Class Act

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It's opening season for the new Winter Garden and Hyde Park Center at the University of Chicago Graduate School of Business.

The Hyde Park Center of the University of Chicago Graduate School of Business opened in September 2004, uniting a dispersed community of faculty and students previously located in five buildings throughout the Hyde Park campus. The new center includes 12 classrooms, 31 group-study rooms, faculty offices, interview rooms, computer rooms and multipurpose rooms.

The Chicago GSB Hyde Park Center is comprised of two distinct building areas: a seven-story base building and a glass-enclosed Winter Garden. The architectural design by Rafael Viñoly Architects responded to the contextual relationship between the new HPC, Frank Lloyd Wright's Robie House to the north and the Gothic-style Rockefeller Memorial Chapel to the west. The building's horizontal massing and cantilevered exterior walls reference the Robie House's Prairie style, while its Winter Garden's form echoes the curved Gothic arches found throughout surrounding campus architecture.

The base building posed significant structural challenges due to its non-repetitive floors, cantilever spans of up to 42′, and column-free spaces. Moreover, the Winter Garden's complex geometry required selecting adequate member profiles and providing suitable connection details, while still achieving simple and clear architectural forms.

Challenging Curriculum

The Chicago GSB Hyde Park Center features five levels above grade with a maximum allowable building height of 85′. Two levels of below-grade construction help to accommodate 415,000 sq. ft of programming within the height limitations of the surrounding structures.

Because of the basement's depth, the high water table (approximately 8′ below grade), and the possibility of ground settlement in this highly sensitive neighborhood, the choice of slurry wall construction was clear. The 24″-thick basement wall typically consisted of one level of tiebacks to support the wall temporarily during the construction, until lower level one and the ground floor slabs reached their design strength. The foundation system also consisted of isolated belled caissons below the base building. Caisson concrete strength was 5000 psi with shafts ranging from 2′-6″ to 5′-0″ and bells ranging from 4′-0″ to 8′-0″.

Lower level two, which houses 170 parking spaces, is 30′ below grade. The parking areas rest on a 6″ slab on grade reinforced with welded wired fabric. A parking ramp/tunnel along the south edge of the building allows access to this area. Lower level one, containing classrooms and computer labs, is 20′ below grade. Because of greatly varying spans and irregular column spacing, the concrete two-way slab is 12½″-thick with some drop panels.

Above: The eight round sections of each main column branch out to become roof rafters in the Winter Garden.

Below: Many of the cantilevers feature moment connected tapered plate girders.

Steel Makes the Grade

At grade and above, the structure transitions to steel. The base building has a square, 300′ by 300′ floor plan, with a 96′ by 108′ wing at the southeast edge. From the center of this square building rises the Winter Garden, with a 96′ by 96′ footprint. Structural steel was the logical material of choice for grade level and above. In total, the base building used 3,007.5 tons of structural steel (14.5 psf), of which 500 tons were plate girders.

Beginning with the southeast wing, the roof levels drop off in a counterclockwise direction. This reduction in building mass helps mitigate the effect of the new structure with its long-time existing neighbors. As a result, each floor plate differs and experiences prevalent snowdrifts. Composite floor framing and steel columns were used to frame the base building at and above grade, while a composite floor deck completed the floor system. RAM Structural System was used for analysis and design. Design snowdrift was determined by a snowdrift study conducted by Rowan, Williams, Davies & Irwin, Inc. (RWDI) from Ontario, Canada. The maximum design drift load was 110 psf.

The architectural design called for massings to project over the building roofs below. The resulting cantilevers ranged from 3′ to 42′ and required over 600 moment connections. SAP 2000 was used for modeling in these areas to evaluate behavior, as transferring columns often supported the cantilevers. Meeting the industry standard deflection for cladding of L/600 or 3/8″ was not always achievable on long cantilevered spandrels with depth restrictions.

Numerous conversations followed between the design team and the cladding contractors, from scope meetings through erection, to discuss how these non-typical deflections would be considered and accommodated in the design and installation of the cladding. Construction documents identified the locations providing anticipated tip deflections. Spacer posts, where architecturally acceptable, were also used at the perimeter of projecting massings to limit differential deflections between floors.

Transfer Credits

Because column-free spaces were required in the multi-function room, lower level classrooms and parking levels, plate girders were typically used to accomplish the more than 100 column transfers. These plate girders varied in depth from 30″ to 73″, depending on architectural requirements, and weighed from 283 to 1,528 pounds per linear foot.

As the superimposed load deflection was limited to the expected foundation settlement of ¾″, the deflection typically controlled the plate girder design. Material plate strengths varied from 50 ksi for plates up to 4″ thick, to 36 ksi for plates greater than 6″ thick. The maximum flange plate thickness was 7½″. Web thicknesses varied from 5/8″ to 1¾″. Charpy V-notch testing was required for plate thicknesses over 2″. When service reaction loads for plate girders exceeded reasonable design limits, a bearing connection was used where possible—in lieu of a shear connection—to eliminate the effects of the eccentricity on the support column.

The lateral system consists of braced framing located around the cores within

These plate girders for the dean's suite cantilever 42'.

the base building "square," as well as one braced frame in the southeast wing. The base building's lateral system is independent from that of the Winter Garden at the ground floor. To isolate the systems, ground-level bridges linking the base building to the Winter Garden are on slide bearing connections. At locations near the grand stairs in the Winter Garden, keeper plates with slide bearings are required to resist the horizontal load.

Lesson in Planning

A signature element of Rafael Viñoly's architectural design for this project, the Winter Garden is framed with structural steel and clad entirely with glass. It soars 83' at its apex, equal to the tallest mechanical penthouse roof of the surrounding building.

Four main columns support the roof. Each column comprises eight 9"-diameter steel pipes with 1⅝" walls clustered together to create a single column with an overall outside diameter of 33". The column bases are located at lower level one, and diagonal bracing hidden in a demising wall of lower level one braces the columns at the ground floor. The columns rise nearly 43' above the ground floor as a vertical cantilever. They were fabricated in two sections, with the column splices hidden within the ground floor slab.

The eight pipes of each main column branch out to become roof rafters. The rafters curve to form intersecting Gothic arches, which create roof "funnels." As they rise nearly 40' above the tops of the columns, the rafters taper from an outside diameter of 9" to just 6". They support continuous purlins spaced approximately 6' on center. The purlins, rectangular tubes with outside dimensions of 6" by 3", support the roof glazing and provide bracing for the slender rafters. The four roof funnels, one centered on each of the four main columns, are interconnected to form the 96' by 96' Winter Garden roof.

While Joseph Gartner fabricated the roof components in Germany, they were test-fit using an assembly jig to hold them in the proper geometry. Once the roof components arrived on site, the same jig was used to assemble each roof funnel on the ground so that each completed funnel could be lifted into place using a single crane pick.

In order to support the glass walls enclosing the Winter Garden, the third floor of the base building cantilevers out to 12". Wall framing consists of 14" by 3" hollow mullions fabricated from ¾" steel plate and 4" by 1½" steel bar transoms. Mullions are spaced at 6' on center, while the transoms are aligned with the fourth, fifth, and sixth levels of the base building. The wall framing was fabricated as a series of "ladders," with two adjacent mullions and the transoms between them shop-welded into a single assembly. As each "ladder" was erected in the field, the transoms between each assembly were installed using countersunk high-strength screws tapped directly into the mullions. At the fourth floor, sloping beams support a glass skylight and brace the Winter Garden wall back to the floor diaphragm of the base building.

Geometry 101

The Winter Garden is seemingly simple and straightforward architecturally as a doubly symmetrical system. However, the structural challenges were evident when determining the appropriate loads and developing the required stiffness to meet serviceability criteria for the light and transparent structure.

Because of the unique funnel shape of the Winter Garden roof and the unusual response characteristics of the flexible structure, the prescriptive wind and snow loads of the Chicago Building Code and ASCE 7 were determined to be an inappropriate basis for the structural design criteria. RWDI performed wind tunnel testing and snow load studies to determine design wind pressures and maximum uniform and unbalanced roof snow loads. RWDI recommended 17 unique wind pressure distributions for design of the main wind force resisting system and seven snow load distributions, including uniform snow and six unbalanced snow load arrangements.

Initially, RWDI indicated that snow drifting and ice bridging could result in design snow loads in excess of 100 psf at the base of the funnels. To mitigate these loads, heat trace was added to the roof glazing to promote snowmelt. Snow guards were added to retain snow on the upper portions of the roof rather than allowing snow to slide to the base of the funnels. The final uniform design snow load recommended by RWDI was just 14 psf.

Resistance to lateral loads is provided by three systems: the cantilevered main columns, out-of-plane bending of the perimeter wall mullions, and the in-plane rigid tube frame (mullions and transoms) of the perimeter walls. Each system provides approximately one-third of the total resistance to lateral loads. Strength criteria were evaluated for a wind return period of 50 years, while drift criteria were evaluated for a return period of 10 years. Lateral drift of the system was limited to the overall height divided by 400, and the in-plane drift of the perimeter walls was limited to the wall height divided by 180. Lateral drift criteria governed the selection of the member sizes.

Head of the Class

The Chicago GSB Hyde Park Center was completed at a total cost of $125 million, $100 million of which was used for construction cost. It opened its doors to students September 23, 2004 and will hold its grand dedication this month. The facility will help draw graduate business students to a university that meets students' needs with a state-of-the-art facility providing a productive and creative environment. On a sub-zero day in January, when the sky is clear and blue, the Winter Garden will no doubt live up to its name. ★

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Winter Garden Structure/Glazing
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