One World Trade Center

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The world knows what happened in Lower Manhattan on September 11, 2001. The twin towers of the World Trade Center and several other buildings were damaged or destroyed, and more than 3,000 people were killed. The ground smoldered for months. Rescue was replaced by recovery, which was followed by eight brutal months of removing thousands of tons of debris from what became known as Ground Zero. What most people do not realize is that reconstruction of the 6.5-hecatre (16-acre) site began soon after the cleanup, due to the fact that the initial work began underground and was therefore out of sight.

One World Trade Center (1WTC), designed by Skidmore, Owings & Merrill LLP (SOM), has risen on the northwest corner and dominates the site, not merely as New York City's (and North America's) tallest building, but as an icon representing perseverance, innovation, and urban modernism. While, in an era of super-tall buildings, big numbers are the norm, the numbers at One World Trade are truly staggering: 5,660 cubic meters (200,000 cubic feet) of concrete, 92,920 square meters (one million square feet) of exterior glazing, 40,800 metric tons (45,000 US tons) of structural steel, and 241,550 square meters (2.6 million square feet) of office space. But the real story of One World Trade Center is the innovative solutions sought for the unprecedented challenges faced in building a project of this size on such a difficult site.

The site sits over a vast tangle of existing subterranean obstacles. The new tower bridges existing PATH train tracks adjacent to existing subway tracks and accommodates a planned network of new development as well. The new World Trade Center Transportation Hub alone occupies 74,300 square meters (800,000 square feet) to serve 250,000 pedestrians a day. The resulting underground challenges can be likened to a four-dimensional chess game. First of all, obstructions existed three dimensionally in overlapping planes at varying depths. Secondly, per the brief, PATH train service had to remain operational and existing structures had to be preserved throughout excavation and construction.

Bridging over the tracks was certainly an engineering challenge. "We used state-of-the-art methods of analysis in order to design one of the primary shear walls that extends all the way up the tower and is being transferred at its base to clear the PATH train lines that are crossing it," explains Yoram Eilon, vice president at WSP Cantor Seinuk, the structural engineers for the project. "…we designed a steel structure that bridges over the tracks, which supported the wet concrete loads during construction and was eventually integrated into the permanent structure."

Structural Design - The tower's structure is designed around a massive, redundant steel moment frame consisting of beams and columns connected by a combination of welding and bolting. Two large Manitowoc cranes – the largest ever used in New York City – positioned the steel columns and nodes, the largest weighing as much as 72.5 metric tons (80 US tons). Paired with a massive concrete-core shear wall, the moment frame lends substantial rigidity and redundancy to the overall building structure while providing column-free interior spans for maximum flexibility. 1WTC is the first project in which 14,000 psi (pounds per square inch) concrete was used in a New York City project. The standard for high-rise buildings in New York was maxed out at 8,000 psi. Since then, 12,000 psi has been used in numerous projects in the city.

The use of a hybrid system of high strength concrete core and structural steel moment frame at the tower perimeter results in an efficient structure. Additionally, the fact that the tower tapers as it rises coupled with the chamfered corners on the floor's footprint forms an aerodynamic and structurally efficient shape. In New York City skyscraper design is governed by wind loads. The geometrical shape of the tower reduces exposure to such loads, as well as the amount of structural steel needed, and, thus, the demand on the lateral system of the tower.

Safety Design - Seven World Trade Center, the first rebuilt structure near Ground Zero, was completed in 2005. The 52-story, 226-meter (741-foot) tower provided an opportunity to enhance the original tower's pure form with precision detailing. Simultaneously, the next generation of life-safety standards was integrated subtly into the infrastructure. The structure incorporates enhanced fireproofing for the structural steel that exceeds current codes. Its core is enclosed by up to three feet of reinforced concrete. There are dual interconnected fire standpipes and extra water storage to allow for high capacity sprinkler heads. If a standpipe is cut or broken, the interconnecting valve automatically cuts off water supply to that standpipe and redirects it to the other standpipe, ensuring that every other floor has sprinkler protection.

In addition to a concrete-enclosed core, the tower includes a protected tenant-collection point on each floor and a separate stairwell for first responders. These features are architecturally integrated into the design without lessening efficiency or constructability. The building incorporates highly advanced state-of-the-art life-safety systems that exceed requirements of the New York City Building Code and lead the way in developing new high-rise building standards.

While the building incorporates unprecedented security, the perception is one of openness and accessibility, which will be a humanizing element for the five million annual visitors expected in the adjacent park. Designed in collaboration with landscape architects Peter Walker and Partners, the collective vision is to connect the tower with nearby neighborhoods and allow views and access into the memorial.

Architectural Design - Entrances, identified by glass canopies and highly transparent glass cable-net wall systems, penetrate the base on all four elevations. The main lobby wraps around the central core and is filled with daylight entering through the entrances and clerestory windows in the north and south walls. As the tower rises from the base, it tapers and its square edges are progressively chamfered, thereby transforming the square into eight tall isosceles triangles in elevation (four that point up and four that point down, alternating). At the halfway point up the tower, the tower forms a perfect octagon and then culminates in a square, glass parapet rotated 45 degrees from the base. The resulting crystalline form captures an ever-evolving display of refracted light: As the sun moves through the sky or onlookers move around the tower, the surfaces appear like a kaleidoscope, changing throughout the day as light and weather conditions vary. The office floors are topped by rooftop observation deck at 415 meters (1,362 feet) with a glass parapet extending to 417 meters (1,368 feet), the heights of the original Twin Towers.

The curtain wall begins at the 20th floor and continues to the observation deck. Architects developed a thermally broken unitized wall system that incorporates insulated glazing units (IGUs) of a new monumental scale that is capable of withstanding the wind pressure experienced by a super-tall building while also meeting stringent security requirements. The metal spandrels are painted a pewter color and are positioned slanting inward. The result is a curtain wall designed for maximum daylight, while reinforcing the tower's monumentality.

Building tenants are educated on building infrastructure, from simple, metal walk-off grilles at major entrances to MERV 16 high-efficiency particulate filters and gas-phase filtration to serve the outside-air intake system and air-handling units on each floor. Written guidelines and an exemplar space help tenants incorporate sustainable strategies in their fit-outs.

For example, individual electrical-supply meters encourage tenants to reduce energy consumption and meet the building's goal of a 25 percent reduction in energy consumption. In addition, strategies for using low-emitting materials – paint, adhesives, wood, fabrics, and carpet – are outlined. The tower is partially powered by 12 hydrogen fuel cells, expected to generate 4.8 megawatts of power for 1WTC and other buildings on the site.

Spire -The spire perform multiple functions, most of which involve broadcasting and digital communication. It is a hybrid structure, consisting of two major components: a 137-meter (450-foot) spire and a three-level communications platform ring. At the base of the spire, the circular lattice ring supports point-to-point microwave dishes, steerable Electronic News Gathering antennas, and whip-type radio communication antennas.

Adapted from "Case Study: One World Trade Center, New York," Kenneth Lewis and Nicholas Holt, Skidmore, Owings & Merrill LLP.