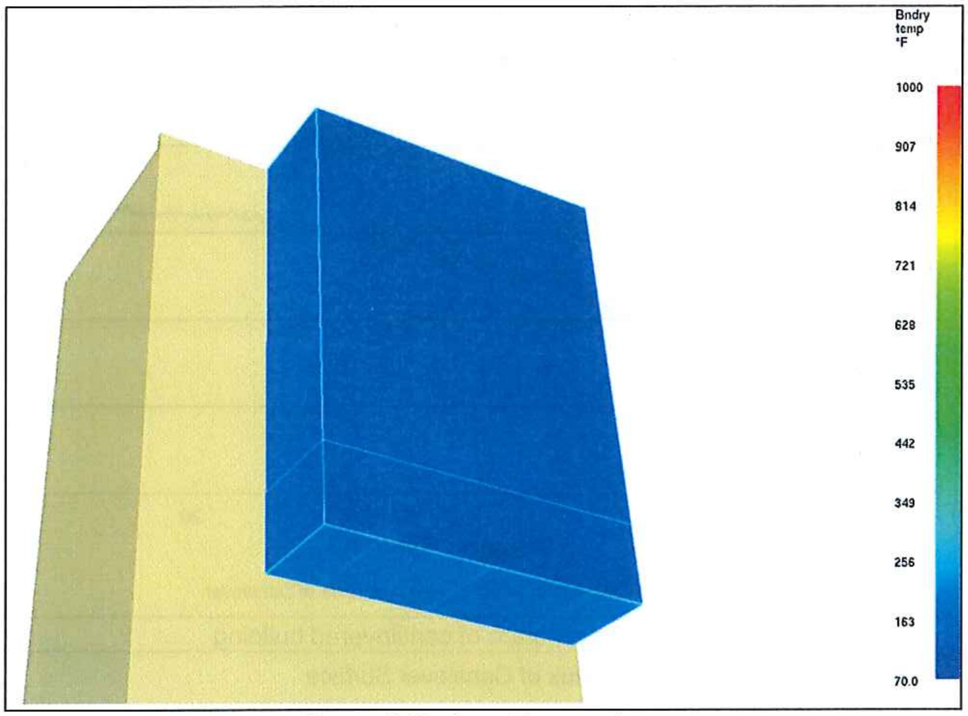

Figure 4. Surface Temperature

As shown in Figure 4 above, the temperature of the underside reaches a maximum of 186˚F while the rest of the cantilever reaches a maximum temperature of 138˚F. Temperature and heat flux values are measured at points that are evenly distributed across each surface. To provide the most conservative view of the data, the graphs below in Figure 6 use the point with the largest value for that given time and location (exterior walls or underside) as each plotted data point.

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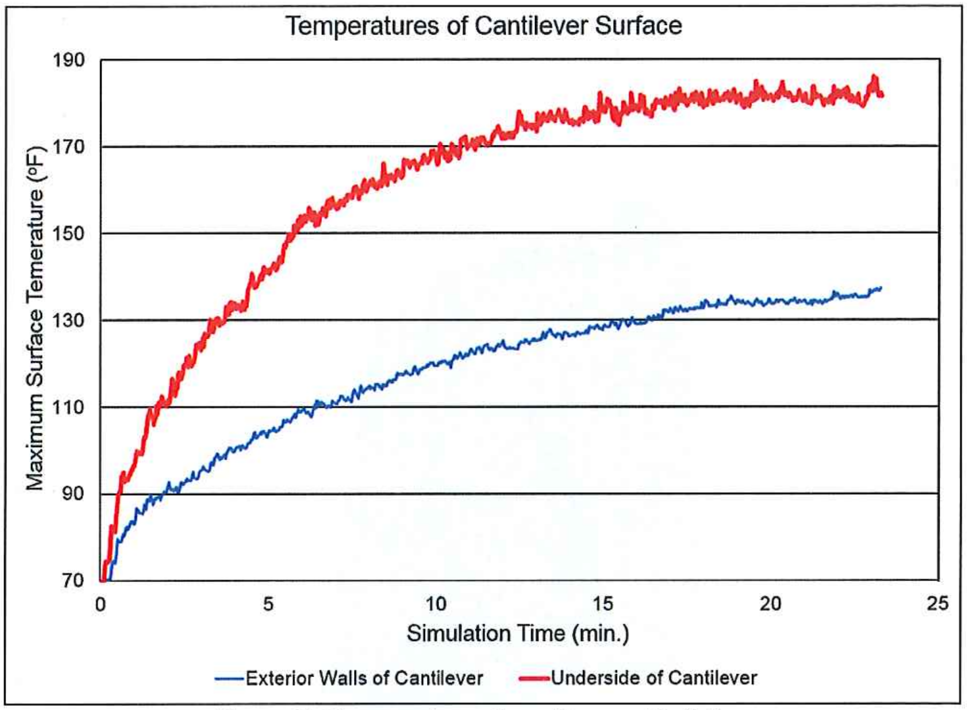

Figure 5: Temperature of cantilevered building

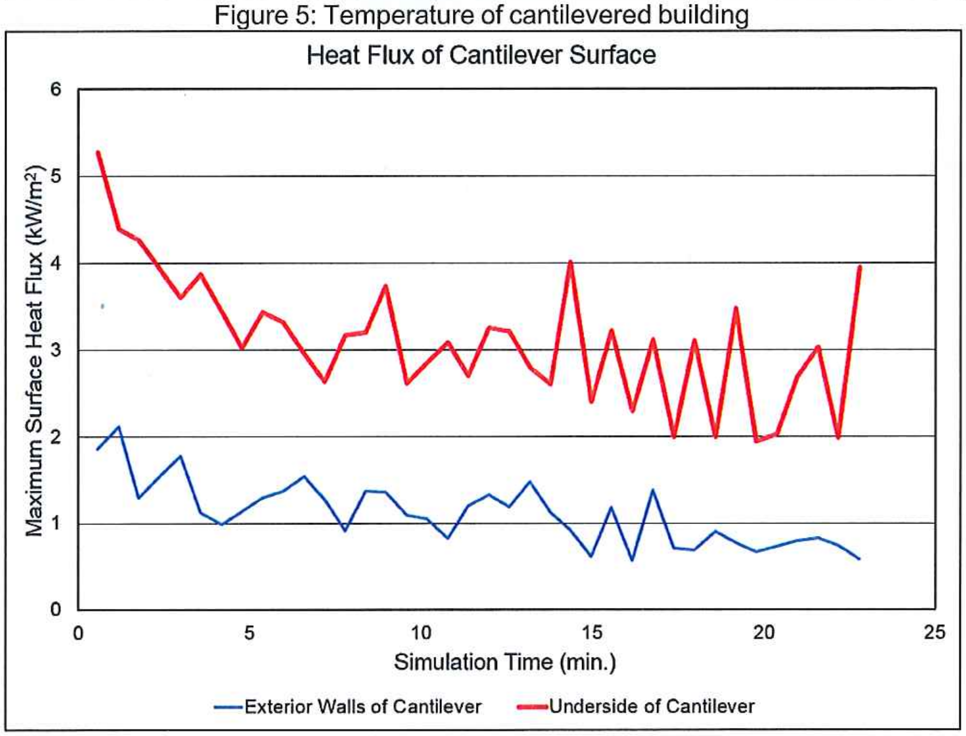

Figure 6. Heat flux on cantilevered building

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As expected, the underside of the cantilevered portion yields the highest values for temperature and heat flux illustrated by the table in Figure 7. The maximum surface temperature of the underside has a Factor of Safety of 537% when using the benchmark of 1000 °F, the temperature set by ASTM E-119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, for when structural steel becomes weakened by elevated temperatures, and the heat flux remains well below that needed to ignite ordinary combustibles.

	Maximum Heat Flux	Maximum Surface Temperature
Underside	5.27 kW/m^2	186.1 °F
Exterior Walls	2.59 kW/m^2	137.7 °F

Figure 7. Table of Results from CFD Simulation

Summary

The results of the analysis demonstrate that the proposed condition will meet 2014 NYCBC provisions for portions of a building that cantilever over existing buildings. In addition, the analysis shows that openings can be permitted in the exterior walls of the cantilevered building, without igniting combustible materials in the 217 West 57th building.

Please contact me at your convenience with any questions or comments.

Very truly yours,

Jason Daniels, LEED AP
Project Manager

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Kevin D. Morin, PE
Principal

JD:crw

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