Nothing can ever turn back the clock or make up for the lost lives of family, friends, associates, and neighbors at the World Trade Center, the Pentagon and in the Pennsylvania airplane crash. Much has and will be said and done as a result of the evil deeds perpetrated on people who never even knew their attackers. In all this cowardly destruction, while the terrorists betrayed our hospitality and took advantage of our freedoms to try to destroy them, the reason the terrorists didn’t achieve the level of mayhem and destruction they had wanted, was because they misestimated the quality of American construction, just as much as they misestimated the courage of Americans, so agonizingly demonstrated by those few good heroes who rushed the hijackers over Philadelphia as soon as they knew the stakes.

In this article, as well as paying tribute to the 15 men (known at this time, one week after the incident) in our trade who lost their lives while going about their work, we have decided to focus on a positive note that many have commented on in passing—the fact that the construction of all three buildings targeted was so solid, that hundreds of lives were saved in the Pentagon, and thousands at the WTC. While we mourn the ghastly, unjust and unmerited end each individual faced at the WTC and the Pentagon, the spirit in which they lived their lives, lives on in all of us. It is the same spirit that made America a great and free nation, the bastion of democracy and the hope for many downtrodden men and women. It is a spirit that forged a country and society out of many parts into a solid whole. And in the same way, it is the spirit that built two of the largest and most memorable building complexes in the world: the World Trade Center and the Pentagon.

As industry professionals, therefore, let’s examine from a physical standpoint, what made the buildings the symbols around the world that they are, and then let others know that these buildings were made in America, and that they saved countless lives despite the greatest of evils. And despite the fact that, according to Robert Vecchio, a metallurgical engineer, “Only the containment building at a nuclear power plant” is designed to withstand the ferocity of the onslaught these buildings experienced.

Day of Infamy

The two giant towers amidst the seven buildings of the World Trade Center rested solidly on bedrock 70 feet below ground level, secure on an 800 x 400-foot foundation box with 3-foot-thick retaining walls, and reached over a quarter of a mile into the sky. They represented the best in “tube buildings,” framed with load bearing exterior walls comprised of 240 14-inch structural steel box columns spaced 39 inches apart, not the usual 20-25 feet, and bound together by steel trusses. Each tower was, in effect, wrapped in a giant, steel tube.

The towers were constructed with major supporting elements on the outer sections in order to increase stability during high winds—not because the building would move almost a foot in either direction, but because it might vibrate like a tuning fork and so fail at a given frequency. Ten thousand dampers or shock absorbers were also built in to convert the wind’s energy into heat.

With the exterior providing all lateral resistance, light horizontal steel trusses were adequate to span the 60 feet from the exterior wall to the steel core which, containing only lift shafts and stairs, was designed to carry only gravity loads. The 40,000-square feet of flooring were made of 4-inch concrete on thin metal decks, while pipework, ducts and cables were concealed in a 20-inch space above ceiling tiles.

In all, the towers’ 200,000 tons of steel and 425,000 cubic yards of concrete sheltered the majority of 50,000 people working and visiting the WTC each day The towers were built to withstand the impact of an airplane and, as the terrorist attack of Feb. 26, 1993, proved, even bombs. That particular attack blew a 60-by-100-foot hole in the basement, but took out only one section of an X-brace in the north tower basement and sections of three structural slabs. The structural integrity of both towers was unaffected.

But they were never designed to withstand a 100-ton Boeing 767 being flown at 500 or more miles an hour, fully loaded with 20,000 gallons of high-octane fuel. One expert estimates the force of the impact to be in the neighborhood of 10,000 tons, more than double the design capacity of the towers under hurricane-strength winds.

Despite this, neither of the buildings collapsed under this terrific onslaught, even though the planes breached the perimeter columns and embedded themselves completely within the buildings, possibly as far as the building cores.

When a relatively small B-25 bomber crashed into the 79th floor of the Empire State Building in 1945, the resulting explosion and fire killed 14 people, but the building remained structurally sound.

The key difference between the two incidents was the 30 tons of fuel being carried by the 767s. It was the conflagration of the tens of thousands of gallons of fuel that brought down the towers, not the impact of the giant aircraft.

The explosion on impact was followed by burning fuel pouring over several floors, fed by the breach to the air opened by the airplane. The aluminum from the aircraft wreckage burned at over 600 degrees centigrade, helping raise temperatures to around 1,000 degrees. While fireproofed steel melts at 1,500 degrees, the high temperatures were sufficient to soften, warp and ultimately buckle the columns on the ignited floors and those that lay above.

It appears the floor diaphragm, which was a vital component in bracing the exterior columns, then lost connection to the exterior wall, causing the exterior columns to buckle outward and the top floor with all its contents to drop onto the floor below, overload it and so setting off the progres-
Rushing to the Rescue

From Day One, construction companies around the country have either been at Ground 0 or helped those at it in any way they could, whether it was cutting through steel beams bringing in equipment, donating supplies or manning the phones.

Members of the Association of the Wall and Ceiling Industries—International have been part of this outpouring of support. According to AWCI Executive Vice president Steve Etkin, “Michael Ford, executive vice president of the New York District Council of Carpenters, and Joe Olivieri, executive vice president of the Association of the Wall-Ceiling & Carpentry Industries, New York, are working together to ensure that 3,000 sets of hard hats, safety goggles, masks and gloves are purchased and delivered to the relief workers at the WTC.

“One of our supplier/distributor companies on the West coast, Nathan Kimmel, is donating more of the same kind of materials as well. Ford and Olivieri are also putting together a fund to benefit the families of the 15 carpenters who lost their lives in the WTC. Other actions being taken among the-se initial and immediate responses include the New Jersey chapter (Drywall & Interior Systems Contractors Association) providing clothing to the relief workers.” Etkin said that other chapters also are contributing to local efforts.

AWCI has been in touch with almost all chapters, asking for cash contributions to the American Red Cross. The response has been 100 percent unequivocal support. Etkin expects that, as a group, “we’ll be contributing well over $30,000.”

Any individuals wanting to make donations to the American Red Cross can do so via their local chapter, or call 1-800 GIVE LIFE. The Federal Emergency Management Agency’s Web site, www.fema.gov, also has information.

Sixty Years on

Meanwhile, another of the world’s largest buildings, with the equivalent floor space of three empire state buildings, was under attack—60 years to the day after ground was broken for its construction on Sept. 11, 1941.
Covering 34 acres and 4,600 feet in circumference, the 6.5-million square foot Pentagon was built as a temporary site for the headquarters of the Department of Defense. The five-sided building was designed with five concentric rings each with five floors, all built of reinforced concrete with a wood and slate roof—none of it fire—or bomb-resistant material. Steel was used sparingly, because it was better utilized in building ships, tanks and artillery pieces for the war effort. As a result, as President Roosevelt boasted later, enough steel was saved (45,000 tons) to build a battleship, which in those days required 43,000 tons.

A Silver Lining

It seems the hijacker made a strategic error in his last-minute change of target from the White House to the Pentagon, because he flew into the first of the five wedges to be fortified under a $1.22 billion renovation program. In fact the renovations were 99.9 percent completed. One consequence was that Wedges One and Two were only half full of personnel—the rest having been moved to temporary offices nearby. But the main consequence was that the damage and mayhem were significantly minimized as a result of the improved defensive capabilities of the building.

In Recognition of those Who Died in the Line of Duty

Larry Cooley, AWCI President, is based in New York and heavily involved in the aftermath at the WTC. He has a brief message for the membership: “We have experienced a terrible tragedy, it means different things to different people. While it has impacted us all, it has been particularly trying for those closest to the tragedies, the people in Washington, D.C., New York and those with friends and relatives on the fight that crashed in Pennsylvania. The important thing is that we all stay the course.”

To the 15 of our profession known to have lost their lives because they went to work on September the 11th, these family members, these constructive and valuable members of their companies and society, we honor you for the lives you lived, the people you helped and cared for, the good times and the bad. May your souls rest in peace.

For the families and friends who feel the sharp blade of loss digging deep into your heart, there is little that can be said. The whole world feels your pain. It may help, through your grieving, to try to remember the words of one sage:

“Never regret yesterday. Life is in you today and you make your own tomorrow.”

There is a future and your ultimate way of winning against the evil that took away the one you loved or counted as a friend, is to be in it, stronger and full of life. Perhaps that is what the person you lost, would most want from you now.

The reason the Pentagon had initiated the renovations in the 1990s, according to Tom Fontana, communications officer for the Pentagon Renovation Program, was to address the fact that “the building did not meet any major building codes: heating, ventilation, plumbing, fire, life safety,
Americans with Disability Act. Because it hasn’t met the electrical codes since 1953, the building experienced 30 localized power outages each day. The building infrastructure had made it difficult to accommodate the seven major changes in technologies over the last six decades; so many conduits and outlet boxes were surface mounted and wires hung down the walls. The increased need for HVAC for cooling computers resulted in problems, and on any given day, the building manager received 60 temperature-related problem calls.

“We determined to renovate one wedge at a time, the same way the Pentagon had been built. Each wedge is a standalone building in many ways, connected at the midpoint between one facade and the other. Part of that wedge has an essential utility distribution system that emanates out to that wedge barrier. So as we took down each wedge in renovating, we had to keep the rest of the building operational, allowing the conduits and communication lines to run through. One of the biggest challenges was dealing with building drawings that had been seldom updated. We almost had to start from scratch and trace every line, conduit and pipe going through the wedge to avoid cutting off somebody on the other side of the building. But these issues were managed and we eventually completed the work

“So it was somewhat fortunate, in a perverse way that the major impact was in this exact area that had been fortified with steel, blastproof glass windows, mesh material to prevent fragmentation of debris, modern sprinkler, fire and life-safety systems, and a PA system that enabled us to alert folks. Firewalls were installed to prevent smoke filtering through corridors. All these things helped, we believe, to minimize the number of casualties.”

**Saving Lives**

When the Boeing 757 flew at full power into the southwest face of the Pentagon, between the newly renovated Wedge One and the about-to-be renovated Wedge Two, it cut a swathe through the first two floors of the first two rings and into the middle “C” ring, where the plane’s nose was found. Fontana states, “The steel reinforcements connected ceiling to slab on all five floors created a web of
steel that slowed down the aircraft and prevented it from reaching the interior two rings.

“Because the building is held up by concrete, much shorter support expanses existed between columns—10 feet off center, typically compared with the 30- to 40-foot expanses of steel. So wherever a column was sheered by the plane’s motion, there was another column within 10 feet to help hold up the adjacent structure.

“Support columns on the first floor and some on the second floor were destroyed but in the end, only part of the outermost ring collapsed completely. A blast effect traveled either side of the impact area and a fireball, fed by 11,000-gallons of aviation fuel, consumed about one-twelfth of the building and ultimately rendered 20 percent of it unusable.

“But it was the renovated Wedge One that restricted the effect of the plane’s collision and blast. The blast-resistant windows immediately adjacent to the impact were still in place, while 150 feet from the impact zone, in the unrenovated portion, windows were blown out.”

When the nose of the plane punched across into Wedge Two, the inadequate sprinkler system there failed to prevent most of the fire damage sustained, while the fire was more easily contained in the renovated section.

“The reinforcing in the facade helped keep the building standing,” explains Fontana, “even after the plane had entered. Our engineers credit the steel not only for holding up the cantilevered portion but the whole portion directly above the crash. With the third to fifth floors still intact for 30 minutes after impact, even above the entry point, people were able to leave their offices. That would not have been the case if the plane had hit a section that had not been renovated. One of our employees, in fact, was doing punch list items above the impact zone and was able, with a colonel and a major, to crawl through the third, fourth and fifth floors looking for victims directly above the crash site.”

Fontana’s best guess, given the amount of people in the area, is that for every life lost, three times as many were saved as a result of the renovations carried out in so timely a manner. A more accurate count will be available later.

Rising from the Ashes

And so what is next? At the Pentagon, contractors are being mobilized right now in three shifts, 24 hours a day, seven days a week to bring the building back to order as soon as possible, including quarrying the limestone for the facade from the original site in Indiana. In New York, volunteers and officials are coming together to clean up the horrifying carnage and destruction. When that is done, no doubt, the buildings will rise again.

The Structural Engineering Institute of the American Society of Civil Engineers is investigating both sites to see what lessons can be learned and applied. The buildings that will reappear from the rubble one day will be even better than those destroyed by the wretched flotsam and jetsam of humanity that leveled them.

Perhaps each building will be dedicated to the memory of those who died on those grounds, so they, too, can live on, even if only in our memories. And for those who survived because the construction and design of the buildings allowed them to escape in time, there may be a small sense of victory—that no amount of evil and destruction, however overwhelming, will ever triumph over decency and creativity.

About the Author

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