Campus Core

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A new cardiovascular facility is the heart of the University of Michigan's medical campus.

Photos: Douglas Steel Fabricating Corp.

EVERY YEAR, MICHIGAN FANS LOOK FORWARD TO FOOTBALL SEASON. And they should, considering the Wolverines' success over the last century or so. This past fall, besides playing host to the 100,000-plus fans that descend upon the Ann Arbor campus for every home game, the University also welcomed a new building, the University of Michigan Cardiovascular Center (CVC).

The complexity of this 350,000-square-foot building took many shapes and forms. First of all, it's connected to existing buildings at five locations, as well as a new parking structure. The structural design also required careful coordination with the architectural design with respect to building massing and open space. From the connecting bridges and tunnels to a winter garden atrium, there were many opportunities for the design team to integrate structural and architectural design and highlight the structural aspects of the building.

Site Conditions

The grade surrounding the CVC varies around the perimeter. The CVC is in the center of the medical campus, surrounded on three sides by existing buildings and a new parking deck that was simultaneously built on the fourth side. The site was so limited on space that workers parked in an off-site lot and were bused in.

With this limited site accessibility, there was an extremely small area for steel lay-down. The fabricator elected to erect the building in thirds, using the area within the building's footprint for lay-down, and gradually emerging out of the basement excavation while erecting the steel. To create lay-down space, the slab on grade was partially installed prior to placing the columns. In order to provide access for column erection at a later date, larger-than-normal column box-outs in the slab were used.

Tunnels

The double-stacked tunnels that connect the CVC to adjacent buildings were constructed 65 ft below grade using internally braced earth-retention walls. Extreme care was taken during the excavation of the tunnels to maintain the integrity of the crossing utilities that remained in service during construction.

Lateral Framing System

The lateral framing for the east-west direction was provided by braces tucked in the duct and elevator shaft bays. Because the braces were in close proximity to the floor openings, diaphragm capacity was poor. Collector links were used to channel the wind and seismic loads to the braces.

The lateral framing for the north-south direction stability was provided by two lines of braces supplemented with moment frames. The west face of the building is concave, and the lateral system was not practical on the building perimeter. The frame was placed one bay in, allowing for continuity of the exterior façade. The east frame line was located on the building perimeter, with the braces located at the stair shafts augmented by the moment frames to avoid interferences with the curtain wall visibility.

Just prior to the contract documents being released for bid, the on-site geotechnical engineers recommended changing the site classification from D to C, thus reducing the seismic design category from D to C. The reclassification to the soil site class was based on their observations during the basement excavation. The amount of fill and undesirable soil was less than expected from the original geotechnical investigation. In addition, the added basement shell space and footprint change contributed to the ability to reclassify the seismic design category. As such, the lateral framing system and supporting founda-

Connector bridges link the new building to the surrounding campus structures.

tion were reanalyzed, reducing the building tonnage by 150 tons, which simplified the lateral member connections and decreased the amount of reinforcing steel and concrete in the foundations.

Exterior Envelope

The exterior of the building utilizes three types of cladding: 12-in. precast sandwich panels, brick veneer with punched windows, and a curtain wall. The precast panel's gravity connections were supported with steel outriggers, minimizing embedded plates in the floor slab. The punched windows were 10 ft wide and required "goal posts" to transfer the lateral forces floor to floor. The three-story curtain wall required wind columns and horizontal spandrel beams. With all three systems, close coordination was required to ensure that the structural members were blended in the architectural design.

Sensitive Equipment

During the schematic phase, AISC's Steel Solutions Center assisted us with evaluating transient floor vibration behavior. They determined that the vibration velocity of 8,000 micro-inches per second could be achieved economically with steel, a conclusion that was in line with our evaluation. During the fast-track design, the equipment selection was not complete, and the owner required the flexibility of either floor- or ceiling-mounted equipment. To provide this flexibility, the floor area above the sensitive equipment areas was also designed for the transient vibration requirements.

Connector Link Bridges

To maximize the university's needs and provide flexibility to move from one building to another, a series of bridges were designed. Three of the four bridges connect the CVC to existing buildings, and the bridge clear spans are in excess of 110 ft.

The sloping bridges span over fire access roads that had to remain open during construction. The overall depth of the bridges needed to remain as shallow as possible to accommodate the varying grades. Exposed tubular steel box trusses provided the necessary clearances, working in harmony with the architectural design and providing excellent horizontal and vertical load capacity.

Connecting new buildings to existing buildings is generally a design challenge, and the CVC situation was no exception. Two of the three building-to-building bridges intersected existing building expansion joints. To maintain the structural integrity of the existing building structures, a combination of slide bearing plates and post-installed cantilevered beams were installed to support the connection portions for all of the new bridges.

Parking Deck Bridge and Canopy

The CVC is connected to a new cast-in-place, post-tensioned parking deck. The deck is built into the side of a hill, with the top level supporting sidewalks, landscaping, and a circular drop-off road.

The bridge from the CVC to the garage spans a permanent roadway that had to remain open during construction for material deliveries as well as fire truck access. The main supporting steel girder spans more than 60 ft, and the bridge was designed in two portions with an expansion joint separating them. Phased construction was extremely important in this area in order to balance the construction of two buildings while maintaining access via the road.

The bridge is covered by an architecturally exposed steel canopy that supports glass panels, providing an inviting entrance. The north end of the canopy bears on W18 outriggers supported off of the CVC at each half bay by corresponding back span girders. The southern supports for the canopy are wide-flange columns on opposite sides of the expansion joint. The engineering to support the canopy included the differential lateral movement between the CVC and parking deck thermal loads. The two columns that bear on the parking deck were designed to be fixed at the canopy steel level and hinged at the parking deck support. The canopy girders and beams have clear spans in excess of 70 ft.

Winter Garden and Auditorium

One of the most prominent architectural features of the building is the winter garden atrium, a 60-ft-diameter, 75-ft-tall curtain wall façade open area that blends seamlessly into the building and interior floors. To achieve the greatest amount of open space, the use of round sections was selected. Architecturally exposed triangular vertical trusses (tri-columns) support the roof truss. Trees and plants were planted and designed to embrace the structural steel.

A large auditorium with a recessed floor is located in the middle of the building. Transfer girders were designed to limit the column interference within the seating area, and topping and in-fill slabs were required to provide the non-linear appearance and stepped seating.

The Keys to Success

To maintain design efficiency and schedule, parallel cost estimates were performed during the schematic and design development phases by the construction manager and an independent estimating firm. Major adjustments were made after the schematic design, and only minor adjustments after the design development phase.

With the project being delivered on a fast-track schedule, the team decided that an architectural core and shell package would be issued with the structural steel. This allowed for complete coordination of the building's miscellaneous steel and eliminated the "phase construction" wasted efforts and money. Ultimately, this process lowered the owner's costs.

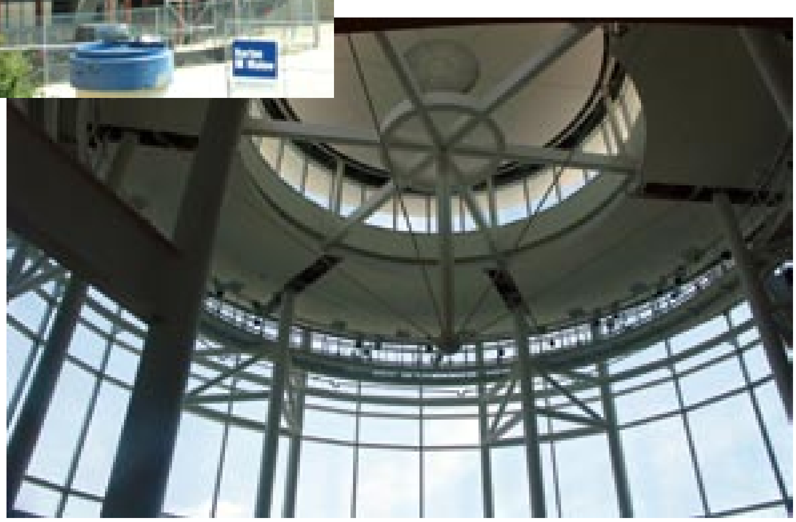
To maintain the architectural design intent, eccentric connections were designed for all of the truss members, with input from the fabricator. The eccentric connections allowed a 2-in. minimum gap between all faces (vertical, horizontal, and diagonal) for the bridges trusses and winter garden tri-columns. The additional space allowed for cleaner welds and a more visually pleasing architectural appearance.

During the bid/award phase of the project, the fabricator proposed changes to the bracing details to match its shop's expertise, a win-win situation for everyone. The building's structural integrity was maintained, the

The winter garden atrium's central connection ring (above) was shop fabricated.

The 60-ft-tall, 75-ft-diameter winter garden artrium (left) is a prominent visual feature of the CVC.

Round HSS tri-columns (visible at left and below) were used around the perimeter to support the façade and the roof structure.



fabricator was able to reduce its costs, the speed of erection was increased, and in the end the owner saved money. MSC

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