Fire Protection

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Reasonable High Rise Fire Safety

The editors of *Plumbing Engineer* have received quite a bit of mail regarding the columns on the collapse of the World Trade Center. One of these letters commenting on the column regarding the use of emotional arguments as a justification for more restrictive fire codes (December, 2002 issue) so superbly summarizes the issues that it is worth studying. This letter reads as follows:

"Thank you so much for your clear thinking regarding 'design standards' and what should, and should not, affect how they are written and modified. I am always amazed at how engineers, who should be 'kings of clear thinking,' allow themselves to be led astray by arguments that have nothing to do with facts. Maybe what we are actually finding out (unfortunately) is how political the code writing process in this country has become.

"Sadly, the $16 million being spent to 'study' this issue [the collapse of the World Trade Center] is only a tiny fraction of the billions being invested in 'Homeland Security,' the entirety of which seems to be driven by the same emotional response as the study of the WTC collapse. And in the same way, and for the same reasons, almost all of this money is being spent without any actual benefit to the citizens of this great nation.

"It seems that we all need to recognize that life is a risk and that

(1) getting that risk to zero is not possible, and

(2) getting that risk to approach zero is cost prohibitive, and

(3) recognizing 1 & 2 we should all spend a little time thinking about what 'reasonable' safety actually is."

Interesting enough, the 2000 edition of the *Life Safety Code* (NFPA101) addresses the issue of "reasonable (fire) safety" in chapter 4. Section 4.1.1 in the *Life Safety Code* states that "the goal of this Code is to provide an environment for the occupants that is reasonably safe from fire and similar emergencies ..."

The actual definition of the term "reasonably safe" (in general terms) is found in section 4.5.2 of the *Life Safety Code*. This section reads as follows:

> "**Appropriateness of Safeguards.** Every building or structure shall be provided with means of egress and other safeguards ... appropriate to the individual building or structure with regard to the following:
> (1) Character of the occupancy
> (2) Capabilities of the occupants
> (3) Number of persons exposed
> (4) Fire protection available
> (5) Height and type construction of the building or structure
> (6) Other factors necessary to provide occupants with a reasonable degree of safety."

Section 4.3.1 in the *Life Safety Code* also provides a statement of the primary design assumption on which all of the prescriptive requirements contained in Code are based:

> "**Single Source Fire.** The protection methods of this Code assume a single source fire."

[Note: Although the *Life Safety Code* and the *NFPA Building Code* are the only model codes used in the United States which explicitly state the design assumptions on which the provisions of the code are based, the three regional model building codes and the *International Building Code* are also based upon these same assumptions. Given that, this discussion is also applicable to the other model building codes used in the United States.]

"... the goal of this Code is to provide an environment for the occupants that is reasonably safe from fire and similar emergencies ..."

If we look at the World Trade Center towers collapse as simply fire incidents (rather than as missile attacks on the buildings that they actually were), it is obvious that a number of the premises on which the provisions contained in the *Life Safety Code* are based were violated. First, the provisions of the *Life Safety Code* assume a "single source fire." The impact of the aircraft caused large simultaneous fires on multiple floors in each of the World Trade Center towers. Given that, we can conclude that the primary design assumption of a "single source fire" was violated. Hence, it should be obvious that the provisions of the Code would no longer be adequate to provide protection for the occupants of the towers.

Second, the *Life Safety Code* indicates that the protection for a building should be based upon the "character of the occupancy" of the building. Both World Trade Center towers

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were office buildings. Given this fact, it would be expected that the structural systems in the towers would be exposed to a fire with a maximum intensity equivalent to a one hour exposure to the ASTM E119 time-temperature curve (assuming that the sprinkler systems protecting the buildings failed to operate). Further, given the “character of the occupancy,” it would be expected that large flammable liquid-fueled fires would not occur in the building, let alone large simultaneous flammable liquid-fueled fires on multiple floors of the building. In other words, the fire which occurred in each of the towers was outside the “character of the occupancy” of an office building.

Third, the *Life Safety Code* indicates that the protection for a building should be based upon the capabilities of the occupants. More than likely, occupants on the floors of impact who managed to survive the initial impact were maimed. This being the case, it can be stated that the impact of the aircraft altered the egress capabilities of the occupants on the floors where the impact occurred.

Fourth, the *Life Safety Code* indicates that the protection required for a building should be based upon the number of people potentially exposed to the fire. With a single source fire, the number of people initially exposed to a fire and the combustion products generated by the fire would typically be limited to the occupants of the floor of fire origin. In the case of the World Trade Center towers, the occupants of multiple floors were instantaneously exposed to large flash fires and the combustion products generated by these fires.

Should the supply piping for sprinkler and standpipe system protecting every high rise building be designed to prevent damage from the impact of an aircraft?

Fifth, the *Life Safety Code* indicates that the protection required for a building should be based upon the fire protection provided for the building. Each of the World Trade Center towers was protected by a sprinkler system. Because the upper floors of each of the towers were offices, the sprinkler systems protecting the upper floors of each building would have been designed to protect a light hazard occupancy. Because sprinkler systems are designed based upon the assumption that only a few sprinklers will operate on a single floor, the sprinkler system protecting each of the towers would have failed, even if the supply piping for the sprinkler systems had somehow survived the impact of the aircraft intact.

Given all the violations of the basic premises of the *Life Safety Code* (and the other model codes used in the United States), a large loss of life would have been expected in the fires in the World Trade Center towers, even if the towers had not collapsed.

Subsequent to the collapse of the World Trade Center, some in the fire protection field have argued that the high rise provisions contained in the building codes used in the United States are inadequate. If you count yourself among those who believe that this is the case, then you should be able to provide an answer to the following questions:

1. Should the structural systems of every high rise building be protected by fireproofing materials adequate to withstand the exposure of an uncontrolled flammable liquids fire? If so, how large of a flammable liquids fire should be anticipated?
2. Should the structural fireproofing materials provided for every high rise building be capable of resisting damage when struck by an aircraft? If so, how large of an aircraft and at what speed is the aircraft

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flying at the time of impact with the structural fireproofing?

3. Should the supply piping for sprinkler and standpipe system protecting every high rise building be designed to prevent damage from the impact of an aircraft? If so, how large of an aircraft and at what speed is the aircraft flying at the time of impact with the supply piping?
4. Should every sprinkler system protecting a high rise building be designed to control a large flammable liquids fire? If so, should the sprinkler design assume that a flammable liquids fire only occurs on one floor or more than one floor simultaneously?
5. Should every standpipe system protecting a high rise building be designed to be adequate to control a large flammable liquids fire? If so, how large of a flammable liquids fire should be assumed in the standpipe system design? And if so, should the standpipe system design assume that a flammable liquids fire only occurs on one floor or more than one floor simultaneously?
6. Should exit stair enclosures in every high rise building be designed to resist damage caused by the impact of an aircraft? If so, how large of an aircraft and at what speed is the aircraft flying at the time of impact with the exit stair enclosure?
7. Should the doors which provide access to the exit stair enclosures in every high rise building also be designed to resist damage caused by the impact of an aircraft? If so, how large of an aircraft and at what speed is the aircraft flying at the time of impact with the stair doors? And if so, how will the occupants of the building be able to open the stair doors (given the weight of the doors required to resist the damage of a high speed aircraft impact)?

Of course, all of these questions are predicated on the assumption that the building structure itself will not be damaged by the impact of an aircraft. If it is assumed that the building structure is damaged by the impact of an aircraft, then the design of the structural fireproofing, sprinkler and standpipe systems and exit enclosures is made all the more complicated.

Actually, it has been hard to keep a straight face as I have been writing the questions above. Perhaps the fire protection professionals who think we need more restrictive high rise provisions (based upon the World Trade Center towers collapse) "should ... spend a little [more] time thinking about what 'reasonable'safety actually is." □

About the Author

Richard Schulte is a 1976 graduate of the fire protection engineering program at the Illinois Institute of Technology. After working in various positions within the fire protection field, he formed Schulte & Associates in 1988. His consulting experience includes work on the Sears Tower and numerous other notable structures. He 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.

This and Mr. Schulte's several previous columns comprising a series on the World Trade Center collapse can be downloaded (in PDF format) from the Plumbing Engineer Web site, www.plumbingengineer.com. They are located in the "Resources" section.

