Designing Against Terrorism

Midway through the design phase on 11 MetroTech Center, an increased awareness of terrorism required basic modifications to the structural system

Photo courtesy of Paul Jeremiah

By Gary Steficek, P.E.

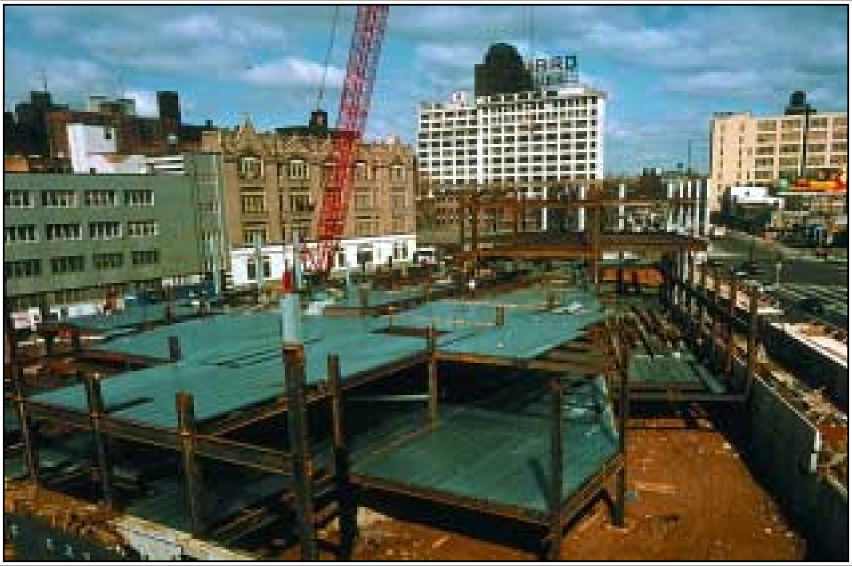
IN ADDITION TO THE NORMAL CHALLENGES OF A TIGHT BUDGET AND A DIFFICULT SITE, the recently completed, the six-story, 313,000-sq.-ft. New York City Technology Center at 11 MetroTech Center in Brooklyn, NY, had to overcome fears of a future terrorist attack. The facility houses New York City's Department of Information, Technology and Telecommunications (DoITT), as well as the N.Y.C. Police Department's new Enhanced 911 Service Center.

The police department occupies the first three floors, while DoITT's offices are located on the next three floors, with two floors of mechanical systems above that.

The owner's program was more complicated than that for most private owners, with the design criteria for the tenant floors included providing a 2-ft.-high raised floor to allow maximum flexibility access to computer and other services. Project owner is Forest City/Ratner Group, New York City. The floors were designed to a live load of 150 psf and floor-to-floor heights reached 16-ft.-6-in. in order to provide adequate ceiling height and room for ductwork without penetrating the steel framework. Half of the first floor—the area housing the 911 operators—is a double height space. Also, due to the critical nature of the services provided by the tenants, special attention was made to have redundant systems for the mechanical services on the top two mechanical levels. The floors were designed for 250 psf live load and house emergency generators, cooling towers, UPS systems and Con Edison transformers. Critical areas of the mechanical floor and the computer floors are waterproofed to guard against any accidental spill finding its way down to the computer floors below. Mechanical engineer was The Kling Lingquist Partnership, Philadelphia.

The building is clad in brick with a precast concrete base and a metal screen wall and features a mansard roof enclosing the two penthouse levels and the cooling tower. Architect for the project was the New York office of Skidmore, Owings & Merrill.

Controlling the cost of construction was crucial to the success of this project, which began in 1992—a low point in banker confidence in building new space. As a result, concrete schemes were compared to structural steel schemes at several points during the design process, but in each case the steel scheme proved most economical. The final structural system was a composite metal deck/concrete slab for the floor system with typical 10-ft. spans of 2.5-in. concrete over a 3-in. composite metal deck. Typical bay size was 30-ft.-by-40-ft. with 40-ft. beams and 30-ft. girders. Construction manager on the project was Lehrer McGovern Bovis, New York City.



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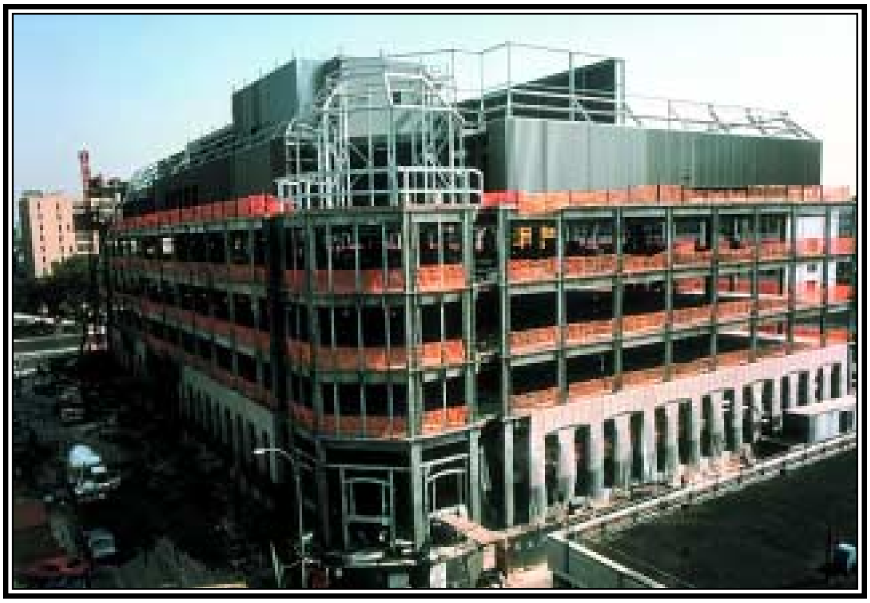
Structural Design

Various bracing schemes were studied during the schematic design phase. However, the tenant's program, which required large unencumbered floor plates, combined with the need to locate the elevator core in one corner of the building and the challenge of providing a usable parking layout in the building's basement, lead us away from any internal bracing. Additionally, the MetroTech standards required a building exterior with a close spaced pattern of punched windows, which made the use of exterior braced frames unacceptable. Finally, the use of semi-rigid or fully rigid connections for the interior beam-to-column connections proved inefficient for the lateral forces due o the long spans of the beams as well as the higher-than-normal floor-to-floor heights. Instead, the lateral loads are resisted by a rigid frame consisting of the exterior spandrel beams and columns.

While the typical interior bay size is 30-ft.-by-40-ft., the exterior columns are spaced 20-ft. O.C. to improve the performance of the rigid frames and reduce the size of the spandrel beams. The use of deep wide flange shapes for the exterior columns, to improve their stiffness, was easily hidden behind the masonry between the punched windows. Typical columns were W24 wide flange sections, while W14s were used on the corners.

While the building was under design, the World Trade Center bombing occurred. This created a lot of rethinking on the part of the tenants, who suddenly saw themselves as potential terrorist targets. At this point, we were directed to make a study of the structure as it was currently designed and determine what



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would happen if the building was attacked and a bomb exploded near an exterior column. We built a computer model of the exterior frame and studied the effect of removing one of the columns from the ground to the second floor.

The bad news was that the building, as designed, was not capable of having a column eliminated from the exterior facade. And if one was removed, there would be progressive collapse of the structure.

The good news was that since we had designed the building with a rigid frame consisting of the exterior columns and spandrel beams, we already had most of the pieces in place to upgrade the structure. We found that by nominally increasing the sizes of spandrels and a couple of the columns and increasing the design capacity and ductility of the beam-to-column connections, we were able to create sufficient redundancy in the structure to allow the demolition of an exterior column without causing progressive collapse. Spandrel beams were changed from W27x84 to W30x99. Columns were looked at individually.

Of course, this was only part of the steps taken to resist a terrorist attack. The facade elements at the base of the building were designed as 8-in. thick precast concrete panels attached to the reinforced concrete foundation walls and precast concrete surface mounted planters were added on the sidewalk around the site to minimize the available approaches to the building. While this building can not be considered to be a "hardened bunker" type structure, the steps taken have greatly increased the safety of the people and the equipment housed inside.

The upgrading of the exterior frame elements also paid off later in the project when the original handset brick facade with concrete masonry unit backup was changed to a precast concrete backed, factory set brick panel to save time and money. The increased stiffness and strength of the frame was more than adequate to allow the attachment of the precast elements directly to the spandrels without the need for reinforcement.

An additional complication was encountered during building department review of the documents. In our initial design, we had taken care to lower our footings along the Flatbush Avenue elevation and move them into the building to avoid introducing a surcharge on the subway tunnel and a 40-in. diameter sewer line that ran alongside the building. The exterior columns were picked up on a cantilevering strap beam, which allowed the columns to be at the face of the building without introducing any load on the sewer line below.

However, a proposed easement for the sewer was discovered by the New York City Building Department during their review. This easement extended 20-ft. above grade over the sewer line, an area that already was designed into the building. Our first approach was that the shortest distance to the sewer would be through the cellar of the new building. If the design remained unchanged, the sewer was only about 8-ft. below the building's slab-on-grade cellar floor, allowing simple access through the building—simpler than a 16-plus-ft. excavation from grade. Unfortunately, the sewer department did not want to count of access through the building and insisted on access from the street, since it was necessary that there be enough room for a back hoe to operate in case there was an emergency failure of the sewer. As a result, our only option was to remove our footings from an 8-ft.-wide swath adjacent to the Flatbush Avenue elevation and that we would have to allow a minimum 20 ft. of headroom above grade in this same swath.

This resulted in a cantilevered transfer of the 10 Flatbush Avenue columns. The transfer occurred at the third floor level and required the use of 40-in.-deep rolled steel shapes. In order to minimize the visual impact of an 8-ft. cantilever supporting a traditional masonry facade building, the architects had us install removable steel column/hangers at the face of the building. These columns are hung from the third floor cantilevers and are clad in precast concrete to give the appearance of structural support under the cantilever. The columns and the precast concrete have been carefully detailed to carry no vertical load and to be fully demountable.

The project required 2,485 tons of structural steel, both ASTM A572 Gr. 50 and ASTM A36.

Gilsanz Murray Steficek has recently begun design on the Headquarters Building for the New York City Fire Department, a 400,000-sq.-ft., 9-story building on an adjacent site at 9 MetroTech Center.

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