More Room to **Run**

BY MICHAEL V. RUSSELL, S.E., P.E., LEED AP

New athletic facilities for the Loyola Ramblers used steel to tackle an aggressive schedule, reduce foundation load requirements, and clear an existing structure.

KEY TO THE SUCCESS of the $25 million Norville Center for Intercollegiate Athletics at Loyola University Chicago is a 100-ton truss spanning portions of an existing building. In early 2009, Loyola University Chicago officially launched a $100 million multiphase building construction campaign to revamp and revitalize student life and facilities on its main Lake Shore campus on the north side of Chicago. Designed by architect Solomon Cordwell Buenz, the three-story Norville Center, totaling 77,000 sq. ft, is the first phase of the project and will provide additional support services for the university's collegiate athletic functions.

Design began in early 2009 with the goal of breaking ground by the end of that year. Loyola University challenged the design and construction teams with an aggressive schedule requiring thoughtful and early collaboration among the architect, consulting engineers, and the general contractor. With an early issuance of foundation drawings and site excavation beginning in December 2009, Halvorson and Partners, the structural engineer of record, continued to coordinate and finalize the remaining balance of the steel framing superstructure with the architect and MEP consultants. In addition to issuing a steel mill order package during the early phases of the project, separate early drawing packages were issued allowing the contractor to begin the steel submittal review process and the start of fabrication, all well in advance of the issuance of final architectural and MEP drawings. Steel erection began in March 2010.

A composite floor framing system consisting of lightweight concrete deck slabs supported by steel framing was selected during the early conceptual phases of the project. Lateral stability for the three-story building is typically provided by concentrically braced frames using rectangular HSS members. Large column-free spaces within the weight room, locker rooms, and office areas resulted in typical column bays ranging in size from 20 ft by 41 ft, 9 in. to 30 ft, 8 in. by 41 ft, 9½ in. To achieve these long spans, a structural steel solution was quickly determined to be the most logical and economical choice for the project.

Minimizing foundation loads also was of concern to the project team. The use of a deep foundation system, versus a shallow foundation system, would not only add cost and lengthen the construction schedule, but also increase the already lengthy permitting process. In Chicago, any permanent or temporary foundation element proposed to be deeper than 12 ft below grade requires an additional permit review process from the city's Office of Underground Coordination. Consequently, the design team was tasked by ownership to provide a building design that would keep foundation loads within a range that would allow the use of shallow footings. The use of structural steel made this possible.

➤ Special attention to the truss top chord was required because the truss had to be several feet deeper than the floor-to-roof dimension.

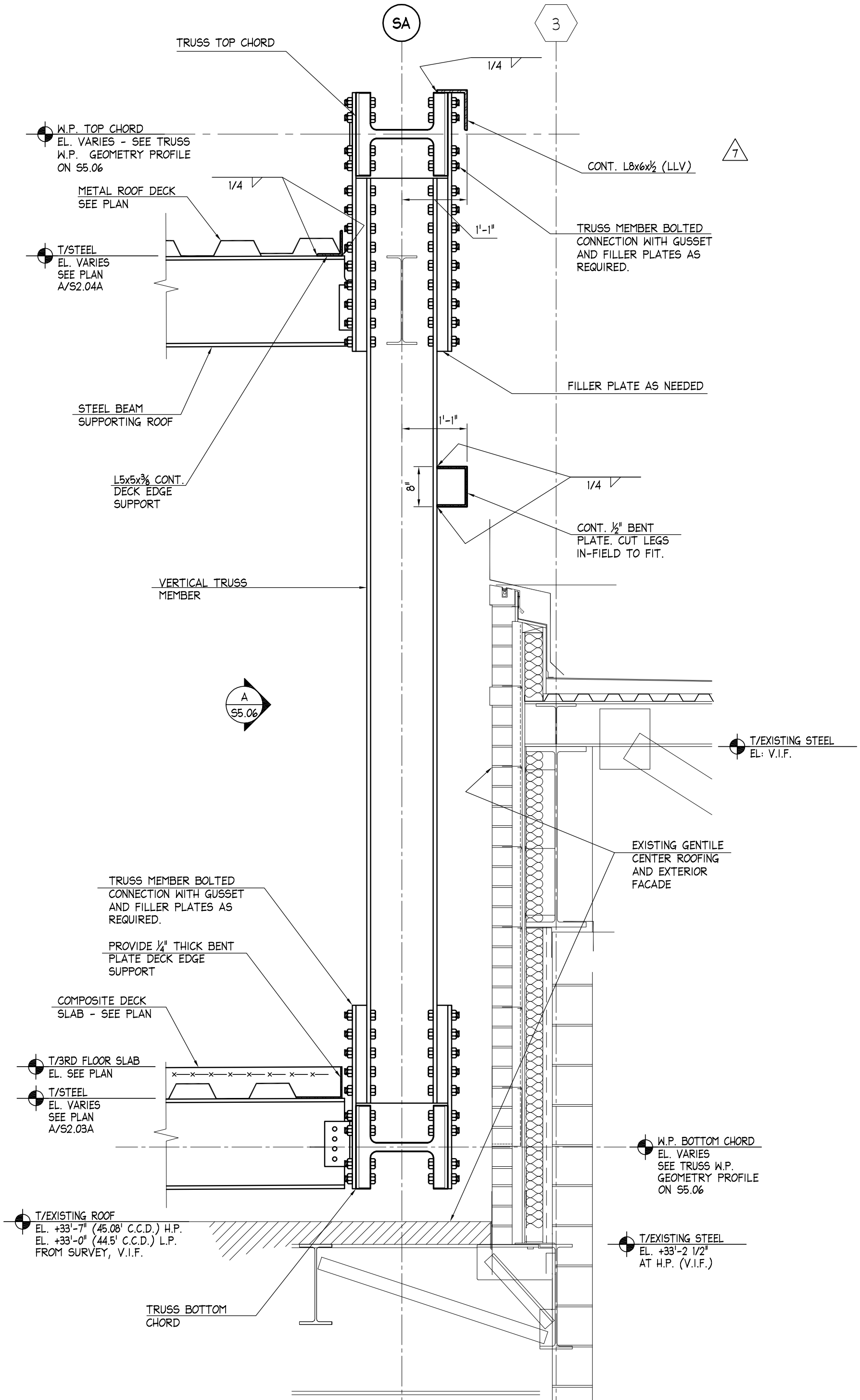
➤ Suspending the 183-ft-long truss over the existing lobby vestibule allowed installation of the third floor in very close proximity to the existing structure.

L-shaped in plan, the Norville Center is located directly along the east and south sides of Loyola's Joseph J. Gentile Center. Although the two buildings behave as independent structures, they are connected at various locations. The existing Gentile Center is a multi-purpose arena which is the home court for both men's and women's Rambler basketball teams. A complete future renovation of the Gentile Center along with the construction of a new student union and other athletic facilities make up the remaining phases of Loyola's campus facility upgrades and improvements. All of these facilities, intended to strengthen the student community, are to be interlinked with indoor corridors, naturally lit atriums, and other common spaces such as a food court and a rock climbing wall area.

The impact to the Gentile Center along the east side, due to the new construction, is minimal. The new perimeter columns and foundations for this wing of the L-shaped Norville Center are intentionally held back approximately 20 ft from the existing arena. Exposed structural steel roof framing members and acoustical decking, along with multiple skylights, bridge this gap to create a full-height naturally lit atrium and interior corridor. This atrium roof framing is vertically supported by both existing columns from Gentile and new columns from Norville. Because the buildings are designed to behave independent of each other with respect to lateral movement, specific detailing was required to ensure this framing did not rigidly link the buildings. This was achieved with the use of structural slide bearings for all roof framing connections to the Gentile Center.

The new construction along the south side presented a challenge for the project team. The existing main entrance lobby vestibule for the Gentile Center projects south of the main arena footprint by approximately 43 ft, 9 in. with an east-west length of approximately 153 ft. Essential mechanical and electrical systems for the arena are located on the second level of this vestibule.

Initial project planning called for the demolition of this south vestibule structure with the intent of relocating the arena's MEP systems into the new Norville Center addition. However, after further studies by the mechanical engineer, engineers concluded that any demolition and subsequent relocation of this MEP equipment would cause too much disruption to the weekly operations of the arena. Because the university uses the Gentile Center to host many other non-athletic functions, the Gentile Center's MEP equipment would need to remain fully operational throughout construction of the



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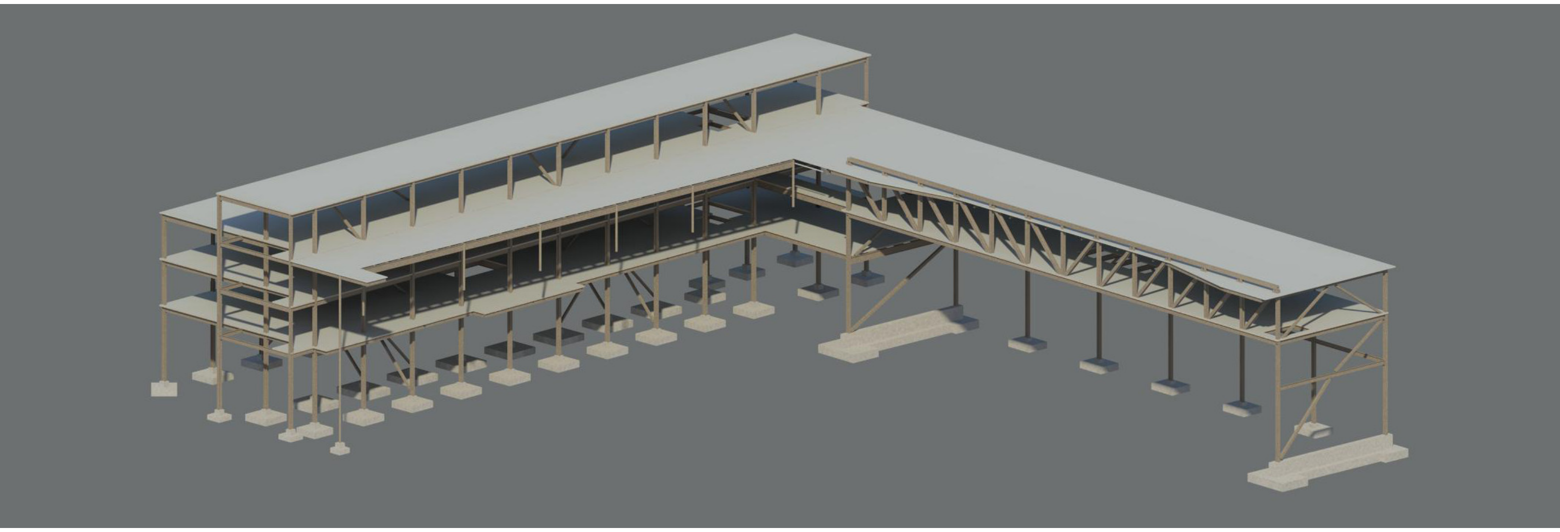

▲ Model of the new L-shaped Norville Center showing the large truss supporting both the third floor and roof.

◄ Field assembly of the 183-ft-long truss, which took about a week, was done on the ground beside the Gentile Center lobby vestibule over which it would soon span. Note the support column on each end adjacent to the existing structure.

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▲ The truss being lifted into place. Orienting the member webs perpendicular to the plane of the truss greatly simplified the field-bolted connections.

Norville Center. After considering various options, it was determined that the most economical solution was to use a long-span truss to bridge the existing vestibule area.

The resulting 100-ton truss adjacent to the south side of the Gentile Center supports both the floor and roof framing of the south wing of the Norville Center. With a depth of 18 ft, 3 in., the truss spans the full 183-ft, 5-in. length of the wing. The third floor beams frame directly into the bottom chord of the truss. Similarly at the roof, all beams frame into truss web members just below the top chord.

Extensive site surveying was completed to verify the proposed elevation of the truss did clear the existing structure. To satisfy the required deflection criteria and to help ease tight clearance and erection tolerances, truss cambering was specified on the design drawings and was built in during the assembly/fabrication process.

Due to span and tonnage, full assembly in the field was required as any significant shop assembly was not possible due to transportation limitations. Truss chord members consist of W14×193, W14×311 and W14×398 with webs oriented horizontally to simplify the all-bolted gusset plate connections to the web members and supporting columns. The web members consist of W14×68, W14×99, W14×109, and W18×76. Early preconstruction meetings included the design team, the general contractor, and fabricator in discussions of connection design concepts and constructability considerations for the truss.

The fabricator, Minneapolis-based LeJeune Steel Company, employed multiple methods to simplify fabrication and erection. To accommodate fabrication and erection tolerances, slip-critical bolts in oversized holes in all plies were used at all gusset plates truss connections. Unstiffened seated connections receive the roof beams that frame into the webs of the truss diagonals and partial-depth stiffener plates were provided at the beam ends for stability, which simplified erection.

To eliminate thick shims at the gusseted connections, nine of the W14×68 truss vertical web members in the original design that connect to the W14×398 chords were replaced with W18×76

➤ Three cranes held the truss in place while ironworkers made the bolted connections to the support column on each end of the truss.

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members. This switch took advantage of the fact that the depth of the W18×76 matches the 18¼-in. depth of the W14×398 whereas the depth of a W14×68 is 4 in. less. The small increase in the weight of those nine members was easily offset by allowing more economical connections.

Bracing the Top Chord

Due to the floor-to-roof height of 14 ft, locating the truss top and bottom chords at this vertical interval was not adequate for both strength and serviceability reasons. Therefore, increasing the truss depth required raising the top chord up above the roof framing, similar to a parapet. Because the truss top chord is located above the roof diaphragm, rather than being directly connected to it, special design and connection considerations were undertaken to account for the strength and stiffness of the framing elements being relied upon to adequately brace the top chord against buckling. Due to the orientation of the chord members, weak axis buckling was only considered for the unbraced length spanning between truss panel points. However, global buckling about the top chord's strong-axis was evaluated along its entire 184-ft length.

Stability bracing in this strong-axis direction is provided by both the flexural stiffness of the roof diaphragm and the flexural stiffness of the vertical truss web members which cantilever up past the roof. Minimum vertical truss web member sizes were selected to ensure this member would act as a proper brace. In addition, all roof beam-to-truss vertical web member connections were designed and detailed to resist an axial force to ensure a proper load path for the chord's stability and bracing forces to be transmitted into the roof diaphragm below. In addition to the metal roof decking, the required roof diaphragm strength and stiffness was provided by a horizontal truss using WT8x22.5 diagonal members located within the horizontal plane of the roof framing.

Field assembly took approximately a week and erection of this 100-ton truss occurred on April 13, 2010. The Norville Center is scheduled to open in March 2011 with the start of construction for the Gentile Center renovation, Phase 2, immediately following in May 2011. **MSC**

Owner
Loyola University Chicago

Architect
Solomon Cordwell Buenz, Chicago

Structural Engineer
Halvorson and Partners, Chicago

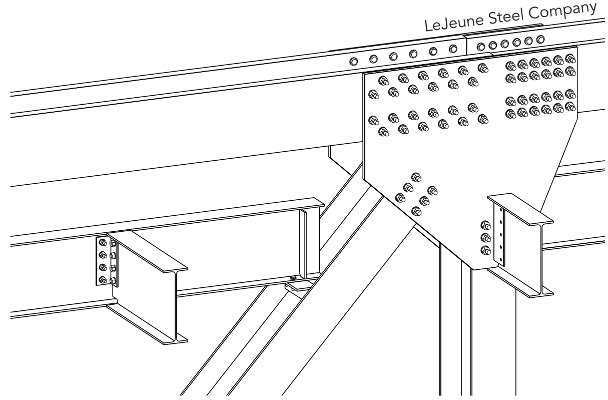
Steel Fabricator and Detailer
LeJeune Steel Company, Minneapolis
(AISC Member)

Steel Erector
Imperial Construction Associates Inc., Joliet, Ill.
(IMPACT Member)

General Contractor
Power Construction Company, Schaumburg, Ill.

Structural Software
Revit, RAM Structural System, SAP 2000

LeJeune Steel Company



▲ Roof framing is attached to the truss below the level of the top chord.

▼ The Norville Center's third floor level is above the Gentile Center's lobby vestibule, supported by the huge truss on the right and columns on the left.

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