



# Fire Protection

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## Facts Don't Matter

Should changes to the fire safety provisions contained in building codes have a technical justification or is an emotional reaction to an event a sufficient justification for making major changes to our construction codes? That sounds like a silly question, but time and time again, proponents of more restrictive code requirements have used emotional arguments as a means, and justification, for getting code changes approved. There is no more brazen example of this than the proponents of more restrictive high rise building requirements using the collapse of the World Trade Center (WTC) towers as a means to promote their agenda.

Two groups, the Skyscraper Safety Campaign and the Voices of September 11, have been advocating more restrictive high rise building requirements using the events of September 11 as their basis. Rather than advance technical arguments for the need for these changes, these groups' appeals have been, for the most part, purely emotional.

On June 24, 2002, in a public forum on the need for an investigation of the World Trade Center collapse, a statement made by a representative of the Skyscraper Safety Campaign included the following quote:

*"What we need is the boot end of a knee jerk reaction to expeditiously kick out the despicable building code provisions that allow 10 story buildings to be treated the same as 100 story buildings!"*

In that same public forum, a statement made by a representative of the Voices of September 11 group included the following quotes:

*"The Towers of the World Trade Center were death-traps. Fire, not planes, brought them down. I've heard the structural engineer and the builder speak with pride of the innovative design of the buildings — how they made them economically viable to build and to rent, by making their interior structure lightweight and open. They used trusses and bolts to hold the house of cards together.*

*"I wish the engineer and builder could have listened to my husband die, the way I did. I wish they could have heard the sound he made when those lightweight trusses melted and those flimsy bolts sheared ... and the floor fell out from underneath him. I wish that they could hear— just once— the sound that will haunt me forever."*

The collapse of the World Trade Center was indeed an

emotional event for the nation, but is the nation served by emotional statements such as these? Without proof, representatives of the Skyscraper Safety Campaign and the Voices of September 11 have referred to the present high rise building provisions included in the model codes used throughout the United States as "despicable" and referred to the construction of the World Trade Centers as "flimsy." These statements regarding the high rise building provisions and the construction of the World Trade Center towers are actually an indictment of the model building code development process and both the structural engineering

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and fire protection engineering professions. Should the structural engineering and fire protection engineering professions be considered negligent because these two professions failed to anticipate the attack on the World Trade Center and propose provisions in structural and fire safety codes which would have prevented (or, at least, further delayed) the collapse of the WTC towers? Similarly, should the model code groups and the National Fire Protection Association be considered to be negligent because the codes and standards these groups publish also failed to anticipate the attack on the World Trade Center and did not include provisions which would have prevented (or delayed) the collapse?

At present, an investigation of the World Trade Center towers collapse is proceeding under the auspices of the National Institute of Standards and Technology (NIST). The Web site for the Building and Fire Research Laboratory

*Continued page 10*

# Fire Protection

Continued from page 8

(BFRL) of NIST provides details on the goals and objectives of the investigation. The BFRL Web site indicates that one of the goals of the investigation is "to serve as the basis for...revisions to codes, standards, and practices." The BFRL Web site also indicates that one of the objectives of the investigation is to "identify, as specifically as possible, areas in building and fire codes, standards, and practices that are still in use and warrant revision."

The BFRL Web site also includes the following statements regarding the investigation:

*"The results of this investigation could stimulate major changes in both U.S. building and fire codes and in engineering practice, despite the unique design features of the buildings or circumstances under which they collapsed.*

*"The WTC Towers and WTC 7 are the only known cases of total structural collapse in high-rise buildings where fires played a significant role. These building collapses provide a unique source of information to understand the complexities associated with the dynamics of building fires and the collapse vulnerability of buildings to fires. Through the analysis of that information, the investigation will provide an excellent case study to apply and gain experience in the use of general methodologies for fire safety design and retrofit of structures."*

The above statements seem to indicate that the Building and Fire Research Laboratory has already concluded that the building codes currently in use in the United States are deficient based upon the events of September 11. This opinion appears to be based upon the view that the collapse of the World Trade Center was simply initiated by fire and, hence, an investigation into the collapse will yield a great deal of information about how large steel structures respond to fire. In my opinion, this view of the World Trade Center collapse fails to put the event in context.

While the collapse of the World

Trade Center towers was caused by fire, the entire event which culminated in the collapse of the towers was actually a "military-style" attack on the towers. The aircraft which struck the towers were "human-guided" missiles which carried incendiary materials (aviation fuel). In other words, the attack on the World Trade Center towers was really no different from the kamikaze attacks on American naval vessels in the Pacific theater in World War II. Clearly, the objective of the hijackers was to cause as much physi-

proofing provided for at least some of the undamaged steel members. This damage to the fireproofing, of course, reduced the fire resistance of the structure even further. As the fire which erupted reduced the structural capacity of the members with damaged fireproofing, the stress on the remaining structural members increased further until stress eventually overwhelmed the vertical supports on an entire floor and the upper portions of the tower structures started to collapse. This, in turn, initiated the progressive collapse

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cal damage and loss of life in the World Trade Center towers as possible. Given this perspective, it is my opinion that the collapse of the World Trade Center towers was simply the result of a successful military assault on the buildings and that we have little to learn from the incident, unless we expect our large commercial building structures to be designed and constructed to resist destruction when attacked by a foreign military.

The impact of the aircraft subjected the WTC tower structures to major damage prior to the fire. Since the fire resistance of a structural element in a building is dependent upon the stress to which the structural element is subjected, the damage to columns in the building caused by the aircraft impact caused the stress in some of undamaged columns to increase. Hence, the structural fire resistance of some of the remaining undamaged columns was reduced by the structural damage caused by the impact. In addition to the reduced fire resistance caused by the increase in stress, the impact of the planes certainly damaged the fire-

of the entire tower structures.

In a typical fire in a sprinklered high rise building, the sprinkler system will control or extinguish a fire. Typically, ceiling temperatures generated by a fire in an office building (with ceilings which are 8 or 9 feet high), will be 800 F or less prior to the operation of the sprinklers. Once the sprinklers operate, the temperatures at the ceiling rapidly decline. Thus, the operation of the sprinkler system will not only control or extinguish a fire, but also provide protection for the building structure. In the World Trade Center incident, the sprinkler system piping was, no doubt, damaged as the aircraft slid through the buildings. More than likely, both the overhead (horizontal) piping system and the sprinkler risers (vertical piping) were damaged. Given this, the protection ordinarily provided by a sprinkler system was completely compromised by the impact of the aircraft.

If we assume that somehow we could protect both the horizontal and vertical supply piping for a sprinkler

Continued on page 14

# Fire Protection

*Continued from page 10*

system from damage from the impact of aircraft, the sprinkler system protecting the World Trade Center towers would still have failed. Sprinkler systems are designed based upon the assumption that only a small number of sprinklers on a single floor in the building will operate (typically 10 or fewer sprinklers for a light hazard occupancy). The aviation fuel which ignited caused large simultaneous fires on more than one floor in each tower and would have caused sprinklers on multiple floors to operate. The fireball which erupted from the buildings would likely have operated almost all of the sprinklers on one or more floors. Given this, the sprinkler system protecting each of the towers would have failed even if the sprinkler supply piping had somehow managed to survive the impact of the aircraft.

The impact of the aircraft no doubt

as to the domestic water supply systems) in the World Trade Center towers more than likely also had an effect on the municipal water supply available at the site, at least for a period of time. With 6-inch (or perhaps 8-inch) risers broken in both of the towers, literally thousands of gallons per minute of water (which could have been used for firefighting purposes) discharged from the damaged systems. This flow would have continued until the control valves for the systems were shut down. The water flowing from the damaged sprinkler and standpipe systems would not only have diminished the water supply available for use by the fire department, but more than likely would have rendered the sprinkler systems in the adjacent buildings ineffective.

The FEMA report on the World Trade Center towers collapse issued in

system and the egress system serving the towers all compromised by the initial impact of the aircraft and the building structural system exposed to a fire on multiple floors fueled by aviation fuel, this incident can hardly be considered to be a typical fire incident in a high rise building. What can we learn from the collapse of the World Trade Center towers? The answer to that question should be obvious. If every fire protection system in a steel-framed building is compromised and a massive fire (which is too large to be controlled by the manual firefighting) occurs in the building, there is a very high probability that a structural collapse will eventually occur.

Certainly, we presently have the technical capability to delay (but, not prevent) the collapse of tall buildings in the event of a similar occurrence. However, there are some important questions which should be answered before we make a decision to incorporate this technical capability into the design of our buildings. These questions are:

- What are the costs?
- What are the benefits?
- What is the risk?

How do we structurally design a steel-framed building to resist collapse under the conditions to which the World Trade Center towers were exposed on the morning of September 11? The answer to that question is relatively simple — massive over-design of the structural systems. Increasing the mass of the steel structural members and reducing the stress to which each member is subjected will increase the inherent fire resistance of the structure (without fireproofing). Can we afford to massively over-design the structural system for a building? My guess is that the general answer to this question is no, but the answer probably depends on the height of the building. More than likely, this approach will limit the height of steel-framed buildings.

What are the benefits of structurally over-designing buildings to resist a

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also damaged the supply piping for the standpipe systems provided in the towers. Even if this piping had managed to survive the aircraft impact, the standpipe system would have been rendered ineffective by the ignition of the aviation fuel and the spread of fire to multiple floors in the building. In the 1980s, NFPA 14 limited the required water supply for a standpipe system to a maximum of 2,500 gpm. The maximum required water supply for a standpipe system was reduced in the 1990s to 1,250 gpm. Neither a standpipe water supply of 1,250 gpm, nor a water supply of 2,500 gpm, would have been adequate to control the enormous fire created by the ignition of the aviation fuel.

The damage to the sprinkler and standpipe system installations (as well

May 2002 indicates that most of the fatalities occurred on or above the floors where the aircraft impact occurred. From this fact it can be deduced that the evacuation routes serving these floors, the stairs and elevators, were severed by the aircraft. Even if the stairs and elevator hoistways had been enclosed in masonry enclosures (which would develop a 2- or 3-hour fire resistance) as suggested by some (rather than gypsum wallboard enclosures), the masonry enclosures would have also been severed by the aircraft impact. Masonry enclosures are simply no match for a Boeing 767-200ER aircraft (weighing approximately 274,000 pounds) traveling at 470 miles per hour at impact.

With the structural fire protection, the sprinkler system, the standpipe

*Continued from page 16*

# Fire Protection

Continued from page 14

September 11-type attack? In just one word, none. Designing a building to resist collapse under the conditions the World Trade Center towers were subjected to on the morning of September 11 only means that the building will resist collapse under the specific conditions which occurred on that morning. Terrorists will still be able to cause the collapse of a “terrorist-resistant” steel-framed tower building simply by using a larger aircraft, by striking the building with more than one aircraft or by using the same size aircraft and striking the building at a higher speed. Of course, structurally over-designing the building to resist an occurrence similar to the September 11 attack will not make a high rise building immune to a chemical, biological or radiological attack. Finally, structurally over-designing the

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building to resist a scenario similar to the September 11 attack does not address the issue of attack with military ordinance with far greater destructive capability than commercial aircraft. Given that our capability to destroy military targets is constantly improving, any “terrorist-resistant” structural design of a high rise (“target”) building will be obsolete by the time the building is ready for occupancy.

Finally, what are the risks that a September 11-style attack will be repeated? Since we can’t predict the future, your guess is as good as mine. We can state with absolute certainty, however, that more people die in traffic accidents in the United States in one month than died in the collapse of the World Trade Center towers. We can also state with absolute certainty that more than 40,000 Americans lost their lives as a result of traffic accidents in the year following September 11, 2001. At this moment in time, we can say that the risk of becoming a traffic fatality statistic is far greater than the risk of dying as a result of a terrorist attack in the United States. Given this, it is my opinion that the American public should certainly be asking why we are spending \$16 million studying the collapse of the World Trade Center towers, rather than spending this money on

preventing traffic fatalities. (No additional research is required to reduce the number of highway fatalities. All we need to do is simply enforce our traffic laws.) Each of the 40,000 Americans who will die in traffic accidents in this next year will be missed just as much by their relatives as the 3,000 Americans who died on September 11. □

## **About the Author**

*Richard Schulte is a 1976 graduate of the fire protection engineering program at the Illinois Institute of Technology. His experience includes work with the Insurance Services Office of Illinois, the Joint Commission on the Accreditation of Healthcare Organizations, Building Officials and Code Administrators, International, Grinnell Fire Protection Systems Company and Schirmer Engineering Corporation. Mr. Schulte formed Schulte & Associates in 1988. His consulting experience includes work on the Sears Tower, the Minneapolis Convention Center, the Philadelphia Convention Center, Milwaukee Center, New Orleans Center and the New Orleans Distribution Center. Mr. Schulte has also acted as an expert witness in the litigation involving the fire at the New Orleans Distribution Center. He can be contacted by sending email to [rschulte@plumbingengineer.com](mailto:rschulte@plumbingengineer.com).*