

BACK TO BASICS: FIRE AND WATER

By Richard Schulte

Section 8.5 in NIST's investigation report on the collapse of the WTC 7 Building (NCSTAR 1-9 dated November 2008), titled "*Lessons from Historic High-Rise Fires*", contains the following statement:

"To determine whether there were aspects of the design and construction of the building [referring to the WTC 7 Building] that could have contributed to column failure by loss of lateral support, NIST considered other buildings that had survived multiple-floor fires, particularly those for which there is documentation on the performance of the structural system as well as characterization of the fire conditions. Three buildings were considered: One Meridian Plaza building in Philadelphia, the First Interstate Bank building in Los Angeles, and the eight story steel frame building used in some Cardington Tests in England. . ." (Page 331)

Excerpts from Section 8.5.5 in NCSTAR 1-9, titled "*Comparison Among Building Fires*", include the following:

"First Interstate Bank and One Meridian Plaza, both commercial office buildings, had fires that fully involved entire floors. . .By contrast, the fires in WTC 7 spread across several floors, but did not involve an entire floor at any time. . .Finally, the combustible load was likely similar in First Interstate Bank, One Meridian Plaza, and WTC 7, with the combustible load in One Meridian Plaza perhaps even greater as it was described subjectively as

"heavy". NIST therefore concluded that the fires in First Interstate Bank and One Meridian Plaza were at least as severe, and probably more severe, than fires in WTC 7." (Page 341)

"Three buildings were considered: One Meridian Plaza building in Philadelphia, the First Interstate Bank building in Los Angeles, and the eight story steel frame building used in some Cardington Tests in England. . ."

“If the fires in the First Interstate Bank, One Meridian Plaza, the Cardington Test Building and WTC 7 generated comparable gas temperatures, and of the four buildings cited only the WTC 7 building collapsed, the reason for the different outcomes likely lay in differences in the structural systems and the details of how the steel frames were constructed. Although all four buildings have been described as “steel frame structures,” comparison of construction features between the three buildings that did not collapse in an uncontrolled fire and WTC 7 revealed the following differences:

- *Simple framing connections for girders in WTC 7 vs. fully restrained moment connections of girders-to-columns in the One Meridian Plaza and First Interstate Bank buildings;*
- *Floor beam spans up to 16 m (52 ft) in WTC 7, rather than a maximum of 9 m (30 ft) in the other structures;*
- *Asymmetric framing in WTC 7 (providing one-sided lateral support to girders) rather than regular floor framing (providing two-sided lateral support to girders) in the other three structures (Section 8.6);*
- *Non-composite girders in WTC 7 rather than composite girders (presence or absence of shear studs) in two of the other three structures; and*
- *Seated connections used for girder-to-column connections in WTC 7; NIST found no evidence that such connections were used in the First Interstate Bank and Cardington buildings.” (Page 341)*

“. . .the reason for the different outcomes likely lay in differences in the structural systems and the details of how the steel frames were constructed.”

What NIST seems to have glossed over in their comparison between the fires in the First Interstate Bank Building (Los Angeles, 1988) and the One Meridian Plaza Building (Philadelphia, 1991) and the fire in the WTC 7 Building is the fact that the fire departments protecting Los Angeles and Philadelphia responded to and actively fought the fires utilizing hose streams, while the FDNY chose not to fight the fire in the WTC 7 Building, principally because there was no water supply in Lower Manhattan after the collapse of the WTC towers. To appreciate the difference between a fire in a high rise office building where hose streams are applied to the fire versus a fire where no attempt is made to apply hose streams on the fire, it is helpful to understand a little bit of the physics and chemistry of water.

The NIST report frequently referred to the combustible loading of the floors where fire occurred in the WTC 7 Building. This combustible loading is often referred to as “fire loading”. Fire loading usually refers to the term “equivalent weight of wood” where it is assumed that the heat content of wood is 8,000 British thermal units (Btu) per pound. Hence, the “wood equivalent” fire loading of various combustibles is computed by dividing the heat content of the material (expressed in Btu/pound) by 8,000.

The latent heat of vaporization of water, the amount of heat energy required to convert water at its boiling point to steam, is 970.4 Btu/pound of water. Given that the density of water is 62.4 pounds per cubic foot and a cubic foot is equivalent to 7.48 gallons, the amount of heat energy required to convert a pound of water (at 212°F) to steam is 8,095.3 Btu. In other words, the latent heat of vaporization of water is roughly 8,000 Btu per gallons.

What this means is that a gallon of water applied to a fire is capable of absorbing all of the heat energy generated by the burning of one pound of wood. Hence, a 100 gpm hose stream applied to a fire is capable of absorbing the heat generated by the burning of 100 pounds of wood in one minute or the burning of 6,000 pounds of wood every hour. Similarly, a 500 gpm master stream applied to a fire is capable of absorbing the heat generated by the burning of 500 pounds of wood every minute or the burning of 30,000 pounds of wood every hour. Of course, since not all of the water applied by a nozzle will reach the fire, the calculation above is only a rough calculation, but you get the idea.

Quite obviously, the application of hose streams on a fire has quite an effect on a fire in a building and the temperatures reached inside the building. Certainly, applying hose streams to a fire, versus not applying hose streams to a fire, will likely result in a major difference in the outcome of the fire.

To appreciate the difference between a fire in a high rise office building where hose streams are applied to the fire versus a fire where no attempt is made to apply hose streams on the fire, it is helpful to understand a little bit of the physics and chemistry of water.

Why did the WTC 7 Building collapse on September 11th, while the First Interstate Bank Building and the One Meridian Plaza Building remained standing? . . . The answer to that question is simply water.

Why did the WTC 7 Building collapse on September 11th, while the First Interstate Bank Building and the One Meridian Plaza Building remained standing? The answer is much simpler than NIST presumed. The answer to that question is simply water. Or to put it in more scientific terms-the latent heat of vaporization of water.

Usually, the simplest explanation to a scientific problem is the correct explanation. There was really no reason to spend millions of dollars on an investigation into why the WTC 7 Building collapsed.

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