The Report on the World Trade Center Incident: A Critique

S ubsequent to the collapse of the twin towers of the World Trade Center (WTC) on the morning of September 11, 2001, the Federal Emergency Management Agency (FEMA) in conjunction with the Structural Engineering Institute of the American Society of Civil Engineers (ASCE) investigated the incident. FEMA’s report, titled the “World Trade Center Building Performance Study: Data Collection, Preliminary Observations, and Recommendations,” was issued in May, 2002.

The following is intended to be a brief synopsis of the incident, as well as an analysis of some of the report’s recommendations relating to fire protection and fire safety. The report in its entirety is available at the FEMA Web site (www.fema.gov). The URL of the report is www.fema.gov/library/wtcstudy.shtml.

The incident

On the morning of September 11, 2001, American Airlines Flight 11 bound for Los Angeles departed from Logan International Airport in Boston at 7:59 a.m. (EDT). Forty-seven minutes later, at 8:46 a.m., the plane slammed into the north face of the north tower of the World Trade Center in New York. One hour and 43 minutes later, at 10:29 a.m., the north tower collapsed.

On that same morning, United Airlines Flight 175, also bound for Los Angeles, departed from Logan International Airport at 8:14 a.m. (EDT). Forty-nine minutes later, at 9:03 a.m., this airplane slammed into the south face of the south tower of the World Trade Center. Fifty-six minutes later, at 9:59 a.m., the south tower collapsed.

Both airplanes that struck the World Trade Center towers were Boeing 767-200ER aircraft. The American Airlines airplane struck the north tower between floors 94 and 98, while the United Airlines airplane struck the south tower between floors 78 and 84. It was estimated the speed of the plane that struck the north tower was 470 miles per hour at impact, while the speed of the plane that struck the south tower was 590 miles per hour at impact.

The population of the World Trade Center complex, which included the two towers and five other buildings, was estimated to be approximately 58,000 people on the morning of September 11. The death toll from this incident exceeded 3,000 people, including 2,830 building occupants, 157 passengers and crew on the two airplanes and 343 public safety personnel. According to the study, almost all of the occupants of the towers who were located on floors below the airplane impact areas were able to safely evacuate.

Executive summary

The executive summary provided in the report provides an excellent overview of the report. The following excerpts are from the executive summary:

• “... In total, 10 major buildings experienced partial or total collapse and approximately 30 million square feet of commercial office space was removed from service, of which 12 million belong to the WTC Complex.

“The purpose of this study was to examine the damage caused by these events, collect data, develop an understanding of the response of each affected building, identify the causes of observed behavior, and identify studies that should be performed...”

• “… Recommendations are presented for more detailed engineering studies, to complete the assessments and produce improved guidance and tools for building design and performance evaluation.

“As each tower was struck, extensive structural damage, including localized collapse, occurred at the several floor levels directly impacted by the aircraft. Despite this massive localized damage, each structure remained standing. However, as each aircraft impacted a building, jet fuel on board ignited. Part of this fuel immediately burned off in the large fireballs that erupted at the impact floors. Remaining fuel flowed across the floors and down elevator and utility shafts, igniting intense fires throughout upper portions of the buildings. As these fires spread, they further weakened the steel-framed structures eventually leading to total collapse.

“The collapse of the twin towers astonished most observers, including knowledgeable structural engineers, and, in the immediate aftermath, a wide range of explanations were offered in an attempt to help the public understand these tragic events...”

• “…FEMA and ASCE formed a Building Performance Study (BPS) Team consisting of specialists in tall building design, steel and connection technology, fire and
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blast engineering, and structural investigation and analysis.”

• “... The fact that the structures were able to sustain this level of damage and remain standing for an extended period of time is remarkable and is the reason that most building occupants were able to evacuate safely.”

• “... the structures were subjected to a second, simultaneous severe loading event in the form of the fires caused by the aircraft impacts.”

• “... However, as the burning jet fuel spread across several floors of the buildings, it ignited much of the buildings’ contents, causing simultaneous fires across several floors of both buildings. The heat output from these fires is estimated to have been comparable to the power produced by a large commercial power generating station.”

• “It was not the purpose of this study to assess the code-conformance of the building design and construction, or to judge the adequacy of these features...

“The study did not reveal any specific structural features that would be regarded as substandard, and, in fact, many structural and fire protection features of the design and construction were found to be superior to the minimum code requirements.”

• “During the course of this study, the question of whether building codes should be changed in some way to make future buildings more resistant to such attacks was frequently explored. Depending on the size of the aircraft, it may not be technically feasible to develop design provisions that would enable all structures to be designed and constructed to resist the effects of impacts by rapidly moving aircraft, and the ensuing fires, without collapse. In addition, the cost of constructing such structures might be so large as to make this type of design intent practically infeasible.

“Although the attacks on the World Trade Center are a reason to question design philosophies, the BPS Team believes there are insufficient data to determine whether there is a reasonable threat of attacks on specific buildings to recommend inclusion of such requirements in building codes...

“... Future building code revisions may be considered after the technical details of the collapses and other building responses to damage are better understood.”

• [Referring to buildings other than the towers] “... the collapse of these [other] structures is particularly significant in that, prior to these events, no protected steel-frame structure, the most common form of large commercial construction in the United States, had ever experienced a fire-induced collapse. Thus, these events may highlight new building vulnerabilities, not previously believed to exist.”

• “The issues identified from this study of damaged buildings in or near the WTC site have been summarized into the following points: “a. ...

“b. Fireproofing needs to adhere under impact and fire conditions that deform steel members, so that the coatings remain on the steel and provide the intended protection.

“c. Connection performance under impact loads and during fire loads needs to be analytically understood and quantified for improved design capabilities and performance as critical components in structural steel frames.

“d. Fire protection ratings that include the use of sprinklers in buildings require a reliable and redundant water supply. If the water supply is interrupted, the assumed fire protection is greatly reduced.

“e. Egress systems currently in use should be evaluated for redundancy and robustness in providing egress when building damage occurs, including the issues of transfer floors, stair spacing and locations, and stairwell enclosure impact resistance.

“f. Fire protection ratings and safety factors for structural transfer systems should be evaluated for their adequacy relative to the role of transfer systems in building stability.”

“Interaction of Structural Elements and Fire. The existing prescriptive fire resistance rating method (ASTM E119) does not provide sufficient information to determine how long a building component in a structural system can be expected to perform in an actual fire. A method of assessing performance of structural members and connections as part of a structural system in building fires is needed for designers and emergency personnel.

“The behavior of the structural system under fire conditions should be considered as an integral part of the structural design. Recommendations are to:

“Develop design tools, including an integrated model that predicts heating conditions produced by the fire, temperature rise of the structural component, and structural response.

“Provide interdisciplinary training in structures and fire protection for both structural engineers and fire protection engineers.

“Performance criteria and test methods for fireproofing materials relative to their durability, adhesion, and cohesion when exposed to abrasion, shock, vibration, rapid temperature rise, and high-temperature exposures need further study.”

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Analysis

While the FEMA report does an excellent job of documenting and explaining the events surrounding the destruction of the World Trade Center towers and the adjacent buildings, the report fails to provide an in-depth perspective on the event itself. Obviously, with an event of this magnitude (with the collapse of the towers shown repeatedly on television), and the wave of patriotism sweeping the country, it is easy to understand why FEMA shied away from including such a perspective.

The attack on the World Trade Center and the collapse of the towers was an event that is unique in history. While a study documenting the event is of general interest to the structural engineering and fire protection engineering fields, as well as to the public at large, the question which begs not only to be asked, but also answered, is whether or not this one event should affect the design and engineering of buildings, particularly tall buildings. While the FEMA report briefly addresses this question (and concludes that there is insufficient data available to make a recommendation), an in-depth discussion of this issue is crucial and should have been included in the report.

Should building codes be modified to address building safety in the event of a terrorist attack on a building? If the answer to this question is yes, then the follow-up to this ques-

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“Fire Protection Engineering Discipline. The continued development of a system for performance-based design is encouraged. Recommendations are to:

- “Improve the existing models that simulate fire and spread in structures, as well as the impact of fire and smoke on structures and people,
- “Improve the database on material burning behavior.”

“Building Evacuation. The following topics were not explicitly examined during this study, but are recognized as important aspects of designing buildings for impact and fire events. Recommendations for further study are to:

- “Perform an analysis of occupant behavior during evacuation of the buildings at WTC to improve the design of fire alarm and egress systems in high-rise buildings.
- “Perform an analysis of the design basis of evacuation systems in high-rise buildings to assess the adequacy of the current design practice, which relies on phased evacuation.
- “Evaluate the use of elevators as part of the means of egress for mobility-impaired people as well as the general building population for the evacuation of high-rise buildings. In addition, the use of elevators for access by emergency personnel needs to be evaluated.”

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The structural loads that would be applied to a building in an incident similar to the attack on the World Trade Center towers would depend upon the size of plane that would strike the building, as well as the speed of the plane at impact. In addition to these two parameters, the location of the impact, as well as the quantity of fuel onboard the aircraft would have an effect on the potential damage to the structural system of a building. Simply because we design a building to resist collapse under the conditions which occurred in the attack on the World Trade Center does not mean that a building could not be destroyed by using a larger airplane or by striking the building at a higher speed. In addition, why limit the damage to a building to a strike by a single plane? The potential “what if” scenarios involving only airplanes are infinite, and why limit the “what if” terrorist attack scenarios to building impacts to airplanes?

The fact is that if terrorists want to accomplish the destruction of a building, there will always be a means to accomplish their goal, regardless of how “hardened” we design and construct our buildings. In other words, there is no building that can be constructed now, or in the future, that will be immune to every form of attack. Given this fact, is it really worth the resources to discuss how to make our building structures “terrorist-resistant,” and then incorporate these concepts into building codes? Or would the public be better served by focusing all of our resources on preventing such attacks instead? The answer to that question seems obvious. To be fair, the report suggests that our first line of defense against attacks similar to the attack on the World Trade Center should be airline security. But by providing recommendations for further study of certain engineering issues, the FEMA report tacitly endorses the concept that buildings can be made “terrorist-resistant” by better (and, of course, more costly) building construction.

One of the recommendations included in the report is that “fire protection ratings that include the use of sprinklers in buildings require a reliable and redundant water supply.” Essentially this recommendation indicates that reductions in fire ratings for the structural system of high rise buildings should not be permitted when a sprinkler system is installed in the building, unless the standard water supply typically provided for a sprinkler system is modified to increase the water supply reliability. The unstated assumption in this recommendation is that the standard water supply provided for sprinkler systems is unreliable, however, our real world experience with sprinkler installations in high rise buildings indicates that this is not the case. Of course, the sprinkler system failed in the World Trade Center incident, hence this recommendation seems to be logical. However, can anyone imagine the design of a sprinkler system that would not have failed at the World Trade Center? Obviously, there is no piping system that can be installed economically which would resist the impact of a large airplane traveling at a high rate of speed. Just exactly what is a reliable water supply for a sprinkler system in the context of the World Trade Center incident?

From a theoretical standpoint, a requirement for redundant water supplies for a sprinkler installation seems logical in order to reduce the required fire ratings of the structural frame of a building. Again, our real world experience over the past 25 years indicates that providing a redundant water supply is unnecessary. A single tragic event, where providing a redundant water supply wouldn’t have made any difference anyway, shouldn’t change what our real world experience tells us.

The report also states that “the existing prescriptive fire resistance rating method (ASTM E119) does not provide sufficient information to determine how long a building component in a structural system can be expected to perform in an actual fire.” The report goes on to recommend that “a method of assessing performance of structural members and connections as part of a structural system in building fires is needed for designers and emergency personnel.” The statement that the ASTM E119 fire test does not provide information on how a structural system will perform in an actual fire is correct, however, is it absolutely imperative that we have this information? Obviously, the performance of a structural system under fire conditions depends upon the fire conditions. No one could have anticipated the fire conditions to which the World Trade Center towers would be exposed to on September 11 prior to that date. Even if we had the capability to determine the actual fire performance of the structural system of these buildings under fire conditions, who would have modeled the fire exposure to the World Trade Center towers assuming the structural damage which occurred prior to the fire exposure? Again, our real world experience with fires in steel structures indicates that our depth of knowledge at present is adequate. The report, in essence, acknowledges this fact with the statement that “the collapse of these structures is particularly significant in that, prior to these events, no protected steel-frame structure, the most common form of large commercial construction in the United States, had ever experienced a fire-induced collapse” until September 11.

The report also includes a recommendation that “egress systems currently in use should be evaluated for redundancy and robustness in providing egress when building damage occurs, including the issues of transfer floors, stair spacing and locations, and stairwell enclosure impact resistance.” Again, our real world experience with building fires indicates that the egress system design practices presently in use are adequate in all but the most extreme cases. The FEMA report,
in effect, acknowledges this with the statement that “almost everyone in WTC 1 and WTC 2 [the towers] who was below the [airplane] impact areas was able to safely evacuate the build-

ings, due to the length of time between the impact and collapse of the individual towers.” Most who observed the events would agree that this fact is pretty remarkable, but what about the building occupants located above the impact? The recommendation regarding “stairwell enclosure impact resistance” is intended to address this prob-

lem. However, it is hard to imagine the stair enclosure construction which would be capable of protecting the integrity of the exit stair enclosures from the impact of a Boeing 767 aircraft flying at 470 miles per hour, sub-

sequently followed by an exposure to an enormous flammable liquids fire. Certainly, the practicality of a recommendation regarding further study of the impact resistance of exit stair enclosures is questionable.

Overall, the recommendations for further fire engineering studies seem more grounded in abstract research than in practicality. This is not unex-

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The incident at the World Trade Center on September 11 was an emotional event, but government policy on funding research should not be based upon emotion.

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Opposing Viewpoints on the WTC Collapse

The fire protection column in the August, 2002 Plumbing Engineer (page 8) reviewed the Federal Emergency Management Agency (FEMA) report titled “World Trade Center Building Performance Study: Data Collection, Preliminary Observations, and Recommendations” issued in May, 2002. The August column included a brief timeline of the events and excerpts from the executive summary of the FEMA report, as well as criticism of some of the report’s recommendations. While the FEMA report is the “official” report on the attack on the World Trade Center, other organizations and individuals have also addressed this incident. This month’s column addresses some of the “unofficial” commentary on the World Trade Center incident.

On the morning of September 11, 2001, each of the World Trade Center (WTC) towers was struck by commercial aircraft intentionally flown into the buildings. The impact of the aircraft caused extensive damage to the structural systems of each of the buildings, however, each tower remained standing. Immediately following the impact, fuel onboard the aircraft ignited and a massive fire ensued in each tower. The fires caused additional damage to the structural systems of the towers and within a relatively short time both towers collapsed. The north tower collapsed 103 minutes after the aircraft struck the building, while the south tower collapsed 56 minutes after being struck by the aircraft.

As might be expected, the collapse of the two towers has generated considerable discussion as to whether the high rise provisions presently contained in building codes are adequate to protect both the occupants of the building and emergency response personnel. There are a number of organizations pressing for more restrictive code requirements. One of these organizations is the Skyscraper Safety Campaign (SSC), an organization of families of firefighters, emergency personnel and civilians who died in the attack on the World Trade Center. Another organization is the Voices of September 11, an organization of family members of victims of the attack on the World Trade Center, the Pentagon and also passengers on board the hijacked airliner that crashed in Pennsylvania.

The Web site for the Skyscraper Safety Campaign (www.skyscrapersafety.org) indicates that the goals of the organization are as follows:

• “To have a Federal Comprehensive Investigation, with subpoena power, into the collapse of the WTC, including design, construction, evacuation procedures and fire fighting techniques.
• “To reform Building Codes in New York City and nationwide, thereby safeguarding Firefighters, as well as persons who must live and work in skyscrapers.
• “To reform codes groups by allowing the Fire Service to have more input into writing Building Codes. We call for at least 50% of all codes groups to be composed of representatives of the Fire Service and the academic field of Fire Science Engineering. (Existing groups are composed of builders, developers, financiers and bureaucrats who know little about Fire and Life Safety.)
• “To prohibit building construction by the Port Authority that is immune from City and State Building Codes, such as was the case with the WTC. To require the Port Authority of New York and New Jersey to rebuild the WTC according to the New York State International Code, and not ‘its own codes.’
• “To insure that all future WTC development be characterized by quality, safety, security and code compliance.”

The SSC Web site also includes transcript of the testimony given at various hearings. The following is an excerpt from testimony of Ms. Monica Gabrielle, co-chairperson of the SSC, on June 24, 2002:

“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!
“’We need to ensure that new high rise buildings are structures of quality, safety, and security ... not the same old bare minimum codes and structural requirements. And we need to have it on the fast track!”

The Voices of September 11 Web site (www.voicesofsept11.org) also contains transcripts of meetings. The following is an excerpt from testimony by Ms. Beverly Eckert, also on June 24, 2002:

“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

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heard the sound he made when those lightweight trusses melted and those flimsy bolts sheared ... and the floor fell out from under -neath him. I wish that they could hear—just once—the sound that will haunt me forever.”

Another excerpt from remarks by Ms. Eckert on August 13, 2002 is as follows:

“And it also needs to be acknowledged that the efforts of the firefighters trying to rescue the occupants were cut short because of the premature collapse of the building. And that happened because the building lacked adequate fire-proofing, had limited fire suppression systems and was constructed with trusses and brackets that made the building little better than a house of cards.”

Another Web site which addresses the collapse of the World Trade Center is the Web site of Chief Vincent Dunn (vincentdunn.com). Chief Dunn, a former deputy chief with the New York Fire Department, writes:

“The computer has allowed engineers to reduce the mass of a structure by its ability to more accurately determine the load bearing capability of structural framework. Years ago before the computer, builders were not sure of a structural elements load bearing capability, so they over built by using a so called ‘safety factor.’ This built in safety factor could result in a structure with twice the required load bearing strength. Because of computer calculation this no longer occurs. The older buildings use[d] to have built in a so called ‘safety factor’ of two-to-one. Not so today, if the building code requires a load bearing fac-

The fact that the towers were able to absorb these tremendous blows without immediately collapsing is actually a testament to the resiliency of the structural systems of these two buildings.

fire suppression systems and was constructed with trusses and brackets that made the building little better than a house of cards.”

Chief Dunn also writes:

“Since the end of WWII builders designed most of the concrete from the modern high-rise constriction. First concrete they eliminated was the stone exterior wall. They replace them with the ‘curtain walls’ of glass, sheet steel, or plastics. This curtain wall acted as a lightweight skin to enclose the structure from the outside elements. Next the 8-inch thick concrete floors went. They were replaced with a combination of 2 or 3 inches of concrete on top of thin corrugated steel sheets. Next the masonry enclosure for stairs and elevators were replaced with several layers of sheet rock. Then the masonry smoke proof tower was eliminated in the 1968 building code. It contained too much concrete weight and took up valuable floor space. Then the solid steel beam was replace by the steel truss. And finally the concrete and brick encasement of steel columns girders and floor supports was eliminated. A light-weight spray-on coating of asbestos or mineral fiber was sprayed over the steel. This coating provided fireproofing. After asbestos was discovered hazardous vermiculite or volcanic rock ash substance was used as a spray-on coating for steel. Outside of the foundation walls and a thin 2 or 3 inches of floors surface, concrete has almost been elimi-

The towers were able to absorb these tremendous blows without immediately collapsing is actually a testament to the resiliency of the structural systems of these two buildings.

Chief Dunn’s Web site includes recommendations for the construction of
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the replacement buildings at the World Trade Center site. The following are Chief Dunn’s “recommendations for constructing the new high rise buildings on ground zero”:

• “The steel columns, girders and floor beams should be encased in masonry or other more effective fire retarding material. Spray-on fire retarding is ineffective. Post fire investigations reveals the spray on fire retardant has scaled off and steel beams and concrete and steel floor slabs crack and allow flame spread.

• “Lightweight bar joists should not be used to support floors in high-rise buildings. The National Fire Protection Association has shown unprotected steel bar joist fail after five or ten minutes of fire exposure.

• “For life safety in high-rise buildings bring back the smoke proof tower. This allows people to escape fire using smoke free stairways.

• “Stairs and elevator shaft ways should be enclosed in masonry to prevent smoke spread.

• “Heating ventilation and air condition HVAC systems should be provided by unit system serving only one or two floors. Central air system serving 10 or 20 floors creates Shaft ways and duct systems that penetrate fire rated floors walls partitions and ceilings. Smoke spreads throughout ducts of central HVAC systems.

• “The high rise building frame work should be skeleton steel framing not center core steel column framing. There should be no bearing wall high rise construction. Reduce the size of open floor design.

• “Increase the thickness of concrete in floor construction. The two or three inches of concrete over corrugated steel fails during most serious high rise fires and must be replaced.

• “Automatic sprinklers should protect all high rise buildings. Firefighters can extinguish approximately 2,500 square foot of fire with one hose line. Two hose steams may quench 5,000 square feet of fire. The World Trade Center floor areas were 40,000 square feet in area.”

Tempering reaction with logic

The response to the terrorist attack on the World Trade Center towers by the relatives of the victims of the attacks is rather interesting, and, perhaps, understandable. The reason for the collapse of the WTC towers seems rather obvious, even to those who are not engineers—buildings are simply not designed to be struck by aircraft. The enormous fire that ensued as a result of the impact of the aircraft fur-
ther damaged the building structure and, as a result, both of the towers collapsed. From the general public’s standpoint, there is little mystery surrounding the collapse of the towers.

Of course, an engineer’s view of the collapse is a little more sophisticated than the simple explanation given above. The planes that struck the World Trade Center towers were large aircraft traveling at high rates of speed when they struck the towers. The FEMA report on the incident indicates that the speed of the plane that struck the north tower was estimated to be 470 miles per hour, while the speed of the airplane which struck the south tower was estimated to be 590 miles an hour. The FEMA report also indicates that the weight of each of the airplanes which struck the towers was approximately 274,000 pounds.

As would be expected, each of the aircraft inflicted massive damage on the building structure. The plane which struck the north tower damaged the structural system on five stories of the building, while the plane that struck the south tower damaged the structural system on seven stories of the building. While the towers were described as being a “house of cards” held together by “flimsy bolts” by Ms. Eckert, the fact that the towers were able to absorb these tremendous blows without immediately collapsing is actually a testament to the resiliency of the structural systems of these two buildings.

Because the buildings were not specifically engineered to absorb the high-speed impact of a large aircraft, one cannot credit the architects, engineers and contractors for purposely designing and constructing the building to resist collapse under the conditions the buildings were exposed to on the morning of September 11, but certainly condemning the design and construction teams for not anticipating this event is ludicrous. The statements referring to the World Trade Center towers as being a “house of cards” and being “flimsy” can perhaps be best described as hysterical and were certainly intended to be inflammatory.

While the World Trade Center towers were able to absorb the initial impact of the aircraft and remain standing, the ignition of the aviation fuel in the planes caused massive fires within each tower and increased the stress the already crippled structural systems were under. As the airplanes slid through each of the buildings, they no doubt compromised the building fire protection systems, including the structural fire protection (on the floors where the impact occurred), the sprinkler system, the standpipe system, the exit stair enclosures, the elevator hoistway enclosures and other floor opening enclosures. With all of the building fire safety systems compromised to one degree or another, the flammable liquids fire roared out of control. Given this, the collapse of each tower was more or less a forgone conclusion. The only question remaining to be answered that morning was how long the buildings could remain standing.

According to the FEMA report, the answer to that question was long enough for most of the people in the World Trade Center complex located below the impact floors to evacuate. Of the 58,000 people estimated to be in the World Trade Center complex that morning, roughly 95 percent of them escaped. According to the FEMA report, most of the building occupants who died in the collapse were located on or above the floors where the aircraft struck the buildings. Despite the fact that the buildings had not been designed and constructed to withstand the impact of a large commercial airliner and the enormous flammable liquids fires that would ensue, the towers’ structural performance was nothing short of astounding. Yes, roughly 3,000 people lost their lives in the collapse, but it was very fortunate indeed that the death toll was not far greater.

Rethinking goals

One of the goals of the Skyscraper Safety Campaign is to have a comprehensive investigation of the terrorist attack on the World Trade Center towers. The SSC would like this investigation to include a review of the design and construction of the World Trade Center, firefighting operations and evacuation procedures. Of course,
tors, and the occupants above the impact floors had no viable escape route from the building. Again, do we need a taxpayer-funded high cost investigation of the obvious?

Another goal of the Skyscraper Safety Campaign is to reform the [model] “code groups” so that 50 percent of the representatives writing codes are either from the fire service or are academics in the field of fire science engineering. The goals of the SSC also state that the present model building code groups are mainly composed builders, developers, financiers and bureaucrats who know little about fire safety.

The statement of this goal is rather interesting given that the two organizations who now develop model building codes in the United States, the International Code Council (ICC) and the National Fire Protection Association (NFPA), are not dominated by members of either the construction industry or the real estate industry. In fact, the International Code Council only permits governmental representatives to vote on code change proposals. Neither the by-laws governing the ICC or the NFPA prohibit fire service participation and, in fact, many members of the fire service already actively participate in the code development process. Similarly, these two organizations do not prohibit the participation of academics in the code development process.

It should be noted that the statement of the goal of the participation of the fire service and academics in the code development process presumes that the fire service and academics are the most knowledgeable people in the field of building fire protection. Speaking from my own personal experience (as a former fire protection engineer employed by City of San Jose Fire Department), few in the fire service actually have a genuine understanding or interest in building fire protection. Generally speaking, the fire prevention bureau (code enforcement) is the “step-child” of most fire departments. Given this, it is obvious that the Skyscraper Safety Campaign has been misinformed about the fire service’s interest in building codes.

**Return to past practices?**

Chief Dunn’s comments regarding the collapse of the World Trade Center towers and the need for changes to the building codes to prevent another such occurrence are interesting from the perspective that Chief Dunn advocates a return to past (pre-World War II) building construction practices. Are high rise buildings constructed in the past actually “safer” buildings from a fire safety standpoint than more modern (post-World War II) high rise buildings?

In particular, Chief Dunn has criticized modern high rise buildings constructed using structural steel framing. If you review the modern construction practices, you will find that high rise office buildings are typically constructed with structural steel framing, while residential buildings are typically constructed using concrete structural framing. Hence, the fire safety statistics for high rise office buildings are of particular interest. Statistics on fire fatalities in high rise office buildings published by the National Fire Protection Association for the 14-year period between 1985 and 1998 are as follows:

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**Total:** 7

These statistics are not only for high rise office buildings in New York City, Chicago or Los Angeles, but are for every high rise office building in the United States. These statistics are also not only for sprinklered high rise buildings, but for both sprinklered and non-sprinklered high rise buildings. To put these statistics in perspective, it is estimated that roughly 75 people in the United States die as a result of being struck by lightning each year. In other words, 10 times as many Americans die as a result of being struck by lightning each year as the total number of Americans who died as a result of fire in high rise office buildings in the 14-year period between 1985 and 1998.

Are modern high rise office buildings really “dangerous” buildings?

Not only do the NFPA statistics not support Chief Dunn’s assertions about modern steel-framed high rise buildings, but information provided in the executive summary of the FEMA study on the collapse of the World Trade Center towers also contradicts Chief Dunn. The executive summary of the FEMA report states “The collapse of these structures [referring to Buildings WTC 5 and WTC 7 in the World Trade Center complex] is particularly significant in that, prior to these events, no protected steel-frame structure, the most common form of large commercial construction in the United States, had ever experienced a fire-induced collapse.” An interesting fact considering Chief Dunn’s comments regarding the “dangers” of modern (post-WW II) steel-framed high rise buildings.

Although the fire record of modern steel-framed high rise buildings is nearly perfect, let’s examine the premise that steel-framed high rise buildings could be made even “safer” by incorporating archaic methods of construction, such as the use of masonry mud as a means of providing fireproofing for the structural frame and enclosing stairs and elevator hoistways. Although the premise seems logical, a close examination of many older high rise buildings shows that the masonry used to provide fire protection is not brick or concrete masonry units (CMU), but is often hollow clay tile. In many cases, the combination of hollow clay tile and plaster results in fire resistance ratings for columns and beams of 1 hour or less, not the 3 or 4 hour fire resistance ratings anticipated by Chief Dunn. In some older high rise buildings, clay tile units are used as forms to create concrete joist floor construction similar to “pan-joist” concrete floor construction. Although the floors may have a total thickness of 8 inches (including the thickness of the clay tile forms), the actual thickness of the concrete used in the floor construction is far less. While there is a perception that pre-World War II steel-framed high rise buildings are more fire resistive than more modern steel-framed high rise
building, this is, in fact, not necessarily the case.

Finally, would substituting masonry stair and elevator hoistway enclosures for gypsum wallboard enclosures in the World Trade Center towers have made any difference on the morning of September 11? Typically, 8-inch-thick concrete masonry units are required to achieve a 2 or 3 hour wall fire resistance ratings. Is 8-inch-thick concrete masonry wall construction capable of absorbing a blow from a 274,000-pound aircraft traveling at a speed of 490 miles per hour and still remaining intact? You don’t have to be a structural engineer to answer that question. Even if the stair and elevator enclosures had been masonry, the enclosures would have been sheared off at the floors of impact and the building occupants above the impact point would have been trapped. Smokeproof enclosures, regardless of whether the enclosures were constructed of gypsum wallboard or masonry, would have suffered the same fate.

The NFPA statistics on fire fatalities in high rise office buildings tell us clearly that high rise office buildings are not dangerous buildings, regardless of whether the buildings are 10 stories or 100 stories in height. Incorporating Chief Dunn’s recommendations into the construction of World Trade Center towers would likely have had little impact on the results of the attack of the World Trade Center towers. However, the adoption of these recommendations would certainly have a major impact on cost of constructing high rise buildings. Increasing the cost of constructing high rise buildings in the name of fire safety, without actually increasing the level of safety provided in these buildings, is foolishness. The events of September 11 were tragic, but adopting new more restrictive, but unnecessary, code requirements will simply compound the tragedy.

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. Mr. Schulte can be contacted by sending email to rschulte@plumbingengineer.com.
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 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

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(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 physical 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 fireproofing 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 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

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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 to 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 1990s to 1,250 gpm. Neither a standpipe system would likely have operated almost all of the aircraft. The impact of the aircraft

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 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 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.

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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 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.

In addition to the reduced fire resistance caused by the increase in stress, the impact of the planes certainly damaged the fireproofing provided for at least some of the undamaged steel members.

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.
Statistics Don’t Matter?

In October, 2002, I forwarded an advance copy of the column on the World Trade Center collapse, titled “Opposing Viewpoints on the WTC Collapse,” to members of the advisory panel of the Skyscraper Safety Campaign. (The Skyscraper Safety Campaign is advocating more restrictive fire safety requirements for high rise buildings in the wake of collapse of the World Trade Center towers on September 11, 2001.) One of the members of the advisory panel responded with the following email note:

“How about examining when there is a serious high-rise fire how many people die and what is the structural damage. You do not assess the adequacy of regulations by looking at statistics, you examine them when they are challenged.”

An excerpt from another email note (from the same member of the advisory panel) reads as follows:

“... Your defense by statistics is very faulty and you should go back to plumbing. In the recent 9/11 event[,] we have 4 WTC buildings and the Pentagon wing collapse due fire, not the airplane collision.”

Looking back at my education as a fire protection engineer at the Illinois Institute of Technology (IIT) in the early 1970s, it is my opinion that the most important course in the fire protection engineering curriculum was the course on probability and statistics. Contrary to the opinion expressed above, it is also my opinion that statistics and probability are the essence of good safety regulations. We simply cannot evaluate the costs and benefits of new and existing building fire safety regulations without statistics, and so this column will (once again) be devoted to a review of some more fire statistics.

In September, 2002, the National Fire Protection Association (NFPA) published a report titled “Fire Loss in the United States During 2001.” Some of the highlights of this report are as follows:

- The NFPA estimates that approximately 521,500 structure fires occurred in the United States in 2001.
- 76 percent of all of the structure fires which occurred in the U. S. in 2001 occurred in residential occupancies.
- Approximately 3,745 (civilian) Americans died as a result of fire in the U. S. in 2001 (excluding the fatalities which occurred in the terrorist attacks on September 11).
- Roughly 83 percent of the (civilian) fire fatalities which occurred in the U. S. in 2001 occurred in dwellings (excluding the fatalities which occurred in the terrorist attacks on September 11).
- Approximately 485 (civilian) Americans died as a result of vehicle fires in 2001.
- Approximately 80 (civilian) Americans died as a result of fires in non-residential (commercial) buildings (excluding the fatalities which occurred in the terrorist attacks on September 11).

As in previous years, fires in residential occupancies caused more than 80 percent of the civilian fire fatalities which occurred in the United States in 2001. The NFPA report also indicates that the number of fire fatalities which occurred in non-residential (commercial) buildings continues to dwindle, down 11.1 percent from the year 2000.

It is rather interesting that more than six times as many Americans died as a result of vehicle fires as in fires in commercial buildings. Also interesting is the fact that the number of Americans who died as a result of fires in commercial buildings in 2001 is on the order of the number of Americans who die each year as a result of being struck by lightning. In other words, the probability of dying as a result of a fire in a commercial building is roughly the same as the probability of dying as a result of being struck by lightning.

Of course, many of the statistics cited above carry the caveat that the fatalities which occurred as a result of the events of September 11, 2001 have been excluded. Why exclude the results of the terrorist attacks on the World Trade Center and the Pentagon? The answer to that question seems obvious — the attacks on the World Trade Center and the Pentagon were “military-style” assaults on these buildings, rather than typical fires. These assaults simply used fire as a means to accomplish their mission. Including the fatalities which occurred in the September 11 attacks would be similar to including war casualties in statistics on gun violence.*

In September, 2001, the NFPA published statistics on fires in high rise buildings. In light of the debate over whether the current high rise provisions contained in the building codes used in the United States are adequate, the
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publication of these statistics couldn’t have been more timely. The NFPA report on high rise fires is simply titled “High-Rise Building Fires.” This report was written by John R. Hall, Jr. of the NFPA Fire Analysis and Research Division.

For purposes of the analysis, the NFPA report on high rise building fires defines a high rise building as a building which is seven stories or more in height. The report further limits the analysis to four main occupancies—office buildings, hotels/motels, apartment buildings and health care buildings.

Some of the highlights of the NFPA report on high rise building fires are as follows:

- In 1998, there were an estimated 13,300 fires and 37 fatalities in U.S. high rise buildings. In 1985, the estimated number of fires in U.S. high rise buildings was between 22,500 and 25,000 and between 70 and 80 Americans died in high rise building fires.
- In 1998, the direct property loss due to fire in U.S. high rise buildings was estimated to be $121 million (measured in 1998 dollars). In 1985, the direct property loss due to fire was estimated to be between $70 and $135 million (measured in 1985 dollars).

* Note: The Federal Bureau of Investigation (FBI) released crime figures for 2001 in late October, 2002. The issue of whether the deaths from the terrorist attacks on September 11 should be included in the murder statistics was also addressed by the FBI. An article on these statistics written by Curt Anderson, a writer for the Associated Press, published on October 28, 2002 included the following statement:

“The FBI did not include the Sept. 11 deaths at the World Trade Center, the Pentagon and the plane crash in Pennsylvania [in the murder statistics]. These deaths, the FBI said, ‘are different from the day-to-day crimes committed in this country.’”

Given that the FBI is excluding the September 11 terrorist attacks from the crime statistics, it doesn’t seem unreasonable that these deaths should also be excluded from the fire statistics.

- The report includes estimates on the number of fire fatalities which occurred in US high rise buildings in the 14-year period between 1985 and 1998. These statistics are as follows:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Office buildings</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Health care buildings</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>Hotels/motels</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>Apartment buildings</td>
<td>707</td>
<td></td>
</tr>
</tbody>
</table>

Total number of fatalities: 784

- The report also includes information on the spread of fire and smoke in high rise buildings for the 5-year period between 1994 and 1998. These statistics are as follows:

<table>
<thead>
<tr>
<th>High Rise Office Buildings</th>
<th>Flame damage</th>
<th>Smoke damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confined to room of origin</td>
<td>94.4%</td>
<td>63.3%</td>
</tr>
<tr>
<td>Confined to floor of origin</td>
<td>2.8%</td>
<td>17.1%</td>
</tr>
<tr>
<td>Spread beyond the floor of origin</td>
<td>2.8%</td>
<td>19.6%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High Rise Health Care Buildings</th>
<th>Flame damage</th>
<th>Smoke damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confined to room of origin</td>
<td>97.9%</td>
<td>78.7%</td>
</tr>
<tr>
<td>Confined to floor of origin</td>
<td>1.5%</td>
<td>15.4%</td>
</tr>
<tr>
<td>Spread beyond the floor of origin</td>
<td>0.6%</td>
<td>5.9%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>High Rise Hotel Buildings</th>
<th>Flame damage</th>
<th>Smoke damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confined to room of origin</td>
<td>95.6%</td>
<td>71.0%</td>
</tr>
<tr>
<td>Confined to floor of origin</td>
<td>1.8%</td>
<td>16.3%</td>
</tr>
<tr>
<td>Spread beyond the floor of origin</td>
<td>2.6%</td>
<td>12.6%</td>
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</table>

<table>
<thead>
<tr>
<th>High Rise Apartment Buildings</th>
<th>Flame damage</th>
<th>Smoke damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Confined to room of origin</td>
<td>94.0%</td>
<td>58.2%</td>
</tr>
<tr>
<td>Confined to floor of origin</td>
<td>4.3%</td>
<td>27.7%</td>
</tr>
<tr>
<td>Spread beyond the floor of origin</td>
<td>1.7%</td>
<td>14.1%</td>
</tr>
</tbody>
</table>

On October 11, 2002, the NFPA also published some statistics on fires in hotel/motel occupancies on the NFPA Web site (www.nfpa.org). Excerpts from these statistics are as follows:

- Fires in hotels and motels accounted for only 0.09% of all the structure fires in the 5-year period between 1994 and 1998.
- In the 5-year period between 1994 and 1998, no fire fatalities were reported in hotels or motels which were protected by sprinkler systems. Is the use of statistics to determine whether or not the United States needs more
restrictive building fire safety requirements appropriate, or should we just ignore the statistics and adopt more restrictive requirements because a few “experts” think we need more restrictive requirements? If I recall my history correctly, the experts used to think that the earth was flat and the sun revolved around the earth. Unfortunately, far too many experts today have conflicts of interest and simply can’t be relied upon to provide objective opinions on the issues.

Speaking more specifically of conflicts of interest, is the World Trade Center collapse incident simply being used by experts to wring more research funding out of the federal treasury? Perhaps the statistics cited above will provide at least a partial answer to that question. A review of the testimony of the director of the National Institute of Standards and Technology, Dr. Arden L. Bement, Jr., before the Congressional Committee on Science on March 6, 2002 might also be of interest in trying to formulate an answer to this question. (Dr. Bement’s testimony can be reviewed on the NIST Web site, www.nist.gov/testimony/2002/abwtc.html.)

Fire Protection

Continued from page 10

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. Mr. Schulte can be contacted by sending email to rschulte@plumbingengineer.com.
The fire protection column published in the January, 2003 Plumbing Engineer concluded with a question:

"... is the World Trade Center collapse incident simply being used by “experts” to ‘wring’ more research funding out of the Federal Treasury?"

Rather than provide an answer to this question, the January column referred readers to the testimony of the director of the National Institute of Standards and Technology (NIST), Dr. Arden L. Bement, Jr., at the Congressional Science Committee hearings on the collapse of the World Trade Center towers on March 6, 2002. (A transcript of Dr. Bement’s testimony can be found on the NIST Web site at www.nist.gov/testimony/2002/abwtc.html.)

The Congressional hearings on the collapse of the World Trade Center held on March 6, 2002 opened with a statement from the chairman of the committee, Congressman Sherwood Boehlert (R-N.Y.), followed by the testimony from five witnesses. Congressman Boehlert’s opening statement included the following excerpts:

“The Committee decided to move forward for two fundamental reasons. First, we believe that we owe it to the victims and their families to learn everything possible about what happened in those horrifying first hours of September 11th—not just to satisfy their immediate needs and yearnings, but to ensure that such a catastrophic building failure, and the resulting loss of life, never happen again.

“Another significant lesson of the Trade Center collapse is that we need to understand a lot more about the behavior of skyscrapers and about fire, if we are going to prevent future tragedies.

“But this hearing is not so much about the past, as it is about ensuring that we protect lives in the future.”

The first witness before the committee was Robert F. Shea, Acting Administrator, Federal Insurance and Mitigation Administration of the Federal Emergency Management Agency (FEMA). Mr. Shea’s testimony included the following:

“... its conclusions and recommendations [referring to the FEMA study issued May, 2002] will help guide future investigative and research efforts connected primarily to understanding the performance of buildings when subject ed to extreme conditions.

“This study [again referring to the FEMA study issued May, 2002] represents an important first step in suggesting how the technical resources of the nation can be brought to bear on protection of lives and property.”

The next witness before the committee was Glenn P. Corbett, an assistant professor of fire science at John Jay College in New York City. Professor Corbett is also a member of the advisory panel of the Skyscraper Safety Campaign, a group advocating more restrictive code requirements for high rise buildings. His testimony included the following:

“For example, our model building codes treat a 15-story building exactly the same as a 100-story building in terms of fire protection—we apply the same level of structural fire resistance, the same fire protection systems, the same everything. We place heavy reliance on automatic sprinkler systems, with little redundancy in terms of structural fire resistance to ensure that the building will stay up long enough to allow for firefighters to reach the fire area, rescue trapped inhabitants, and generally deal with the situation. Automatic sprinklers are the best protection against fire, but we need to have a backup when we are 1,000 feet high in a building on fire. We need a proper balance of passive and active protection in larger high-rise structures.

“This test, commonly known as A.S.T.M. E-119, was developed to provide assurance that the fire protection coating/encasement provided for beams and columns would allow them to be subjected to high temperatures and not collapse. This test, however, dates back to the 1920’s and is based upon the temperatures recorded when a set of buildings were burned back then for study purposes. Today, we basically still use the same test with the same ‘fire’ temperature and exposure conditions developed over 75 years ago. I would argue that the fires of the 1920’s are different than those of today, and that this nationally accepted test needs to be thoroughly reexamined in light of what happened on 9-11.”

The final witness before the committee was Dr. Bement, the director of NIST. Dr. Bement’s testimony included the following:

“The tragedy that the United States experienced on September 11, 2001, was unprecedented when compared with any prior accident, natural disaster, or terrorist/war
attack. The collapse of the twin World Trade Center towers was the worst building disaster in human history...

“The implementation of the results of such an investigation would be critical to restore public confidence in the safety of tall buildings nationwide, enhance the safety of fire and emergency responders, and better protect people and property in the future. To cite one example, the February 4th issue of ‘Crain’s New York Business’ reports that an increasing number of tenants are leaving the Empire State Building, which is again the tallest building in New York City, because of fears of another terrorist attack. Anecdotal evidence also suggests that building vacancy rates have doubled in Manhattan, despite the 15 million square feet of space that was lost on September 11th.

“The Building and Fire Research Laboratory is the foremost fire research laboratory in the United States, and through the National Earthquake Hazards Reduction Program (NEHRP) NIST is the principal agency for research and development to improve building codes and standards...

“Fourth, to study procedures and practices used to provide adequate structural reserve capacity to resist abnormal loads (e.g. blast, explosion, impact due to aircraft or flying debris from tornadoes, accidental fires, and faulty design and construction), especially those that can be anticipated prior to construction (e.g. impact of a Boeing 707)...

“This broader program would address critically and urgently needed improvements to national building and fire standards, codes, and practices that have begun to be recognized in recent years. The events of September 11th have brought even more focus and priority to this already important issue.

“The goal of this broader program would be to produce cost-effective retrofit and design measures and operational guidance for building owners and emergency responders.

“Current building design practice does not consider fire as a design condition. Instead, structural fire endurance ratings are prescribed in building codes using standard tests on individual components. The current testing standards are based on work carried out at NIST in the 1920s. They do not represent real fire hazards in modern buildings. They also do not consider the fire performance of structural connections or of the structural system as a whole, or the multiple performance demands on fireproofing materials.

“In short, NIST would provide the technical basis and guidance for fire safety design and retrofit of structures, the predictive tools and test methods for fire resistance determination, and the performance criteria for fireproofing materials. In addition, NIST proposes to develop guidance and retrofit...

Perhaps if the Science Committee had heard from a more diverse group of “experts,” the committee would have developed a far different perspective on the relative importance of a study of collapse of the World Trade Center Towers.

“The final program element supports a construction-industry-led roadmapping effort to reflect changed priorities for development and deployment of safety and security standards, technology, and practices.

“The effort would complement and support parallel efforts of technical organizations to improve standards, codes, and practices.

“In conclusion, I believe it is imperative for the U.S. to learn from the worst-ever building disasters in human history and take aggressive remedial action to minimize future losses.

“In the wake of September 11th, the private sector’s willingness to take necessary corrective action to strengthen building codes and stan...
investigations into the structural failures of the World Trade Center and suggest appropriate new standards and potential retrofits..."

As a result of the hearings, the House Committee on Science drafted a letter to Mr. Mitchell Daniels, the director of the Office of Management and Budget (OMB), regarding funding for a federal government study of the collapse of the World Trade Center. The opening paragraph of the letter reads as follows:

“We are writing to you as a result of today’s House Science Committee hearing on the collapse of the World Trade Center buildings. There was unanimity among the witnesses on the need for a comprehensive assessment and research agenda to address evacuation procedures, emergency response, and structural analysis of the site’s buildings. The goal of such a study would be to improve the safety of both the public and the emergency responders in the event of another building collapse.”

The letter to the director of OMB also includes the following excerpt:

“...the Federal Emergency Management Agency’s (FEMA) Building Performance Assessment Team (BPAT) has estimated that $40 million would be required to fund a comprehensive study of an event of this magnitude and complexity.”

From the standpoint of the overall federal budget, a proposal to spend $40 million for a study of the collapse of the World Trade Center is “chicken feed,” but certainly any decision to devote this amount of taxpayer money (or the $16 million which was actually allocated for the study) to studying a single disaster should be based upon credible testimony by witnesses before a Congressional committee. Unfortunately, the testimony from some of the experts at the March 6 hearing of the House Science Committee was less than factually accurate. Perhaps if the Science Committee had heard from a more diverse group of “experts,” the committee would have developed a far different perspective on the relative importance of a study of collapse of the World Trade Center Towers.

Next month we will continue this series by presenting an analysis of the various statements presented on these pages.

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**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

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**Next month:**

Analysis of Congressional Testimony on the WTC Collapse
Analysis of Congressional Testimony on the World Trade Center Collapse

Last month in this column we offered a compendium of testimony presented before the House Science Committee of the United States Congress. (See March 2003 Plumbing Engineer, page 8.) This month we provide an analysis of those remarks.

To begin his testimony, the director of NIST, Dr. Bement, stated that the terrorist attack on September 11 was “... unprecedented when compared with any prior accident, natural disaster, or terrorist/war attack.” Dr. Bement further stated that “the collapse of the twin World Trade Center towers was the worst building disaster in human history.” Obviously, these statements are an exaggeration. Without thinking very hard, several other major building disasters which were far greater in magnitude and impact come to mind, for instance, the Great Chicago Fire in 1871, the San Francisco earthquake and fire in 1906, the destruction of Dresden by Allied bombers in 1945 and the destruction of Hiroshima and Nagasaki using atomic weapons also in 1945. The destruction of the World Trade Center towers pales in comparison to these events. The difference between these events and the collapse of the World Trade Center towers is that the collapse of the towers was recorded on film and played ad nauseam on television, while the Great Chicago Fire, the San Francisco earthquake and fire and the destruction of German and Japanese cities in World War II are “ancient” history. Although these other events are “ancient” history, one would have expected that the director of NIST could have put the destruction of the World Trade Center towers into proper perspective for a Congressional committee.

The inaccurate historical perspective on the magnitude of the collapse of the World Trade Center towers was not the only major distortion of facts contained in Dr. Bement’s testimony. As one justification for a major investigation into the collapse of the World Trade Center, Dr. Bement stated that “an investigation would be critical to restore public confidence in the safety of tall buildings nationwide ...” Dr. Bement further stated that “anecdotal evidence also suggests that building vacancy rates have doubled in Manhattan, despite the 15 million square feet of space that was lost on September 11th.” Of course, one way to restore the public’s confidence in the safety of high rise buildings would be to conduct an expensive research study by NIST. Another, far more immediate, and far less expensive way of restoring the American public’s confidence in the safety of our tall buildings would be for “experts” to simply stop scaring the public and cite the actual facts about high rise building safety.

The truth is that the fire record of American high rise buildings has been excellent over the last 20 years. This statement is supported by statistics published in a report written by Dr. John Hall, Jr. of the Fire Analysis and Research Division of the National Fire Protection Association (NFPA). Dr. Hall’s report titled “High-Rise Building Fires” was published (coincidentally) in September, 2001. (A summary of some of the statistics presented in Dr. Hall’s paper appeared in the fire protection column in the January, 2003 issue of Plumbing Engineer, along with other fire statistics published by the NFPA.) It is unfortunate that Dr. Bement did not provide the Congressional Science Committee with Dr. Hall’s report, along with a summary of the statistics contained in the report. Dr. Bement missed an excellent opportunity to reassure the American public about the “dangers” of fires in high rise buildings.

Dr. Bement’s reference to the fact that the (commercial) building vacancy rate in Manhattan has doubled since September 11 as an indication that the American public has developed an aversion to living or working in high rise buildings is a rather curious statement. Dr. Bement seems to have totally neglected the impact of the events of September 11 on the economy in New York City and the rest of the nation. Was the increase in the vacancy rate in Manhattan due to the fact that companies were fearful that other high rise buildings would be attacked by terrorists as suggested by Dr. Bement or could it be that the increase in the vacancy rate was mainly due to the impact that the September 11 attacks had on the economy? Common sense tells us that the impact of the September 11th events on the local economy had far more to do with rise in the vacancy rate in Manhattan than the fear of another terrorist attack.

Dr. Bement’s testimony also included a statement that improvements in building and fire codes used in the United States are “urgently needed” and that the deficiencies in the codes “have begun to be recognized in recent years.” Dr. Bement’s testimony also stated that “the events of September 11th have brought even more focus and priority to this already important issue.” If it is NIST’s opinion that improvements in the building and fire codes used in the United States are so “urgently needed,” why was NIST no where to be found when the two newest model building codes in the United States, the 2000 edition of the International Building Code and the 2003 edition of NFPA Building Code, were being developed? (It
should be noted that Mr. Richard Bukowski of the Fire Research Division of the Building and Fire Research Laboratory of NIST did participate in the development of the first edition of the International Performance Code published by the International Code Council.)

A review of the fire statistics in the United States (published annually by the NFPA) indicates that the number of fire fatalities in the United States has steadily declined over the last quarter century, despite the fact that the population of the United States has continued to grow. The NFPA statistics for 2001 indicate only 80 Americans died as a result of fires in U.S. commercial (non-residential) buildings (excluding the fatalities which occurred as the result of the September 11 terrorist attack). These same statistics indicate that roughly 83 percent of the fire fatalities which occurred in the United States in 2001 occurred in residential occupancies (excluding the fatalities which occurred on September 11) with 70.7 percent of the fatalities occurring in one- and two-family dwellings. (That means that more American civilians died as a result of fires in one- and two-family dwelling in 2001 than died as a result of the collapse of the World Trade Center towers.) Given these statistics, just what are these “urgently needed” improvements in our fire codes? If there are any “urgently needed” improvements in our fire codes, the NFPA statistics seem to suggest the need to address the fire problem in the smallest buildings that we construct, one- and two-family dwellings, not high rise buildings.

Dr. Bement’s testimony also included a statement that “current building design practice does not consider fire as a [structural] design condition.” Along these same lines, Dr. Bement’s further stated that “the current testing standards are based on work carried out at NIST in the 1920s” and that the test standards “do not represent real fire hazards in modern buildings.” Dr. Bement’s statements regarding structural engineering design practice is correct, as is his statement regarding the fire resistance test (ASTM E119), but his inference that somehow these are major problems is another distortion of the facts. The reason that fire conditions are not presently considered in structural engineering design is that our “real world” experience with building fires indicates it simply isn’t necessary. While the fire exposure (the time-temperature curve) required to be used by ASTM E119 may not represent time-temperature curves derived from real fires, more than 50 years of experience with the ASTM E119 fire test indicates that the results derived from this test are adequate. Based upon fire testing, we are aware that the temperatures developed in a fire vary with the type of fuel, the quantity of fuel, the fuel configuration and the ventilation available to the fire. Hence, any standardized test using a single time-temperature curve will necessarily be a compromise.

It is assumed by many in the fire protection field that hourly fire resistance ratings assigned to structural assemblies represent the actual fire resistance of a structural assembly in a real fire. This assumption is erroneous, however. The variable with the greatest impact on the fire resistance of a structural assembly is the fire itself. If a structural assembly is exposed to a fire which is more severe than the ASTM E119 time-temperature curve, the actual fire resistance of the assembly will be less than indicated by the fire rating assigned to the assembly by testing per ASTM E119, while if the fire exposure is less severe than the ASTM E119 time-temperature curve, the actual fire resistance of the assembly will be greater than indicated by the fire rating assigned to the assembly. If you have an actual understanding of the E119 test standard, the above is obvious.

The issue of the actual structural fire resistance, versus the severity of the fire exposure, has implications in the collapse of the World Trade Center towers because the fire to which the structural systems in the towers were exposed was far more severe than the fire exposure utilized in the ASTM E119 fire test standard. (The severity of a massive flammable liquids fire will far exceed the
severity of the ASTM E119 time-temperature curve.) Hence, it should be obvious that the actual fire resistance of the structural systems in the World Trade Center towers would have been less than indicated by the hourly ratings assigned to the structural systems assuming that all of the structural fire protection provided for the structural systems in the building was intact. Of course, the impact of the aircraft damaged the structural fire protection provided for the towers reducing the actual fire resistance of the overall structure. (The damage to the building structural systems caused by the impact of aircraft also would have reduced the actual fire resistance of the structure by increasing the stress in some of the undamaged structural members.)

In Professor Corbett’s testimony, he in essence attacked the model building codes because the code requirements that apply to high rise buildings “treat a 15-story building exactly the same as a 100-story building in terms of fire protection.” Professor Corbett further stated that the model building codes “place heavy reliance on automatic sprinklers, with little redundancy in terms of structural fire resistance ...” The professor’s testimony also included the statement that “we need a proper balance of passive and active [fire] protection in larger high-rise structures.” As with some of Dr. Bement’s testimony, Professor Corbett’s statements regarding the high rise building provisions contained in the model building codes lack an historical perspective.

The high rise provisions presently included in the International Building Code and the NFPA Building Code (NFPA5000) were originally developed in the early 1970s and first included in the regional model building codes in the middle 1970s. The issue of whether sprinkler protection should be mandated in high rise buildings was the subject of much debate in the early 1970s and the first set of high rise building provisions included in the three regional model building codes contained two alternatives for protecting high rise buildings. One alternative was to “compartment” the building, while the other was to provide sprinkler protection in lieu of “compartmentation.”

At that time, it was acknowledged that providing sprinkler protection in a high rise building would provide superior protection for the occupants of the building, however, there were concerns about the cost of installing sprinkler protection. To encourage the installation of sprinkler protection in high rise buildings, the high rise provisions included a number of “trade-offs” in the passive fire protection normally required. The purpose of allowing these “trade-offs” in passive protection was to at least partially offset the cost of installing sprinkler protection. Among the “trade-offs” allowed in the high rise provisions were reductions in the structural fire protection required, the elimination of fire dampers and the substitution of pressurized stair enclosures for smokeproof (exit stair) enclosures. It was not until the 1980s that the high rise provisions included in the three regional model building codes were revised to mandate the installation of sprinkler protection in high rise buildings.

Since the inclusion of the high rise provisions in the three regional model building codes, there has not been a major fire disaster in an American high rise building protected throughout by a sprinkler system (with the exception of the World Trade Center towers). Based upon the experience of the last 25 years, many, if not most, code professionals have accepted the con-
cept of “trade-offs” in passive fire protection when sprinkler protection is installed. In recent years, however, manufacturers of passive fire protection products have begun to attack the concept of “trade-offs” for the installation of sprinkler protection and have developed a concept which is referred to as “balanced” fire protection. The implication is that allowing “trade-offs” in passive fire protection when sprinkler protection is installed is somehow “unbalanced” fire protection. One of the problems with the “balanced” fire protection concept as it applies to high rise buildings is that it neglects the history of the development of the high rise building provisions (and the fire record of sprinklered high rise buildings in the last 25 years). Unfortunately, Professor Corbett’s testimony before the Congressional Committee implied that the concept of “balanced” fire protection is generally accepted in the fire protection field.

Common sense tells us the impact of the September 11th events on the local economy had far more to do with rise in the vacancy rate in Manhattan than the fear of another terrorist attack.

Does the fact that both of the World Trade Center towers collapsed on the morning of September 11 validate the concept of “balanced” fire protection and does the World Trade Center towers collapse indicate that additional fire protection should be required in 100 story high rise buildings? The answer to both of these questions might be affirmative if the fires in the World Trade Center towers were typical fires which occur in high rise buildings, but the fires in the World Trade Center towers were anything but typical. The key question which must be answered in this debate is not whether the high rise building provisions contained in our model building codes are adequate, but what are our expectations regarding the structural stability of high rise buildings? It appears that the witnesses before the Congressional Committee have assumed that there is a consensus that buildings should remain stable, regardless of the magnitude of damage done to the building by terrorists (or the cost to construct such buildings).

Professor Corbett’s testimony also addressed “inadequacies” in ASTM E119 stating that “today, we basically use the same test with the same ‘fire’ temperature and exposure conditions developed over 75 year ago. I would argue that the fires in the 1920s are different than those of today, and that this nationally accepted test needs to be thoroughly reexamined in light of what happened on 9-11.” Are fires really different today, from fires which occurred in the 1920s? Obviously, the physics of fire is the same today as in the 1920s, but what Professor Corbett appears to be referring to is the increased use of petrochemical products (plastics) in modern American society. What
Professor Corbett has neglected in his assessment that the contents of buildings are different today than they were in the 1920s are the advancements made in material science over the last 80 years. In the early part of the 20th century, furniture and wall and ceiling finishes were combustible. Today, much of our furniture in commercial occupancies is constructed with non-combustible materials with only minor quantities of plastic finishes, and wall and ceiling finishes are mostly noncombustible. Astrong argument can be made that the contents of a modern building are far less combustible and safer today than the contents of buildings in the 1920s. The fire safety statistics collected and published by the NFPA support this point of view, rather than Professor Corbett’s viewpoint. The number of structure fires continues to decrease each year, as do the number of civilian and firefighter fatalities caused by fire, despite the fact that the population of the United States continues to grow. Over the past quarter century, we have, in essence, conquered the hazard of fire. Given this, is it really absolutely essential to address some of the “well-known” deficiencies in ASTM E119 test standard?

Closing comments

This column offers a far different perspective on the hazard of fire in the United States than that presented by Dr. Bement and Professor Corbett. Although the money to fund the NIST study of the World Trade Center towers collapse has already been appropriated and the study is under way, the Congressional Science Committee should be aware that some of the testimony before the committee provided a less than objective assessment of the importance of the World Trade Center collapse to our understanding of the hazard of fire in high rise buildings. It is likely that the staff of NIST wrote Dr. Bement’s remarks for him. If this is the case, Dr. Bement can, perhaps, be excused for some of his misstatements.

Finally, back to my original question. Is the World Trade Center collapse incident simply being used by “experts” to “wring” more research funding out of the federal treasury? Why else would witnesses before the Congressional Committee exaggerate the magnitude of the World Trade Center collapse in comparison to other major building disasters and “cover up” the excellent fire record of American high rise buildings? Did the Congressional Science Committee get “rolled” by the “experts” who testified at the March 6, 2002, hearing? It certainly appears that the answer to this question is yes.

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.
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* (NFPA 101) 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.]

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.

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...
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
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The fire protection column that appeared in the April, 2003 issue of *Plumbing Engineer* discussed the issue of “reasonable” fire safety in the context of the collapse of the World Trade Center. The basis for last month’s analysis and discussion was the general provisions that are contained in Chapter 4 in the 2000 edition of the Life Safety Code. To review, the general goal (in other words, the intent) of the Life Safety Code is outlined in section 4.1 of the Code. Section 4.1.1 defines the goal (the intent) of the Life Safety Code in the following terms:

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

Section 4.5 in the Life Safety Code (NFPA 101) is titled “Fundamental Requirements.” This section in the code outlines the basic concepts on which the prescriptive requirements contained in the code are based. Section 4.5.1 in the Life Safety Code reads as follows:

“Multiple Safeguards. The design of every building or structure intended for human occupancy shall be such that reliance for safety to life does not depend solely on any single safeguard. An additional safeguard(s) shall be provided for life safety in case any single safeguard is ineffective due to inappropriate human actions or system failure.”

During the course of the development of the International Building Code (IBC) and the NFPA Building Code (NFPA 5000) over the last few years, much of the debate that occurred (and is still occurring) has essentially centered on how to apply these two general provisions in the Life Safety Code. (Although the International Building Code and the regional model building codes on which the IBC are based do not contain similar provisions to those cited above, these provisions also are the unstated concepts on which the IBC is based.) The debate over these two concepts can be distilled into one question: how much fire safety should we mandate as a minimum? More specifically, much of the debate has been over the extent of reductions in passive fire protection requirements (i.e. structural fire protection, reduction in wall and floor fire ratings, omission of fire dampers), which should be allowed when sprinkler protection is installed in buildings.

Today, it is recognized by most fire safety professionals that sprinkler system protection provides the best defense available to safeguard building occupants from fire. That, hasn’t always been the case.

for installing sprinkler protection in light hazard occupancies (such as assembly occupancies, residential occupancies, churches, schools and offices), particularly buildings of fire resistive construction, were minimal. To address the cost issue, fire safety professionals proposed numerous changes to NFPA 13 to make sprinkler installations less costly, as well as proposed changes to building codes to reduce the requirements for passive fire protection when sprinkler protection is installed. These “trade-offs” in passive fire, in effect, subsidized the installation of sprinkler protection.

Now that the installation of sprinkler protection has more or less become a standard feature in most new buildings (with the notable exception of one- and two-family dwellings where more than 60 percent of the fire deaths
occur in the United States), a substantial number of fire safety professionals are questioning the concept of the reduction of passive fire protection features when sprinkler protection is provided. As expected, many of those who question the wisdom of “trade-offs” in passive fire protection are connected with trade associations who represent manufacturers of materials and/or products used to provide passive fire protection. Surprisingly though, many in the fire service also are opposed to providing “trade-offs” in passive fire protection when sprinkler protection is provided.

Opponents of reductions in passive fire protection when sprinkler protection is provided have developed a concept that has become known as “balanced” fire protection. The concept of “balanced” fire protection acknowledges that sprinkler protection provides a high level of protection for the occupants of sprinklered buildings, but the proponents of this concept argue that, since sprinkler systems are not 100 percent reliable, additional passive fire safety features are necessary to ensure that building occupants and firefighters are protected from fire in the event of the failure of the sprinkler system.

A number of proponents of the “balanced” fire protection concept have used the collapse of the World Trade Center towers on September 11 as a justification for this concept. One such example of this is the testimony of Professor Glenn P. Corbett, an assistant professor of fire science at John Jay College of Criminal Justice in New York, at the Congressional Science Committee hearings on the collapse held on March 6, 2002. The following is an excerpt from Professor Corbett’s testimony at the hearing: “Our current high-rise code requirements do not address the real world issues encountered when fighting fires in high-rise buildings. For example, our model building codes treat a 15-story build-

“Current high-rise code requirements do not address the real world issues encountered when fighting fires in high-rises”

ing exactly the same as a 100-story building in terms of fire protection – we apply the same level of structural fire resistance, the same fire protection systems, the same everything. We place heavy reliance on automatic sprinkler systems, with little redundancy in terms of structural fire resistance to ensure that the building will stay up long enough to allow firefighters to reach the fire area, rescue trapped inhabitants and generally deal with the situation. Automatic sprinklers are the best protection against fire, but we need to have a backup when we are 1,000 feet high in a building on fire. We need a proper balance of passive and active protection in larger high-rise structures.”

Those who use the collapse of World Trade Center towers as evidence that the present fire safety requirements for high-rise buildings (including the “trade-offs” allowed for sprinklered high-rise buildings) are somehow “unbalanced” neglect the fact that the World Trade Center towers actually collapsed as result of what amounted to a missile attack on the buildings. Rather than use a Tomahawk cruise missile loaded with a payload of high explosives to attack the target buildings, the terrorists used two Boeing 767 “missiles” with a payload of enough aviation fuel to destroy the buildings. (As evidenced by video from the war in Iraq and video from September 11, missiles fired by the U.S. military and the Boeing 767 missiles used by the terrorists both cause fires that enhance the destruction of their targets.) At present, no building code used in the United States today has been written to provide protection for building occupants in the event of
structural damage and subsequent fire caused by a missile attack. Given this, the use of the collapse of the World Trade Center towers as an example that supports the use of the “balanced” fire protection concept is, to put it politely, simply absurd.

What is interesting about the arguments made by the proponents of the concept of “balanced” fire protection is that these arguments never include relevant statistics or cite examples, other than the World Trade Center. The “balanced” fire protection proponents state that the fire “problem” in the United States is the worst of any industrialized nation, but always fail to mention that more than 80 percent of the civilian fire deaths that occur in the United States occur in residential occupancies. Some of the other statistics that the proponents of the “balanced” fire protection concept fail to mention have been reviewed many times in this column in previous issues of Plumbing Engineer. (See the fire protection columns that have been published in the November, 2001; July, 2002; and January, 2003 issues of Plumbing Engineer for more statistics.) A recent example of where the application of the “balanced” fire protection concept would have failed to make a difference in the outcome of a fire with multiple fatalities is the fire at a small nightclub in West Warwick, Rhode Island, on the evening of Feb. 20, 2003. In this fire, exposed foam plastic materials on the stage were ignited by a fireworks display and the nightclub rapidly filled with smoke and hot gases. Since the fire started on the stage, the audience was fully aware of the fire in its early stages, yet 99 people have died as a result of the fire. Since the building was not protected by a sprinkler system, the fire scenario that occurred would have been the same as if the building had been protected by a sprinkler system and the water supply control valve had been closed. Would the results of the fire been different if the roof of the building had had a one- or two-hour fire-resistance rating, rather than non-rated roof construction? The answer to this question would be a definite no, since the occupants who died in the fire were rapidly overcome by smoke and hot gases in the very first minutes of the fire. Would the results of the fire have been any different if the building had been provided with a smoke detection system throughout? The answer to this question would again be a definite no, since the audience was fully aware of the fire at the time of ignition. The only fire protection feature that would have definitely had an impact on the results of the fire would be a sprinkler system. So much for the concept of “balanced” fire protection as it is currently being sold by many of its proponents.

About the Author

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A short (one page) article titled “Life Safety in High-Rise Buildings After 9/11” written by W. Gene Corley, P.E. appeared in the spring 2003 issue of Fire Protection Engineering magazine, the official magazine of the Society of Fire Protection Engineers (SFPE). Mr. Corley, a structural engineer employed by Construction Technology Laboratories, Inc., was part of the team that performed the preliminary study of the collapse of the World Trade Center and wrote the Federal Emergency Management Agency (FEMA) report titled “World Trade Center Building Performance Study: Data Collection, Preliminary Observations and Recommendations” published in May 2002.

The following are a few excerpts from Mr. Corley’s article:

“By 1927, the Uniform Building Code, written by western United States building officials, required buildings that were taller than 8 stories or 85 feet have fire resistance of structural elements of three hours for floors, four hours for columns and beams.”

“Following the adoption of fire-resistance requirements for high-rise buildings, the experience has been very good. No modern fire-protected building had collapsed as a result of a burnout prior to 9/11. Similarly, the fire related casualty rate for occupants of high-rise buildings has been extremely low.”

“In the 1970s [..] it became clear to model code groups that sprinkler systems in high-rise buildings would further reduce the property losses during a fire.”

“Sprinkler systems are mandatory by these codes [the International Building Code and NFPA 5000] in all buildings that exceed 12 stories or 180 feet. While sprinklers can be expected to reduce property loss and contain many fires when they work properly, sprinklers cannot always be expected to function. Sprinklers can malfunction due to inadequate inspection, willful shut off of valves, or catastrophic events interrupting the water supply. Since inspection and maintenance of sprinklers are seldom mandatory in commercial buildings, the potential failure rate is of concern.”

Despite the recognition that sprinkler systems do not always function properly, model building codes have continued to reduce the fire-resistance requirements of structural elements where sprinklers are used...These reductions in structural safety are based on a growing belief that fire-protected buildings will not collapse, even in a burnout.”

“Sprinklers should continue to be mandatory in high-rise buildings. However, it is clear some fires in buildings, both low-rise and high-rise, cannot be controlled. When control is lost, a burnout will occur. For the life safety of those who may be trapped in the building and of those who must fight these fires, the design objective should be that no collapse occurs with a burnout. Also, the burnout considered should be related to the amount of fuel in the building if the fuel exceeds the amount that would produce a standard ASTM E119 fire.”

“Sprinklers should continue to be mandatory in high-rise buildings. However, it is clear some fires in buildings, both low-rise and high-rise, cannot be controlled. When control is lost, a burnout will occur. For the life safety of those who may be trapped in the building and of those who must fight these fires, the design objective should be that no collapse occurs with a burnout. Also, the burnout considered should be related to the amount of fuel in the building if the fuel exceeds the amount that would produce a standard ASTM E119 fire.”

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“The lessons from the horrible tragedy of 9/11 should be used to improve the safety of later generations who live and work in high-rise buildings.”

This article is of interest for a number of reasons: First, it contains a number of obviously erroneous statements and, second, the article appeared in the SFPE magazine, erroneous statements and all.

In the article, Mr. Corley asserts that the fire record of high-rise buildings “has been very good.” He also states that “the fire related casualty rate for occupants of high-rise buildings has been extremely low.” Although this may just be a matter of semantics, it is my opinion that the fire record of high-rise buildings has been far better that just “very good,” it has been excellent, particularly in recent years. NFPA statistics, which have been cited in previous columns in Plumbing Engineer, indicate that fewer Americans die each year as a result of fires in high-rise buildings than those who die as a result of being struck by lightning. There are notable exceptions to this statement, however. In 1980, more than 80 people died in a fire at the MGM Grand Hotel in Las Vegas. One also might cite the fire at the World Trade Center towers on 9/11; however, that fire resulted from a “military-style” attack on the towers, hence, this fire is a special case.

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Mr. Corley also states in the article that “in the 1970s it became clear to model code groups that sprinkler systems in high-rise buildings would further reduce the property losses during a fire.” This statement indicates that Mr. Corley is not acquainted with the history of the development of the high-rise provisions in the 1970s. The inclusion of the requirement to provide sprinkler protection in high-rise buildings had nothing to do with “property losses” whatsoever. Sprinkler protection was mandated in high-rise buildings to provide protection for the occupants and to provide protection for fire department personnel.

Not only is Mr. Corley’s research into the history of the high-rise provisions lacking, but so is his research into the requirements for sprinkler protection contained in the International Building Code and NFPA 5000. He writes that “sprinkler systems are mandatory by these codes [referring to the IBC and NFPA 5000] in all buildings that exceed 12 stories or 180 feet.” In fact, the 2000 edition of the International Building Code (IBC) requires sprinkler protection to be provided throughout all buildings that have floors with a design occupant load of greater than 30 people who are located more than 55 feet above the lowest level of fire department access (see the IBC for exceptions to this requirement).

Additionally, the IBC requires sprinkler protection in all hotels/motels with interior corridors, regardless of the building height, and hotels/motels with exterior egress balconies that are more than three stories in height measured above the lowest level of exit discharge. Furthermore, the IBC requires that all multi-family residential (apartment) buildings that are three or more stories in height (including stories classified as basements) or that include more than 16 dwelling units (regardless of the building height) be provided with sprinkler protection. NFPA 5000 requires office buildings classified as high-rise buildings (buildings with a height exceeding 75 feet measured from the lowest level of fire department vehicle access to the elevation of the highest normally occupied floor) must be protected by a sprinkler system. NFPA 5000 also requires that all hotels/motels – except hotels/motels with exterior egress balconies that are three stories or less in height – must be protected by a sprinkler system.

NFPA 5000 also requires that all apartment buildings be protected by a sprinkler system (with exceptions for apartment buildings designed as townhouses). The actual requirements for sprinkler protection contained in both the International Building Code and NFPA 5000 are far more restrictive than indicated by Mr. Corley. A review of these requirements clearly demonstrates that the rationale behind the requirements to provide sprinkler protection is occupant (life) safety, not property protection. Of course, the installation of sprinkler protection will always provide protection for property.

Mr. Corley again alludes to sprinklers and property protection, stating that “while sprinklers can be expected to reduce property loss and contain many fires when they work properly, sprinklers cannot always be expected to function. Sprinklers can malfunction due to inadequate inspection, willful shutoff of valves, or catastrophic events interrupting the water supply.” Mr. Corley’s statement is, of course, true. Sprinkler systems do occasionally fail, but his statement infers that sprinkler system failures are common events and that the sprinkler system failures result in major catastrophes. If this were actually the case, Mr. Corley should be able to cite cases where the failure of a sprinkler system to control a fire resulted in major life loss. Other than the World Trade Center disaster, I have no recollection of a catastrophic fire occurring in a high-rise building that was protected throughout by a sprinkler system.

In this same paragraph, Mr. Corley states “since inspection and maintenance of sprinklers are seldom mandatory in commercial buildings, the potential failure rate is of concern.” Obviously, he is unfamiliar with build-
ing and fire prevention code requirements regarding the testing and maintenance of sprinkler system installations. In addition to the requirements contained in building and fire prevention codes, NFPA 13 specifically requires compliance with NFPA 25, the Standard for the Inspection, Testing and Maintenance of Water-Based Fire Protection Systems. Non-compliance with the testing and inspection requirements contained in NFPA 25 is a code violation. It is true, however, that the requirements contained in NFPA 25 are often not enforced by the code enforcement authorities typically responsible for enforcing the fire prevention code – the fire service.

Mr. Corley also writes, “despite the recognition that sprinkler systems do not always function properly, model building codes have continued to reduce the fire-resistance requirements of structural elements where sprinklers are used...These reductions in structural safety are based on a growing belief that fire-protected buildings will not collapse, even in a burnout.” This statement again shows a lack of a historical perspective on the “trade-off” in structural fire resistance when sprinkler protection is provided in high-rise buildings. This reduction in the structural fire protection dates back to the development of the high-rise provisions in the early and mid 1970s. More than a quarter century of experience with “trade-offs” in structural fire protection when sprinkler protection is provided clearly has demonstrated that sprinkler systems are sufficiently reliable to justify this “trade-off.”

NFPA fire statistics show a dramatic reduction in the number of civilian fire deaths (down from 7,395 deaths in 1977 to 4,045 deaths in 2000), civilian fire injuries (down from 31,190 injuries in 1977 to 22,350 injuries in 2000) and firefighter deaths (down from 157 deaths in 1977 to 102 deaths in 2000) in the last quarter century, despite the fact that the population of the United States has grown from 226 million people in 1980 to 280 million in 2000. While there are numerous factors that account for these reductions, including safer electrical and heating equipment, fewer people smoking, the installation of smoke detectors in dwelling units, better code enforcement and better fire departments, Mr. Corley provides no evidence that buildings are less “safe” because of reductions in the structural fire protection of buildings allowed when sprinkler protection is provided.

In the second to last paragraph in the article, he states that “sprinklers should continue to be mandatory in high-rise buildings.” Given his previous statements regarding
the lack of reliability of sprinkler systems, one certainly wonders why Mr. Corley would continue to support the installation of sprinkler protection in high-rise buildings. Surely, when it comes to the protection of the occupants of high-rise buildings and firefighters, and a choice between structural fire protection and sprinkler protection, it is clear that sprinkler systems provides far superior protection when compared to structural fire protection.

The second to last paragraph in the article continues with “however, it is clear some fires in buildings, both low-rise and high-rise, cannot be controlled. When control is lost, a burnout will occur. For the life safety of those who may be trapped in the building and of those who must fight these fires, the design objective should be that no collapse occurs with a burnout. Also, the burnout considered should be related to the amount of fuel in the building if fuel exceeds the amount that would produce a standard ASTM E119 fire.”

While Mr. Corley’s topic appears to be confined to high-rise buildings, the above statement expands his opinion on the structural stability of buildings under fire conditions to both high-rise and low-rise buildings. In essence, he is advocating the elimination of unprotected wood and unprotected steel construction, in both sprinklered and unsprinklered buildings, regardless of the size or use of the building. A bold proposal to be sure, but Mr. Corley offers no statistics to support his proposal. Just how many American civilians and firefighters typically die each year as a result of structural collapses caused by fire?

It is interesting to note in the statement quoted in the preceding paragraph that Mr. Corley proposes that buildings should be constructed to remain stable during a “burn-out” of the building, but he doesn’t provide any elaboration on the conditions under which the “burn-out” occurs. Should the design of the building anticipate structural damage before the fire occurs, as in the World Trade Center disaster, for instance? And what fuel should the building design assume is burning during the “burn-out”? The fuel typically found in the building, or should the design anticipate that a large flammable liquids fire occurs on multiple floors, as in the World Trade Center disaster, for example?

The article concludes with the statement that “the lessons from the horrible tragedy of 9/11 should be used to improve the safety of later generations who live and work in high-rise buildings.” Yes, the collapse of the World Trade Center towers was a horrible tragedy, yet, fortunately, the design of the building was able to limit the number of fatalities to roughly 3,000 people. That is fewer than the number of Americans who died as a result of traffic accidents in the month of September 2001, and fewer than the number of Americans who have died in traffic accidents each and every month thereafter. As a safety engineer, it seems like common sense to me that the death of more than 40,000 Americans on our nation’s roads each year is a far greater tragedy than the World Trade Center disaster, and that addressing our nation’s traffic safety problem should be a far higher priority than addressing the problem of building collapse due to terrorist attacks.

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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.

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