

# structural forum

## World Trade Center Disaster

### Sifting Through the Debris

By Jim DeStefano

Since the tragic collapse of the World Trade Center towers over two years ago, a plethora of reports and studies have been printed examining every aspect of the buildings' construction and performance. I have sifted through many of the reports, desperately searching for lessons that our profession should learn from the tragedy.

It is clear that the structural frames displayed remarkable redundancy and robust performance immediately following the aircraft collisions. The towers continued to stand after suffering significant structural damage, allowing thousands of the building occupants to escape. Had it not been for the ensuing fires, the towers might still be standing today.

The active fire protection systems in the towers were not capable of suppressing a fire that engulfed several floors, even if the systems had not been disabled by the collisions. There is some evidence that much of the spray fireproofing that provided passive fire protection to the structural steel had become dislodged. The structures were defenseless against the intense heat of the fires.

Arthur Scheurman, Battalion Chief FDNY (retired) has released a report that is very critical of the Building Codes and of the WTC construction (go to [www.structuremag.org](http://www.structuremag.org) for the full text of the report). While many in our profession have rushed to the defense of our Building Codes, Mr. Scheurman raises some interesting points.

*"Fire protection is delegated to the Architect..."*

As structural engineers, we are committed to designing structures to resist natural disasters such as hurricanes, floods and earthquakes. But we pay very little attention to the fire resistance of our structures. Fire protection is delegated to the Architect, who is seldom interested in doing any more than the Building Code or local Fire Marshall forces him or her to do. Is it any wonder that members of the firefighting community view Architects and Engineers as part of the problem rather than part of the solution?

In recent history, there have been two major high-rise fires in this country, the 62 story First Interstate Bank fire in Los Angeles (1988), and the 38 story Meridian Plaza fire in Philadelphia (1991). In both cases, the buildings sustained significant fire damage but did not collapse. We had become complacent and believed that we were doing everything right. On September 11, 2001, not only did the WTC towers collapse due in part to fire, but WTC Building 7 collapsed due to fire alone.

Firefighters have long known that lightweight floor structures perform poorly in fires. Structural engineers seldom consider this when selecting the structural system for a building. It is often a source of pride in our profession to design an efficient high-rise or long-span structure with a low structural weight.

*"...considering banning bar joist construction from high-rise buildings."*

New York City is currently considering banning bar joist construction from high-rise buildings. Although the floor trusses used in the WTC towers are technically not bar joists, they did resemble bar joists.

The most popular material used for passive fire protection of steel structures is low-density fiber spray fireproofing. This material is not particularly durable, and can be dislodged from the steel by the stream from a fire hose. Current E119 fire testing of structural assemblies does not subject the assembly to a hose stream. Medium-density spray fireproofing materials are far more durable, but are seldom specified due to their higher cost.

The lesson that we should learn from the WTC disaster is that structural engineers need to get more involved in the passive fire protection of our structures. This does not mean that we need to become fire experts and analyze fire effects as a loading condition. It means that we need to consider the fire resistance of the structural systems that we design, and we need to take an active role in specifying and inspecting the passive fire protection system applied to the structure.

*Jim DeStefano is the Principal of the structural engineering firm DeStefano Associates, and is a Partner in the firm of Coastal Engineering Partners. Jim currently serves as the Chair of the STRUCTURE magazine Editorial Board.*



New York, NY, September 27, 2001 -- New York City firefighters battle smoldering blazes from a fire truck at the World Trade Center. Photo by Bri Rodriguez/ FEMA News Photo

# Our Buildings and Building Codes are Safe

By Charles J. Carter, S.E., P.E.

While building fire safety is today the role of the architect, perhaps there is a more prevalent role for structural engineers in the future. It is wrong, however, for engineers and building codes to be criticized based upon the results of deliberate and malevolent terrorist actions against the World Trade Center towers and Pentagon. It is also wrong for representatives of special interests to attempt to use these tragedies to advance their agendas.

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*“...the worldwide statistics for high-rise buildings include only 17 cases of fire-induced collapse...”*

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Simply stated, the U.S. record of life safety in all buildings and all materials is exemplary, particularly as it relates to resisting fire-induced collapse. Since 1970, the worldwide statistics for high-rise buildings include only 17 cases of fire-induced collapse: six reinforced concrete buildings, two structural steel buildings, five masonry buildings, two wood buildings, and two buildings of unknown construction material. Nine of these cases affected buildings located in the United States. When compared to the number of significant fires that occurred in high-rise buildings in the United States during this same time period, the effectiveness of our building codes and structural systems in preventing collapse and protecting life safety is emphatically impressive.

On September 11, 2001, three WTC complex buildings (WTC 1, 2 and 7) and the Pentagon suffered collapse due to a combination of structural damage and fire effects. These effects were extreme in all cases – even for WTC 7, which the National Standards and Technology (NIST) now reports did have significant structural damage on September 11, 2001, contradicting earlier reports.

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*“...emotions surrounding these events have played far too great a role in what we seem to be seeking to learn...”*

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There are many things we can learn from the performance of these and the other affected buildings. But the emotions surrounding these events have played far too great a role in what we seem to be seeking to learn – or are being told. Some representatives of the fire service

and victims’ families have been vocal critics of the engineering and construction of the WTC towers. The emotional impact of September 11, 2001 is strong.

But should engineers and building codes be blamed? I don’t think so. I believe we should honor the engineers who created these buildings, which withstood unimaginable events and permitted tens of thousands of people in two of them alone to escape. Are there any other buildings that could be expected to do the same under similar circumstances?

As we consider what changes are appropriate for our building codes and engineering practices, I also think it is important to act upon technical facts, and not be swayed by emotions and agenda-driven “solutions”, such as:

- The fire service has long opposed much of the progress in building design and construction technology, citing reductions in fire safety, particularly for emergency responders. Yet the leading cause of death among fire service personnel remains stress and overexertion during firefighting operations. For all the good intentions we must assume led to the Scheuerman report, its technical claims are of questionable benefit for routine fire design. Furthermore, it is likely that nothing recommended in it that would have changed the outcomes we all experienced on September 11, 2001.
- Concrete and fire protection industry representatives have rejuvenated age-old criticisms of sprinkler performance and the building code provisions that surround them, quoting National Fire

Protection Association (NFPA) statistics. Yet those very same statistics – which NFPA has repeatedly stated are being abused by those industry representatives – show that the addition of a sprinkler system is the only design choice that reduces the fatality rate in building fires.

- Concrete trade groups are touting inherent fire resistance, lower insurance premiums and lack of fire damage in reinforced concrete. Yet the technical literature establishes quite the opposite: fire can and does significantly damage reinforced concrete structures. Additionally, there is no basis upon which to claim insurance premiums are lower for any construction material that qualifies for a certain class of construction.
- Concrete and masonry trade groups are also promoting the use of concrete and masonry walls based upon the events of September 11, 2001. Apparently they have not read the Pentagon building performance report, which shows that many such walls were obliterated in the damage swath in the Pentagon.

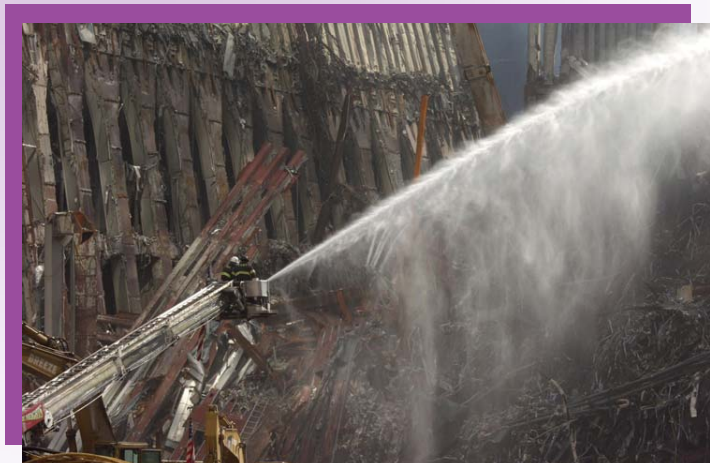
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*“...fire can and does significantly damage reinforced concrete structures.”*

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There are many more examples, but the bottom line is exactly as an independent structural engineer not swayed by special interest would expect. All modern building materials are safe and effective when we use them properly and appropriately. And conversely, all modern building materials can be unsafe and ineffective when used improperly and inappropriately.

*article continued on page 12*



New York, NY, September 26, 2001 -- New York City Fire Department firefighters continue to extinguish smoldering fire that has burned in various areas of debris at the site of the collapsed World Trade Center since the terrorist attack two weeks ago. Photo by Mike Rieger/ FEMA News Photo





New York, NY, September 29, 2001 -- Firefighters continue to battle smoldering fires at the World Trade Center. Photo by Andrea Booher/ FEMA News Photo

Building fire safety is today the role of the architect. Assuming compensation and risk issues can be addressed, the capable structural engineer or a fire engineering consultant could assume this role, either for the selection of prescriptive protection systems or the use of a more advanced fire engineering approach. Whatever we do, let's just not forget that our buildings and building codes are safe.■

*Charles J. Carter is Chief Structural Engineer with the American Institute of Steel Construction, Inc. (AISC) in Chicago. He is a registered Structural Engineer and Professional Engineer in the State of Illinois. Charles currently serves on the Editorial Board for STRUCTURE magazine.*

**Editor's Note:** It's clear from articles by others outside the structural engineering community that suggestions for improved fire safety will have structural implications. STRUCTURE magazine does not endorse or recommend any of the strategies outlined in these articles at this time, but encourages the structural engineering community to stay abreast of, and involved in, the issue.

What are others saying about the World Trade Center disaster? "The Towers, Fire- Induced Collapse, and the Building Codes" by Arthur Scheuerman, Battalion Chief FDNY (Ret.), former Instructor Nassau County Fire Training Academy and high-rise Fire Safety Director for NYC, cites a changing attitude in code development in New York City since 1968 that reduces fire safety in high-rise buildings.

Mr. Scheuerman makes several recommendations to NIST for its follow up studies and for building code changes. One specific change is to separate high-rise buildings into at least two areas for the full height of the building with a 4 -hour rated fire/blast wall. He also suggests 4-hour rated, hardened corridor walls to link stairways. Each is aimed at greater safety for egress and firefighting.

Arthur Scheuerman's article is available for review on the STRUCTURE website, [www.structuremag.org](http://www.structuremag.org). STRUCTURE magazine has a new section on the website dedicated to these types of structural issues. Please visit our FORUM pages, and follow the discussion. If you know of an article, report or website link that should be included in FORUM, please email [publisher@structuremag.org](mailto:publisher@structuremag.org)

Many other articles have been written that present suggestions for changes in the way high-rise structures are designed and constructed. An excellent source for links to these articles is the Penn State Architectural Engineering "World Trade Center" pages ([www.engr.psu.edu/ae/WTC/WTCTragedy.html](http://www.engr.psu.edu/ae/WTC/WTCTragedy.html))

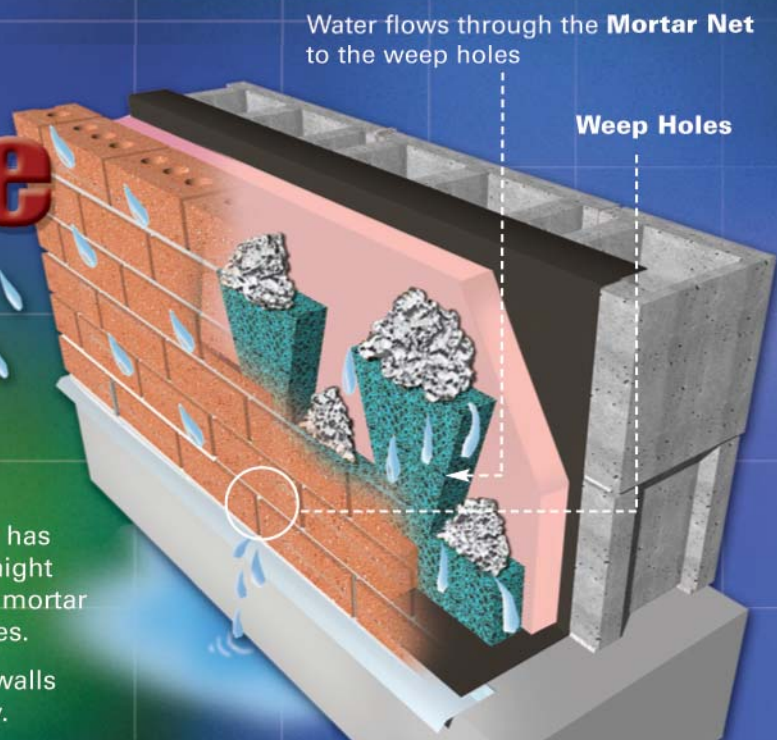
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