Performance of Masonry at The World Trade Center

Reported by David T. Biggs, P.E. of Ryan-Biggs Associates

Georgia Masonry Institute
Vol. 2.8
August 2004

On September 11, 2001, airplanes struck two 110-story office towers in New York and the Pentagon in Washington, D.C. The towers (WTC 1 and WTC 2) collapsed in less than two hours, and another building in the complex (WTC 7) collapsed later in the afternoon. These buildings had few or no masonry components. All of the surrounding buildings suffered damage from falling debris, wreckage, and fire from the towers. While the impact of portions of the collapsing buildings did the majority of harm, there was also damage from flying debris and air to the masonry used in their construction.

The Investigation

Six days after the attacks, teams of engineers, notably from the Structural Engineering Association of New York and the New York City Department of Buildings, began evaluating the structural integrity of over 400 buildings surrounding the WTC site. Using a rapid visual evaluation system, they performed immediate assessments and made decisions regarding continued use and occupancy of buildings in lower Manhattan. Damage was described as either structural or collateral. The buildings with structural damage were inspected in detail. Buildings immediately surrounding the plaza were most heavily affected by the disaster. They were generally constructed from 1906 through the 1980s; most had some masonry components.

Masonry Performance: Verizon Building, 140 West Street

One of the closest neighbors to the WTC site, the 30pstory Verizon building, is a steel-framed, brick building constructed circa 1924. The typical floors, composed of concrete-encased steel beams and girders, are redundant and robust. The exterior face of the perimeter framing is encased in brick and serves as both exterior wall and infill. Header bricks connect the exterior brick to the backup and support the weight of the exterior wythe. Columns are also brick encased.

The façade, floors, and framing of the south and east sides of the building sustained heavy damage, as did several exterior columns. Although the framing deflected as much as 2 feet into the building, the masonry infill restrained the columns from collapse. The steel structure was not affected. None of the damage threatened the structural integrity of the building. And although there was a substantial fire in WTC 7, there were no fires reported in this building. It was never out of service. The structure was shored and repaired.

Masonry improved the performance of the Verizon Building because:

- Perimeter brick masonry walls absorbed much of the impact from both WTC 1 and WTC 7, resulting in less damage to the steel structure.
- Masonry infill of the exterior wall provided a redundant load path and helped prevent collapse.
- Framing damage was localized, partially due to masonry infill.
- Exterior brick headers held the upper brick from collapsing above a damaged section.

- Brick encasement of the columns and concrete encasement of the steel framing provided fire and impact resistance.
- Built-up sections appeared to be more ductile and better able to absorb energy along with the masonry info.
- The building did not experience fire damage - masonry and (safety glass) windows limited penetrations through exterior walls.

Summary

In the towers themselves, the stairwell and elevator walls were constructed of gypsum products. Evidence indicates most of the floors of impact were damaged and rendered unusable. While it is presumptuous to assume that masonry enclosures would have survived the attacks, it is obvious that more durable wall systems would have improved chances for survival for occupants above the level of impact. Future research should be devoted to evaluating and developing durable, fire-rated egress enclosures for high-rise buildings. Reinforced masonry and concrete are two effective solutions that can be used without further development.

Example after example demonstrate how masonry helped prevent greater destruction during the World Trace Center disaster. Some of the lessons learned:

- Older framed buildings with masonry components performed generally better than newer buildings with lightweight curtain wall construction.
- Masonry (walls, beams, partitions, infill) served as fireproofing and provided significant structural redundancy.
- Masonry infill absorbed impact energy to minimize damage locally.
- Masonry veneers and panelized systems are readily repaired.

Masonry proved in this event that it does more than simply enclose space; it provides fire protection, structural capacity, and even structural redundancy. It can provide safer enclosures for stairways or other exit routes, affording egress in high-rise buildings during emergencies.