

Metals in construction



Steel Staggered Truss System used for Embassy Suites Hotel



Front entrance

Photos these pages: Chuck Choi

The development of Battery Park City is progressing with construction of a new multi-use complex in its northern residential zone. The complex, which includes a 463-room Embassy Suites Hotel and a Regal multiplex cinema, the first major chain to open in the neighborhood, further enlivens lower Manhattan, "making it a 24-hour community," according to Forest City Ratner, the developers.

The coexistence of different functions within the complex also permitted designers and engineers to explore the use of a combination of steel support systems to accommodate the diverse space requirements.

The hotel-cinema complex is essentially a 617,340 square foot rectangular area bounded by Murray and Vesey Streets to the north and south respectively, and North End Avenue to the west. On the south and west sides is the 14-story hotel portion, an L-shaped building that wraps around the three-level cinema which houses 16 theaters with stadium seating.



Hotel Lobby



A full building-height, block-long glass atrium runs most of the length of the structure from east to west, separating in halves the two portions of the complex. However, the complex is considered a single building from a structural standpoint and was constructed as one integral unit without expansion joints.

The complex is a steel-framed structure whose column grid and floor framing systems vary to accommodate distinct functions of the various spaces. The cinema portion, which occupies most of the north and east sides of the complex, is the same height as the hotel.

The 105,000 square-foot space consists of three levels with floor-to-floor heights of 30 feet. For the schematic phase, the cinema was considered retail space, with the same design criteria and parameters. This portion of the structure is conventionally framed.

Varying Space Requirements

Since the theater spaces inside vary, clear spans of 40 to 60 feet were required. Typical beam sizes are 18 to 27-inches deep, with girders 30-inches deep. Floor slabs consist of 2-inch metal deck with a 2 1/2-inch normal weight concrete topping, spanning between composite steel beams.

The 60,000 square foot retail space, mostly located on the ground floor, acts as a base for the cinema and hotel and has a column grid dictated by the uses of the spaces above. The structural system is the same as that of the cinema, with slab-on-metal deck spanning between composite steel beams. Bay spacing is typically 25 to 30 feet. Beam and girder depths are typically 18 and 30-inches respectively.

According to Jonathan Stark of Perkins Eastman, architects for the project, rather than conventional framing, staggered truss framing with spans of approximately 40 feet was



Photo: Chuck Choi



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Column Placement Advantages

The system has a number of benefits, Stark noted. "It makes it possible to span a long distance with a truss system hidden within the walls," he pointed out. "It also permits the placement of columns in only two locations-at the perimeter and the interior of each room and allows the low floor-to-floor heights that would traditionally be achieved in a concrete structure to be done in steel."

But the major advantage for this project, was that the staggered truss system was the most economical framing system explored. "The use of conventional steel framing would not have been economically feasible, but the staggered truss system, which uses less steel, is less expensive," Stark noted. "Furthermore, the members are small and light, so the use of the system made the entire structure lighter."

The staggered trusses combined with the precast plank floors resulted in the overall structural weight being approximately 30% less than a traditional cast-in-place concrete hotel. This meant that the foundation, constructed on inferior subsoil, required fewer piles and was less costly. The resulting cost saving is estimated at \$2.5 million.



Photo: Bernstein Associates

Courtesy of Thornton-Tomasetti Engineers

chosen as the basic structural support system for the 383,000 square foot hotel. "This system, developed at MIT in the mid-1960's, has not often been used in New York," Stark explained. "It is particularly suited to tall, narrow high-rise building types with regular walls, such as apartment buildings and hotels."

In the Embassy Suites hotel, the system consists of rectangular tube trusses that are one story, 8-feet, 10-inches deep, spaced at 60 feet on center and staggered in location on alternate floors to provide a 30-foot span for the floor system. The trusses are located within the partition walls. The floor slab is composed of 8-inch lightweight precast, prestressed hollow core planks which span 30 feet between the top chord of one truss and the bottom chord of the adjacent one. The planks act as a diaphragm to transfer lateral loads to staggered trusses on alternate floors.



Staggered trusses
Photo: Fran Soloman



Erecting brick panels

Photos: Bernstein Associates

Courtesy of Thornton Tomasetti Engineers



From a construction viewpoint, the truss system allowed for quick erection. The trusses and planks were fabricated off-site and assembled quickly in the field. The steel contract for job provided for 4,000 tons of steel at a cost of \$10 million.

The disadvantage of the system, Stark commented, is that it offers little flexibility, since every bay contains a big truss. "It works well for hotel rooms," he said, "because flexibility is not usually an issue, but it may not be desirable in other areas." For this reason, the ground level of the hotel, which required open space, is conventionally framed, as are the double-height "back-of-the-house" areas and meeting rooms.



Spandrel moment frame Photos: Courtesy of Thornton Tomasetti Engineers

The bridges are framed-out with conventional steel sections. Diagonal hanger rods that tie back to the main building structure help provide their support. The use of exposed horizontal "K" braced-bays at the fourth, eighth, twelfth floors and the roof tied the two hotel wings together structurally, making an expansion joint unnecessary.

Although it is self-supporting for gravity, the glass wall that faces the Hudson on the western side of the atrium is traditionally framed in steel to support the loads of the curtain wall. Steel beams in the roof support the gravity load of the skylight above the atrium.

Construction of the complex, which began in the fall of 1998 was completed in mid-2000.

Panelized Exterior Systems

The exterior walls of both the hotel and the cinema are panelized systems that span between columns. For the cinema wall, intermediate spandrel beams at 10-foot intervals between floors provide intermediate lateral support for the panels. For the hotel, lateral resistance for wind and seismic loads is provided by the staggered trusses in one direction and an exterior spandrel moment frame in the lengthwise direction of each hotel wing. The cinema and hotel portions of the building act in conjunction to resist lateral loads.

The 9,200 square foot, 13-story atrium that separates the two portions of the building serves as a public seating area and provides access to both the cinema and the hotel. Bridges that cross the atrium at every hotel floor link the atrium to the southern side of the building and tie the structure together. They serve as both a stabilizing element and a connection between the western and southern wings of the hotel.



Lateral moment frame

EMBASSY SUITES HOTEL

Owner: Forest City Ratner Companies, Brooklyn, NY

Architect: Perkins Eastman Architects, PC, New York, NY

Structural Engineer: Thornton Tomasetti Engineers, New York, NY

Construction Manager: Lehrer McGovern Bovis, New York, NY

Structural Steel Erector: Falcoln Steel Co. Inc., Wilmington, DE

Metal Deck Erector: A.C. Associates, Lyndhurst, NJ