Roosevelt University's new 32-story vertical quad is a showcase for the versatility of steel framing.

Higher Education

BY ROB A. CHMIELOWSKI, S.E., P.E.

VOA Architects

Robert A. Chmielowski, S.E., P.E., is a principal at Magnusson Klemencic Associates, a 140-person structural and civil engineering firm with offices in Seattle, Chicago, Shanghai and Riyad, Saudi Arabia.

IN 2007, Roosevelt University, an independent non-profit institution in the Chicago metropolitan area, faced a dilemma regarding the future of its main downtown campus. The City of Chicago had just instituted new code provisions requiring that all high-rise buildings, new or old, be fully sprinklered, and the university's 17-story residential and student life building, the Herman Crown Center, did not meet those criteria. Because the university's downtown campus revolved around the Center and the adjacent world-renowned historic Auditorium Building, tough decisions had to be made whether to renovate the existing building or abandon it and start anew.

After evaluating the costs of upgrading the existing building and considering future growth projections, the university's board of trustees approved a plan to demolish the Herman Crown Center and build a new, modern structure that addressed the university's specific requirements.

Nowhere To Go But Up

The university engaged VOA Architects, Chicago, to design a new building that would meet all needs while creating an enduring symbol for the campus. The new 470,000-sq.-ft building would include all common uses found in today's university campuses: classrooms, laboratories, student services, offices, a cafeteria, fitness center, and meeting spaces. The building also would augment the existing university space in the adjacent Auditorium Building and provide a new 600-room residence hall for the university's burgeoning student population. However, while the new building would contain all of the amenities and features of a modern university, there was one critical element missing—horizontal land area. By the nature of its downtown location and small 16,000-sq.-ft lot, the entire program would need to exist in a vertical configuration rather than a traditional horizontal campus layout. The concept of a university quad would literally need to be turned on its side.

With this is mind, VOA Architects, in conjunction with the university and development managers The John Buck Company and Jones Lang LaSalle, developed a striking 32-story building that cleverly meets all programming requirements in one vertical stack. The building is located on the site of the demolished Herman Crown Center and a second smaller demolished building to the north. It is divided vertically into three distinct zones. Levels 1 through 5 include student services and student life functions; Levels 6 through 13 contain classrooms, laboratories, and offices; and Levels 15 through 31 include dormitories. At 475 ft, the building will be the second tallest educational building in the United States and the sixth tallest in the world.

To handle this unique and complex stack of building uses, multiple framing system options and materials were considered early in the design. Structural steel was ultimately selected for its ability to provide column-free spaces at the classrooms and laboratories, allow future flexibility as the University's needs change, and accommodate the project's required framing complexities.

Interfacing With History

The new tower is immediately adjacent to the historic Auditorium Building and connects to it in five places. Designed by famous American architects Louis Sullivan and Dankmar Adler, the Auditorium Building was declared a National Historic Land-


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▲ A three-story diagonal hanger is lowered into place with the north face of the Auditorium Building in the background.

◄ A rendering from the northwest of the completed tower with the Auditorium Building in the foreground.


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▲ The new tower structure is prepared to take over the task of laterally supporting the historic Fine Arts Annex façade. The braced frame, which supported the façade during demolition of the building and during construction, is visible in the background.


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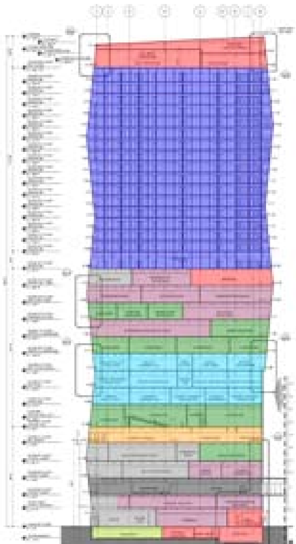
▲ Two-story deep outrigger trusses connecting to built-up box columns increase the lateral stiffness of the concrete core and maintain accelerations in the tower's residential levels within recommended limits.



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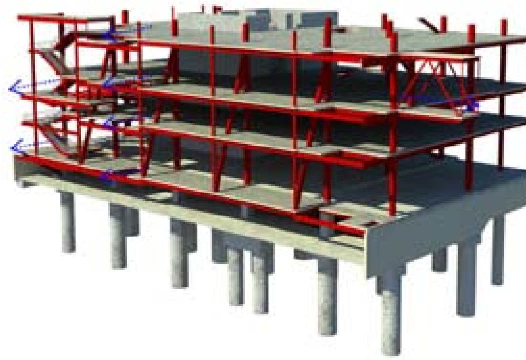

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▲ An image from the Revit model shows the series of three-story hanger trusses, which abut the Auditorium Building, and the one-story cantilevered bridge connection over the alley. New connections to the historic building are shown with blue arrows.

◄ The complicated vertical stack of the university's program along with the undulating façades results in no two floors being alike.

► A rendering from the street level with the Auditorium Building to the right and the restored Fine Arts Annex façade to the left.

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mark in 1975 by the National Park Service. At the time of its completion in 1889, it was the tallest building in Chicago and the largest by volume in the United States. It was also, reportedly, one of the nation's first mixed-use buildings containing offices, a 400-room hotel, and a world-class 4,300-seat theater.

Over time, the Auditorium Building's heavy brick masonry walls and large, tiered, shallow foundations settled up to 2 ft over the soft clay of downtown Chicago. The tiered footings extend onto the property, precluding the addition of columns near the Auditorium Building and requiring the new structure to cantilever up to 17 ft to meet the historic building. Rather than use heavy and deep cantilevers at each floor, MKA used a series of three-story steel hanger trusses to cantilever the building to the south. The stiff trusses minimized structural depths at each floor, reduced displacements, and efficiently carried the eccentric building loads to the lateral system by decoupling the hanger forces to a horizontal steel truss at Level 3 and a concrete diaphragm at ground level. A similar one-story cantilevered truss was used to extend a bridge over an alley and connect to a portion of the Auditorium Building to the east.

At the northwest corner of the site, the new tower also interfaces with history at the location of the second demolished building on the site—the Fine Arts Annex Building. The Commission on Chicago Landmarks mandated that although the building's floors could be demolished, the west-facing façade would need to be preserved and restored. The six-story building and its terra cotta and stone façade, built in 1925, were supported by a series of riveted steel frames. The plan developed by MKA involved salvaging the steel frame directly behind the façade to function as the façade's gravity and in-plane lateral load-resisting system. However, for out-of-plane bracing, the new tower buttresses the façade via a series of lateral-only connections.

Prior to making any connections, the chemical composition of the historic steel was assessed to determine its weldability. All connections allowed for some form of differential vertical and in-plane lateral movements between the new tower and the façade while resisting out-of-plane forces. During demolition, contractor Power Construction installed a temporary vertical braced frame to laterally support the façade until the new tower had been constructed to Level 6, at which point the task of laterally supporting the façade was transferred to the new tower.

Framing Challenges: No Two Floors Alike

Unlike many high-rise buildings where the floor shape and loading are consistent over many floors, there are no two floors alike, from a framing standpoint, in the new tower. The mixed-use nature of the building, numerous building setbacks, and distinctive undulating faces of the east and west facades of the tower resulted in 33 different framing layouts and presented significant framing challenges for the design team.

VOA's design called for varying extensions of the floor structure at many levels of the tower. These extensions are framed with variable-length cantilevered steel framing of lengths up to 10-ft, 6-in. While the cantilever lengths themselves are not particularly noteworthy, the complex and varying framing in these areas necessitated close scrutiny. A beam cantilevering over a column commonly supports a beam which itself cantilevers to support a spandrel beam. While this provides dramatic column-free experiences at the building edge, it required careful consideration of cumulative vertical displacements from the complex framing. Stiffness rather than strength considerations often governed the sizing of the steel beams in order to minimize differential floor deflections for the cladding system.

While the stacking of various programming uses in this project solved the challenge of limited space for the campus, it resulted in the need for careful consideration of serviceability issues, especially vibration control, for sometimes very different occupancies. The fitness center at Level 5 is situated between spaces sensitive to vibration and acoustics, such as lectures halls and conference rooms. The aerobics room in the fitness center proved especially challenging, given the applied rhythmic excitation and limited available structural depth to increase floor stiffness. The architect and acoustical consultant specified isolated, floating slabs to manage acoustics. MKA used detailed SAP 2010 dynamic modeling and relied on AISC's *Steel Design Guide No. 11*, *Floor Vibrations Due to Human Activity*, to ensure that accelerations were within recommended limits.

Although the design and construction communities often think of concrete for residential occupancies, the upper 17 levels of the building provide an excellent example of the use of structural steel for this application. MKA worked closely with VOA to locate the main beam and girder lines on demising partitions. This allows the beams to be hidden within the partitions, providing an opportunity for increased ceiling heights between the beams while maintaining a floor-to-floor height of 10 ft, 10 in. Floor vibrations were studied closely to ensure a serviceable final condition.

Steel Bolsters Lateral System

The primary lateral load-resisting element of the tower is the concrete core. The interior space planning required that the core be situated at a significant offset west of the ideal location, which would have been at the center of the floor plate. To deal with the significant torsion developed due to the offset location and to minimize the in-plane shear demands on the floor diaphragms, a steel braced frame was utilized at the eastern end of the building. The braced frame, which runs full height of the building, was arranged in concentric and eccentric configurations as necessary to work with the interior layouts.

Lateral resistance in the east-west direction proved to be a significant challenge. The aspect ratio of the concrete core was such that the building accelerations at the upper levels, as determined by a wind tunnel analysis, exceeded recommended limits. The fact that the most sensitive occupants for accelerations will reside in the dormitories at the upper levels only compounded the challenge. Again, structural steel was utilized to solve the issue. A pair of two-story-deep steel outrigger trusses extends from the west face of the concrete core at Levels 15 through 17 to increase the "stance" of the concrete core and bring wind accelerations to within acceptable limits.

The tip of each outrigger truss connects to a 1,275-lb-per-lineal-foot built-up column consisting of a W14×730 with two 4-in. by 20-in. cover plates to provide the necessary axial stiffness. The contract documents required the bolts of each outrigger brace remain loose until the building was topped out and all floor concrete cast to prevent possible overload of the outrigger trusses while the core concrete and outrigger columns shortened differentially.

When completed in March 2012, the new tower will form an exciting addition to Roosevelt University's growing downtown campus. This unique building epitomizes the definition of mixed use, reviving the tradition originally set forth by the Auditorium Building more than a century ago. As a true "vertical university," the project provides an excellent model for other universities with similar space constraints. As desired, the tower serves as an iconic symbol for Roosevelt University as well as a bold new addition to the Chicago skyline. MSC

Owner
Roosevelt University

Architect
VOA Architects, Chicago

Structural Engineer
Magnusson Klemencic Associates, Seattle

Steel Team

Fabricator
Zalk Josephs Fabricators, LLC, Stoughton, Wis. (AISC Member)

Erector
Chicago Steel Construction, LLC, Chicago

Steel Detailer
Ken Boitz & Associates, Bloomingdale, Ill. (AISC Member)

Development Managers
The John Buck Company, Chicago, and Jones Lang LaSalle, Chicago

General Contractor
Power Construction Company, Schaumburg, Ill.

▼ The entry to the tower at the street level will provide an excellent vantage point for the dramatic undulating west façade.

Magnusson Klemencic Associates

Solving An Erection Challenge

An accelerated schedule dictated that the tower crane would best serve the project on the outside of the structure in order to eliminate all comeback work on the interior after the crane's dismantlement. With no location available for a standard concrete footing due to property line constraints, Robert J. Herm, S.E., vice president of Chicago Steel Construction, LLC, used a creative solution. The crane base was put on two large plate girders that were run through the concrete core, extending out about 12 ft from the north property edge. Having the crane base roughly 10 ft above grade allowed for the utilization of every precious square foot of ground on the very limited site. Engineering for the crane support was provided by AISC professional member Christopher Kohout, S.E., principal structural engineer with ACK Engineering Services, Ltd., Chicago.