WORK of *Art*

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With an official dedication by Mayor Richard J. Daley, the School of the Art Institute of Chicago unveiled its new state-of-the-art residence hall in August 2000. Located on the Block 36 Project at the northwest corner of State and Randolph Streets in downtown Chicago, the new complex will include apartments for 500 students, as well as 40,000-sq. ft. of retail space, a theater for a performing arts company and the Gene Siskel Film Center.

The project required the construction of a new 17-story, 200,000-sq. ft. building that was connected to an adjacent vintage building to its north, the 16-story terra cotta-clad vintage Butler Building. The design team of architect Booth/Hansen Associates, structural engineer Thornton-Tomasetti Engineers and contractor Wooton Construction collaborated with Smithfield Properties to create a new building with a link to the old.

Steel Framing

Designed by Christian A. Eckstrom, the 1924-built Butler Building is a terra cotta clad structure with clay tile arch floors. Because it has a steel frame, the design team explored the possibility of designing the new construction with a steel frame as well, rather than a concrete frame more typically used in residential structures. The floor elevations of both the new and the old buildings had to match seamlessly, thus the Butler Building's 12′ floor-to-floor heights had to be maintained in the new structure. As they enabled ceiling heights of 8′-6″ in the corridors and 10′-6″ in the rooms, both limitations would accommodate a steel frame.

The owner elected to use a structural steel frame and reserved a slot in his chosen steel fabricator's schedule for the project. Since the design team began the project in late November 1998, a steel mill order date was set for February

1999 to meet the aggressive design/ build schedule.

Lateral Systems

The architectural design called for the removal of part of the south wall of the Butler Building to allow hallways to pass over an existing elevator shaft and between the old building and the new construction. Therefore, it was desirable to tie the two buildings together without costly and cumbersome expansion joint details; however, the lateral stiffness of the Butler Building was unknown. A search for architectural and structural drawings of the original building was unsuccessful. Thus, it was decided to structurally link the new building with the old and carry the wind loads of both the old and new buildings with the new construction's braced structural steel frame.

Determining column locations and possible bracing locations was complicated by the plan for commercial retail space in the first three floors of the building. Moreover, the three-story low-rise portion of the new building was to contain the film center and theater. Column locations were then set at almost 14′-6″ on center on the exterior of the building to coincide with the desired architectural expression of the building, and interior columns were located at every second perimeter column. Major bracing locations were permitted in three areas: alongside the new elevator core between the old and new buildings in the east-west direction, on the extreme west end of the building adjacent to the existing Oriental Theatre and adjacent to connecting stairs in the north-side direction.

Because large wind forces would be exerted on the two buildings and the new steel frame, additional bracing locations in the east-west direction were required. A series of three eccentrically braced frames were carefully placed amid closets, fan coil units and bathroom plumbing in the walls between the dormitory rooms. The lateral forces carried by these frames were transferred through the floor diaphragm system to the other frames that carried to the basement. As most of the bracing had to terminate at the fourth floor because of the retail space below, a perimeter moment frame was utilized at the third through fifth levels.

Floor slab construction utilizing 3″ composite metal deck with 2-1/2″ lightweight concrete topping was selected for the 14′-6″ spans and stretched the deck capacity to its limit. Typical A572 Grade 50 beams of W18 through W24 support the residential floors, while W21 and W24 were used in the retail areas. The bracing itself used W-shapes—more efficient than large double angles or double tees.

The new steel frame erected over and through the Old Heidelberg at the corner of the site.

The site of the new 17-story building, after demolition of the existing low-rise building. The 1924 Butler Building on the right (north) and the southernmost bay of the Old Heidelberg (left) remain.

The GFRC panels were reinforced with lightweight steel studs and/or structural tube sections and were connected to the building columns.

The frames were optimized to control deflections by using virtual work and energy methods designed to identify those members contributing significantly to the building deflection and stiffening them accordingly. The steel mill order resulted in approximately 1,500 tons of structural steel, or approximately 14.5 psf over the 200,000-sq. ft. enclosed area of the new building. Although there was a lack of information on the older building, the owner paid a relatively small premium for the design that carried the wind loads from both buildings.

Investigation of the Butler Building

The design assumption of the old building "leaning on" the new one became more necessary when the owner and architect elected to use new, larger elevators within the old elevator shafts. This forced the design team to remove an exterior column and both associated spandrel beams over the entire height of the building. In so doing, it was feared that not only would the Butler Building be temporarily weakened if part of its skeleton were demolished, but that the City of Chicago Building Department would question the stability of the old building in this situation. To determine whether temporary bracing of the structure was necessary, the owner asked Thornton-Tomasetti Engineers to conduct an investigation and analysis to determine if the old building was capable of remaining stable with a weakened structural system.

The investigation of the Butler Building identified the existence of a series of partially restrained moment frames at each column line in both the north-south and east-west directions. Three types of beams were utilized in these frames: relatively small rolled shapes, back-to-back channels riveted together, and large built-up members. The columns were also built-up members, fabricated by riveting together plates and angles. Connections varied with member type. The larger built-up beams and the double channel members had T-shaped extended end-plate connections that extended significantly beyond the beam depth. Upon inspection of these connections, it became clear that the connection capacity was well in excess of that of the beam. The smaller rolled shapes in the interior bays were connected with top and bottom angles. A moment rotation curve was created using an empirical formula by Frye and Morris and compared to the "beam line". The intersection of these lines indicated that the connection would develop over 90% of the moment of that of a purely fixed connection. Because of this high stiffness, the connections throughout the building were considered fixed. The analysis of the temporarily weakened structure revealed that the building would be stable and able to resist wind loads during the construction phase. As a result, the design team avoided the need for temporary additional bracing and its resulting interference with construction activities.

Old Heidelberg

The original four- and five-story buildings on the site were scheduled to be entirely razed. However, the westernmost edge of the site was occupied by the historic Old Heidelberg Restaurant, designed by Graham, Anderson, Probst and White. The City of Chicago required that the façade of the Old Heidelberg be preserved and restored. Thus, most of the building was demolished beginning at the alley at the north end of the site and progressing southward. It was decided that the last, southernmost bay of the building remain intact until the existing structure could be studied and a final shoring scheme could be designed to work with the new facility.

To provide as much leasable space as possible, as much of the old structure was removed as could be safely done. The newly constructed steel frame made the removal of nearly all but the outer wall possible. At the fourth level of new construction, a new spandrel beam was placed just above the peak of the old building to clear span over the existing structure and frame into a new column that had been inserted within the footprint of the Old Heidelberg. The peak of the Old Heidelberg's roof was attached to this spandrel beam, providing support for the historic structure and enabling the maximum amount of leasable space. The use of steel framing, without the need to shore either the frame or slab components, made this whole procedure viable.

Construction

With the steel framing components ordered and a building permit in hand, the buildings at the southern part of the site were demolished and the new foundation system began. Following the caisson and foundation installations, the steel frame proceeded in the month of June 1999 and was "topped out" in late October.

The contractors then began installing the exterior wall panels made of glass fiber reinforced concrete (GFRC). These relatively lightweight, one-story panels were constructed using ¾" of articulated GFRC material anchored to a backup structure of lightweight steel studs and/or structural tube sections. The light-colored panels spanned typically from column to column and weighed only 15 psf. At the top of the building, a GFRC cornice was installed, extending approximately seven feet outward from the column centerlines. The use of GFRC on this project is believed to be the most extensive use of this material to date in a Chicago high-rise building.

The engineers used RAM Structural System, including RamSteel for design of the composite beams and RamFrame for the lateral system. Also, CSI's ETABS program checked the lateral system results.

The new structure blends nicely with the adjacent Butler Building and is reminiscent of the architecture of the recently renovated Reliance Building, which is located one block directly south the project. It stands as a salient example of how structural steel can meet an aggressive construction schedule, be effectively used in residential projects and enable the renovation of a vintage building to meet modern needs.

The exposed steel frame at the south building line of the Butler Building. Diagonal tension rods below the spandrel and extended end-plate connections of the spandrel, provide wind bracing for the 1924 structure.

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Software:
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Contractor:
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