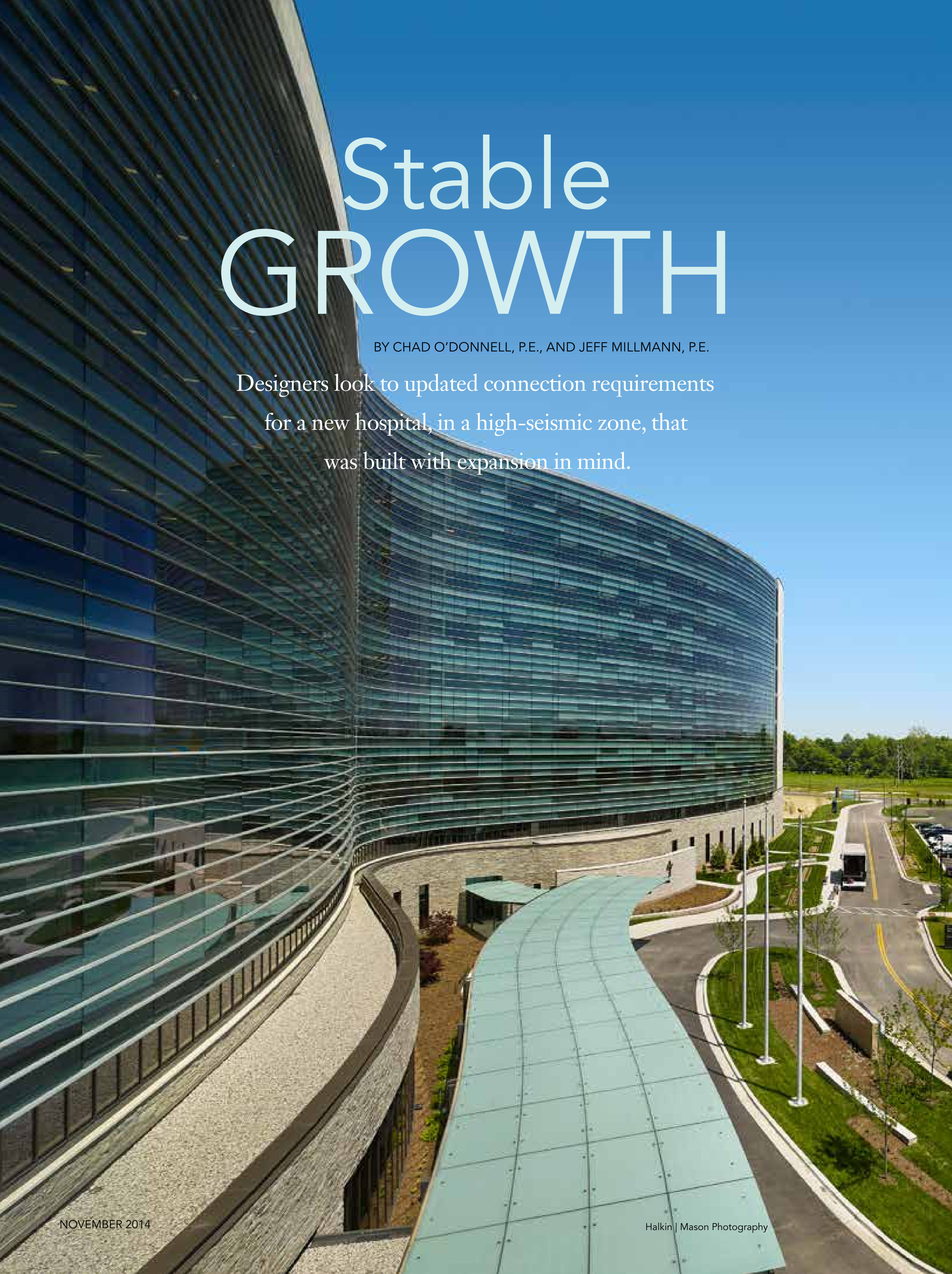
Stable GROWTH

BY CHAD O'DONNELL, P.E., AND JEFF MILLMANN, P.E.

Designers look to updated connection requirements for a new hospital, in a high-seismic zone, that was built with expansion in mind.



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The new hospital includes a 480,000-sq.-ft, nine-story bed tower and a 300,000-sq.-ft, three-story diagnostic and treatment building.

WITH ITS GLISTENING, curvilinear glass façade, Owensboro Health Regional Hospital has made a striking presence on the landscape since opening in Owensboro, Ky., last year.

Replacing an existing hospital, built in 1927, that had limited additional growth potential after numerous expansions and renovations over the years, the new hospital includes a 480,000-sq.-ft, nine-story bed tower and 300,000-sq.-ft, three-story diagnostic and treatment building designed to accommodate flexible growth, new technology and system-wide service integration throughout the Owensboro Health system. And while the original hospital had physical constraints between adjacencies, the new hospital promotes patient comfort and operational efficiency through streamlined space planning. Decentralized nurses' stations are tucked outside each patient room, allowing nurses to stay closer to patients. All medicines and supplies are kept in the room or within 20 steps from the bedside so caregivers can quickly attend patient needs.

Healthy Integration

From the project's outset, the engineering team collaborated with the owner's representative, medical planners, architects and contractors to identify structural issues that could impact the building, using an integrated project delivery (IPD) method. The design team, in fact, had used IPD on several large healthcare facilities previously, yet Owensboro offered new opportunities. Here, the project's successes rested on each partner (owner, architect and contractor) relinquishing individual risk in favor of a collaborative process that encouraged creativity, innovation, transparency and shared decision-making for on-time, on-budget delivery. The project actually launched at the beginning of the economic crash in 2008 and 2009, yet the IPD team was able to add $5 million to the scope without increasing overall budget, largely through efficient planning and securing competitive bids.

Owensboro Health Regional Hospital replaces an existing hospital from 1927 that had limited growth potential after numerous expansions and renovations over the years.

Curves Ahead

The bed tower's curvature presented one of the largest challenges, resulting in skewed framing layouts that required collaboration between the engineers and steel contractor Midwest Steel, Inc. (an AISC Member erector/AISC Advanced Certified Steel Erector) to ensure that 5,600 tons of steel could be erected at the proper skew and in a cost-effective manner. This involved rotating columns along the curve to create single-bay moment frames with orthogonal beam-to-column moment connections. This was important in satisfying the requirements of the prequalified bolted flange plate moment connections and eliminating localized out-of-plane forces at these connections.

The combination of limited columns, curvature of the building and lack of consistent columns on the radial grids created a challenge for resisting building lateral loads. Using columns up to 30 in. deep and beams up to 36 in. deep allowed the seismic load resisting system to achieve a design that supports the architectural form. The structural steel framing also supports flexibility for future advancements in patient care because there are no shear walls and only two braces in the entire facility, creating a building that can be modified through multiple renovations.

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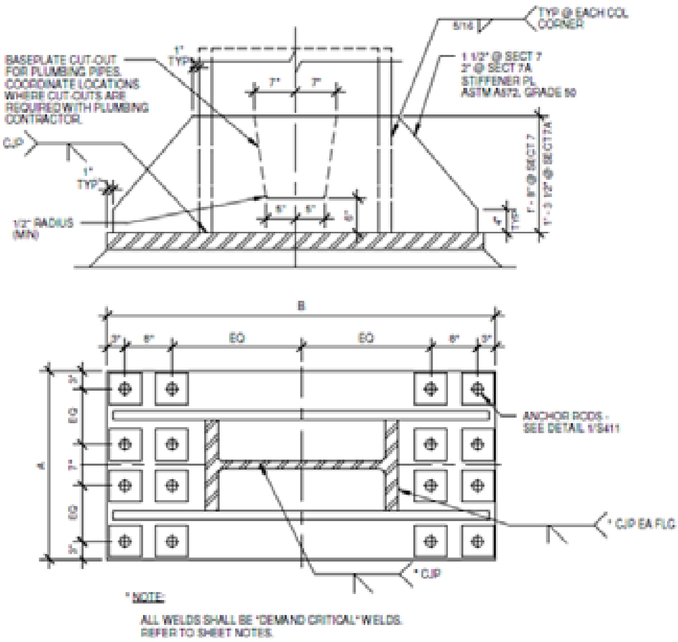
▲ The green roof/courtyard on top of the diagnostic and treatment building.

▼ Baseplates use up to twenty-four 2½-in.-diameter anchors each.



▲ A baseplate detail.

Additionally, some portions of the seismic system were required by code to be designed for amplified seismic loads, which created complex column baseplate and anchor rod designs and details. These baseplates, which measured up to 4½ in. thick, needed to be stiffened with a pair of plates that ranged from 1 in. to 2 in. thick, and the base details included up to twenty-four 2½-in.-diameter anchors per baseplate. The anchor rods needed to resist large tension loads, which resulted in embedment depths into the foundations as long as 7 ft. This also resulted in large quantities of shear reinforcing in the foundations to resist anchor rod pull-out and concrete breakout failure modes.

The structural layout freed up interior space to improve operational workflows in the bed tower. Three column lines were used across the width of the approximately 73-ft-wide tower. Since two of these column lines were held at the perimeter of the building, significant open space was provided for programming flexibility. The column layout also increases available space for windows—allowing abundant daylight to spill into the interior spaces to provide a bright and natural atmosphere for patients—as well as reduces electrical usage throughout the facility.

The structural design of the more linear three-story diagnostic and treatment building required looking at multiple options to accommodate future vertical and horizontal expansion. The building's seismic load resisting system needed to be tuned based on these different expansion options. Several design iterations were performed to determine the correct balance between the different expansion options; each of these models (created in RAM Structural System) represented a different future expansion option. In addition, the top level of this building included a landscaped courtyard. HGA's in-house landscape architect proposed a design with plant types that required soil media up to 18 in. thick, which increased the seismic mass of the building. Guidelines were developed by the landscape and structural design team to allow the structural design to progress while the landscape design was still being developed.

New Rules

The project site was located in a flood plain containing liquefiable soils and is close to the New Madrid and Wabash Valley Seismic zones; this required the buildings to

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The project uses 5,600 tons of structural steel in all.

Every floor offers views of the 162-acre campus.

meet Seismic Design Category D standards. In addition, the beam-to-column bolted flange plate moment connections of the seismic load resisting system for both buildings were designed per Supplement No. 1 to ANSI/AISC 358-05 *Prequalified Connections for Special and Intermediate Steel Moment Frames for Seismic Applications*, which was released during the design of the project and provided additional prequalified connection options. The connection behavior characteristics and design processes are described in the supplement, which proved to be a great guide for the design of these connections.

The project construction documents were issued in eight construction packages to reduce the overall design and construction schedule, and foundation and structural steel packages were issued long before other disciplines completed their work. Using BIM software was critical for this aggressive schedule, and clashes between structure and mechanical, electrical or plumbing were discovered in a virtual setting and resolved before construction for these components started; this was especially critical at the bed tower mechanical rooms. Steel moment frames with deep beams flanked the sides of these rooms, and large mechanical ducts needed to pass under these beams. Electrical closets were located just outside these mechanical rooms, which required large quantities of conduit. BIM facilitated the ability to fit all of these components above an 8-ft to 9-ft ceiling. In addition, real-time cost evaluations (also known as target value costing) were employed to keep project costs within budget.

An integrated design approach and innovative engineering solutions resulted in the successful completion of the Owensboro Health Regional Hospital. The structural steel frame supports the elegant shape and curvature of the building, reinforcing the integrated relationship between architecture and engineering. The structural team invested early in the design process to develop cost-effective solutions to complex design problems without sacrificing function, flexibility and future growth. As a result, the hospital supports operational efficiency and structural integrity. ■

Owner
Owensboro Health Regional Hospital

General Contractor
Turner Construction

Architect and Structural Engineer
HGA Architects and Engineers