Mandarin Oriental, BOSTON

Designing for the Urban Luxury Experience

By Kevin Westerhoff, P.E.

Figure 1: Artists Rendering.

Mandarin Oriental, Boston is scheduled to open its doors this summer and promises to deliver guests a level of luxury that is well known worldwide, but will be new to Boston.

The site is located within the footprint of the Prudential Center in the heart of Boston's Back Bay office and residential neighborhood. Most of this 2.21 million square-foot complex of buildings was constructed during the sixties, and includes office and residential towers ranging in height from 30 to over 50 stories. It also includes a vast multi-level underground parking structure containing approximately 2,500 parking spaces constructed of cast in place concrete. Mandarin Oriental, Boston occupies what was one of the few remaining undeveloped parcels of land in this complex. Prior to development of the Prudential Center in the sixties, this land served as a rail yard. In fact, many remnants of this rail yard were discovered during excavation of the Mandarin Oriental's lowest parking level.

Overview

Upon completion this summer, Mandarin Oriental, Boston will offer 149 luxury hotel rooms including a restaurant, a lounge, a fitness center and a 15,000 square foot spa. This mixed-use development structure also contains 50 private condominiums, 35 luxury apartments, 7 retail spaces totaling 30,000 square feet, and two levels of below grade parking exclusively for the condominium residents. With all of these programs, CWB Boylston, LLC, developers of the project, believes that the Mandarin Oriental, Boston will provide a haven of luxury living for the most demanding and discriminating clientele.

Before construction could commence on the Mandarin Oriental building, an enabling project was required. This project involved reconfiguring some of the existing entry and exit ramps, including a loading dock for the Prudential Center Garage. In addition, the enabling package included upgrading and relocation of several major utilities.

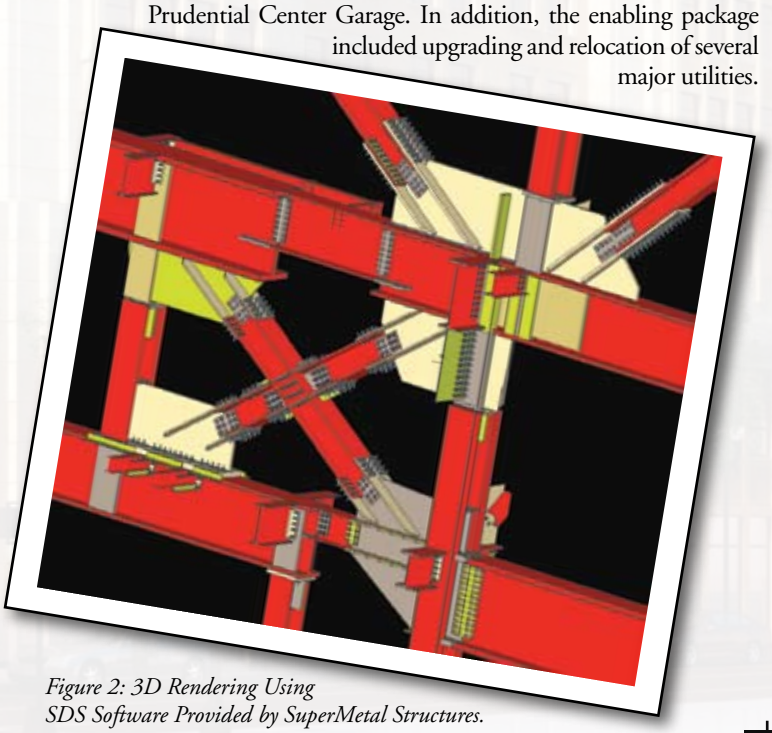

Figure 2: 3D Rendering Using SDS Software Provided by SuperMetal Structures.

Design

The structure of Mandarin Oriental, Boston was designed from the inside out. Designing the structure to accommodate the architecture associated with such high expectations and multiple programs proved to be a challenge.

The overall design of the interior and exterior of Mandarin Oriental, Boston is complex and detail-oriented. The project consists of two laterally independent fourteen story towers separated by a slide bearing expansion joint system. Retail and hotel functions, including a reception and a ballroom, occupy the majority of the first two main framing levels. These levels are also designed to integrate with the existing Prudential Center shopping arcade. A new arcade structure was designed, including a 60-foot pedestrian bridge, in order to link Mandarin Oriental, Boston with the Prudential Center Arcade. The hotel occupies the 4th through 8th levels of the larger tower, and apartments occupy the same levels in the smaller tower. The remaining 9th through 14th levels of both towers house private luxury condominiums, which include such features as private elevators that transport owners to their private rooftop terraces.

Materials

One of the first and easiest design decisions was choice of building material. Structural steel was chosen for the building to provide flexibility to facilitate the architecture and to accommodate schedule constraints. Typical floor plate construction consisted of 3-inch composite metal deck with 3¼-inch light weight concrete topping. At street level and below, the topping was increased to 4½-inch and a normal weight concrete was used. The thickened slab was necessary to assist in distribution of lateral diaphragm loads and to support increased loads associated with the buildings' retail programs and mechanical systems.

At the 9th level and above, a proprietary slab system, which is known as Filigree, was used in order to achieve 30-foot clear spans required by CBT Architects. This system offers the benefits associated with concrete and structural steel construction by providing performance similar to that of a post tensioned flat slab construction system while allowing the speed associated with a structural steel framing system. The system consists of precast concrete panels that are pre-stressed and receive a topping pour cast in the field. The typical system at the Mandarin Oriental, Boston consisted of a 4½-inch precast, prestressed panel with 2½-inch normal weight topping pour. Once the topping pour achieves strength, the system allows for long uninterrupted spans by taking advantage of continuity. Panels are typically shored for two levels in order to allow laborers to place reinforcement required by the system, and to complete other activities such as installation of shear

studs for the composite beams. At times, three levels of shoring including span transfers were required to accommodate constantly changing condominium unit layouts given the irregularity of the structural steel framing system. Addition of these transfers added another level of complexity to the system. *(See STRUCTURE Magazine article "Mandarin Hotel Shoring," January, 2008.)*

Lateral System

The lateral system of the building consists of a combination of moment and braced frames. Moment frames are used exclusively at the 9th level and above to allow uninterrupted space for the high-end condominiums. Over 600 column transfers – many within the lateral system – were introduced in order to accommodate the architectural layout and variety of building programs. In response to large forces that resulted from these transfers, over 90 custom plate girders, which ranged in size from 12½ to 60 inches deep, were designed. Additional methods, such as sloped columns and story deep trusses, were also used to accommodate transfers within the lateral system. Further, web reinforcement of rolled wide flange shapes was used for transfers in which shear controlled the design. *Figure 2* illustrates one of the unique transfer conditions created in Mandarin Oriental, Boston. McNamara/Salvia, Inc. worked closely with the fabricator SuperMetal Structures, Inc. of Quebec, Canada, during the detailing phase to develop specific connection details that satisfied the design and facilitated erection. In Massachusetts, it is standard practice that the fabricator owns the specific connection design as a means and methods issue. Ultimately, some pieces weighed over 30 tons and required tandem cranes to lift them into place.

Some of the transfers mentioned above created large discontinuities within the lateral framing system. This in turn placed a large demand on the diaphragm slabs by requiring them to transfer lateral load horizontally to adjacent frames based on stiffness. These slabs were reinforced with rebar or, when necessary, with structural steel diaphragm trusses. As a result of the large number of column transfers and vertical discontinuities in the lateral system, even the gravity dead and live load cases placed large demands on the diaphragm slab systems. A careful study of both lateral and gravity models using RAM Structural System to accurately envelope forces was required to ensure the most economical design. In addition, given all of the transfers, a detailed study of cambering was required to ensure that absolute deflections at upper levels of the building were within tolerance.

Foundation

The buildings' foundation systems consisted of 220 ton high capacity mini piles for the smaller tower and a mat supported system for the larger tower. High capacity mini piles were chosen for the smaller tower because of the decision to preserve a portion of the existing garage concrete framing and mat slab system at street level and below. The requirement to maintain access throughout construction for an active loading dock to the Prudential Center drove this decision to preserve existing framing in the footprint of the smaller tower. Pile caps for this mini pile system were doweled into the existing 27-inch thick mat foundation system to take advantage of the existing mat slab's support capacity. The analysis program Safe was used to create a finite element model of this condition.

The footprint of the larger tower required a deep excavation to provide an additional level of parking. The bulk of the existing cast in place structure, except for the length of the existing foundation wall adjacent to Boylston Street, was removed because there was an additional depth of excavation required beyond the foundation of the existing structure. This portion of the foundation wall was salvaged in order to provide a staging and delivery area for construction activities

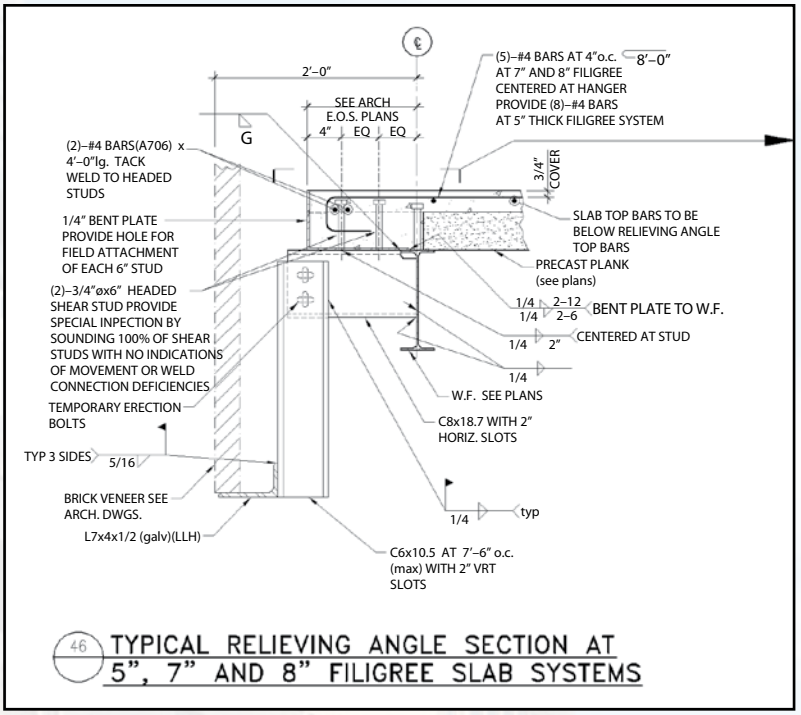

Figure 3: Typical Relieving Angle Detail.

along Boylston Street. The decision to keep this portion of the wall intact was also influenced by the numerous utilities located in the area immediately behind the wall and a tunnel for the subway system. Careful sequencing was required in order to brace this wall while the existing structure behind it was demolished and removed.

A soil mix wall system with steel soldier piles was chosen to support excavation of the hole for the lowest level of parking. This system required one level of whalers and 36-inch diameter cross lot braces to achieve the depth of approximately 25 feet. Pre-trenching was carried out to ease installation of the soldier piles and soil mix wall. However, numerous obstructions were encountered during the process. These included abandoned wooden piles, which had supported the previous rail yard. To complicate things further, an existing siphon traversed the site. Existence of this siphon necessitated careful excavation, and it ultimately had to be integrated into the new structure.

Façade

The façade of the structure consists mainly of limestone and marble, with masonry at the hotel and apartment levels. In order to eliminate the need for kickers – which would have obstructed interior soffits – McNamara/Salvia developed (with feedback from the fabricator SuperMetal) a relieving angle detail integrated with the slab (*Figure 3*). This need for kickers was successfully eliminated and ample field adjustment was provided for the erector by incorporation of the cantilever capabilities of the slab into the relieving angle design.

Conclusion

Even with many challenges in design of the structure, fabrication and erection of the steel for this project was completed in less than a year with Suffolk Construction's assistance. In total, the building required over 6,800 tons of structural steel. In November of 2007, the Canadian Institute of Steel Construction awarded Mandarin Oriental, Boston an Excellence in Design Award as a tribute to the design and construction process of this building.▪

Kevin Matthew Westerhoff, P.E. is a Project Manager with McNamara/Salvia, Inc. located in Boston, Massachusetts. He can be reached by email at ***westerhoff@mcsal.com****.*