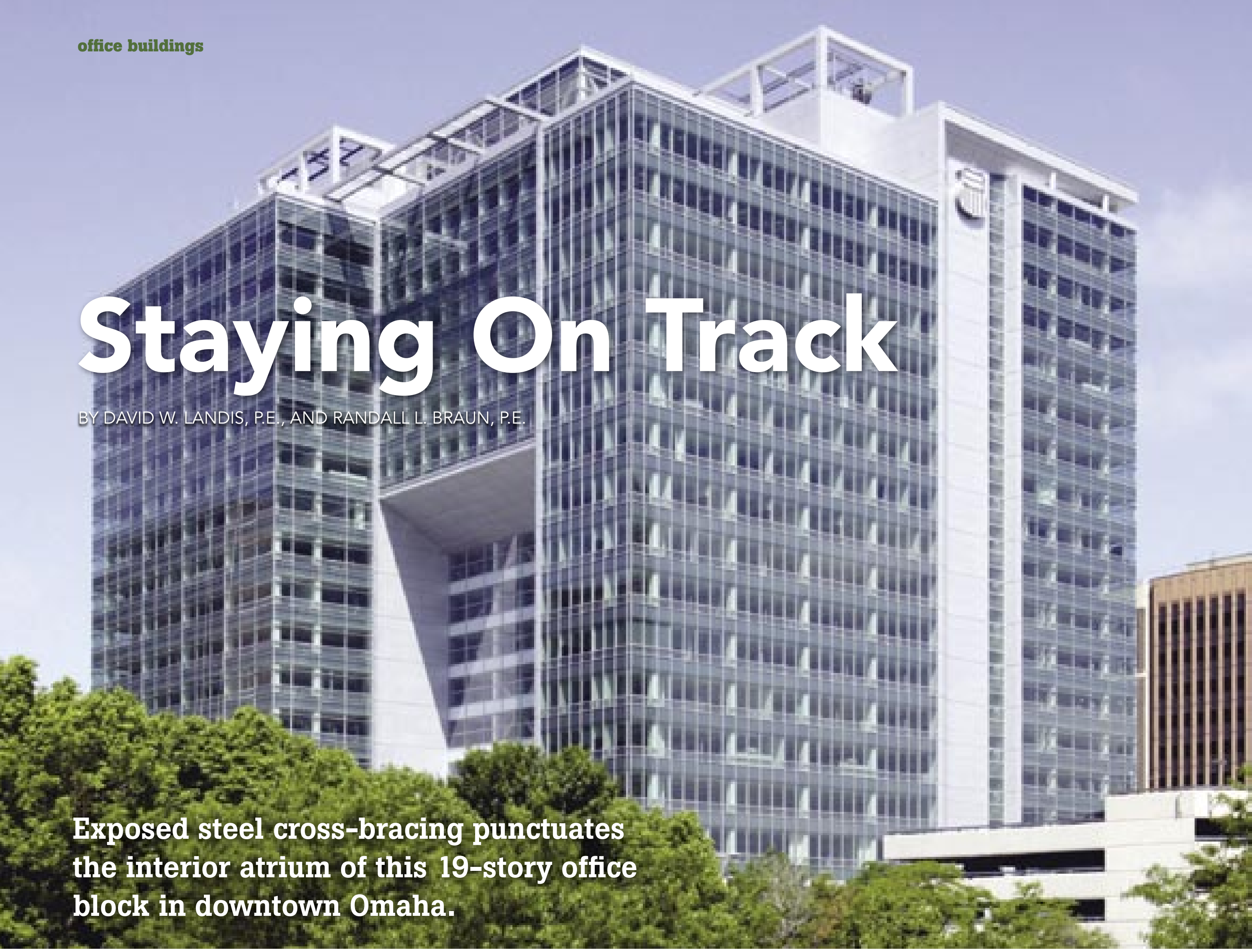


Staying On Track

BY DAVID W. LANDIS, P.E., AND RANDALL L. BRAUN, P.E.

Exposed steel cross-bracing punctuates the interior atrium of this 19-story office block in downtown Omaha.

Union Pacific Railroad

Joe Aker, Gensler

UNION PACIFIC RAILROAD HAS BEEN AROUND FOR ALMOST A CENTURY AND A HALF. But when it came to designing its new headquarters in downtown Omaha, Neb., company leaders didn't want an old-fashioned building.

Instead, they envisioned a progressive work environment that would let the world know the 140-year-old railroad company was moving boldly into the 21st century. They also wished to consolidate their scattered workgroups into an aesthetically pleasing, light-filled space for more than 4,000 employees. The challenge to the design team was to create a space that would be attractive to potential employees, motivational to the current staff, cost-effective, and able to accommodate future organizational change.

And they were able to rise to that challenge. Occupying a full block in the heart of downtown Omaha, the 19-story, $260 million Union Pacific Center boasts 1.3 million sq. ft of inviting and flexible space. With plenty of natural lighting, a conference and learning center, 600-seat dining room, fitness center, data center, retail space, and one of the nation's largest video screens, the building provides a productive and high-quality work environment for its employees.

Illuminating the Workplace

The most immediately notable design feature—a dramatic glass-clad atrium extending the full height of the building—provides a welcoming entry to visitors. Topped with a tall clerestory, the atrium floods the building's core with natural light. And with glass on all sides, the atrium supplies natural light to the inner portions of each floor as well, creating a bright and open office environment. The atrium also visually connects employees to one another, as they are able to see coworkers across the building and on other floors, enhancing the sense of one big team.

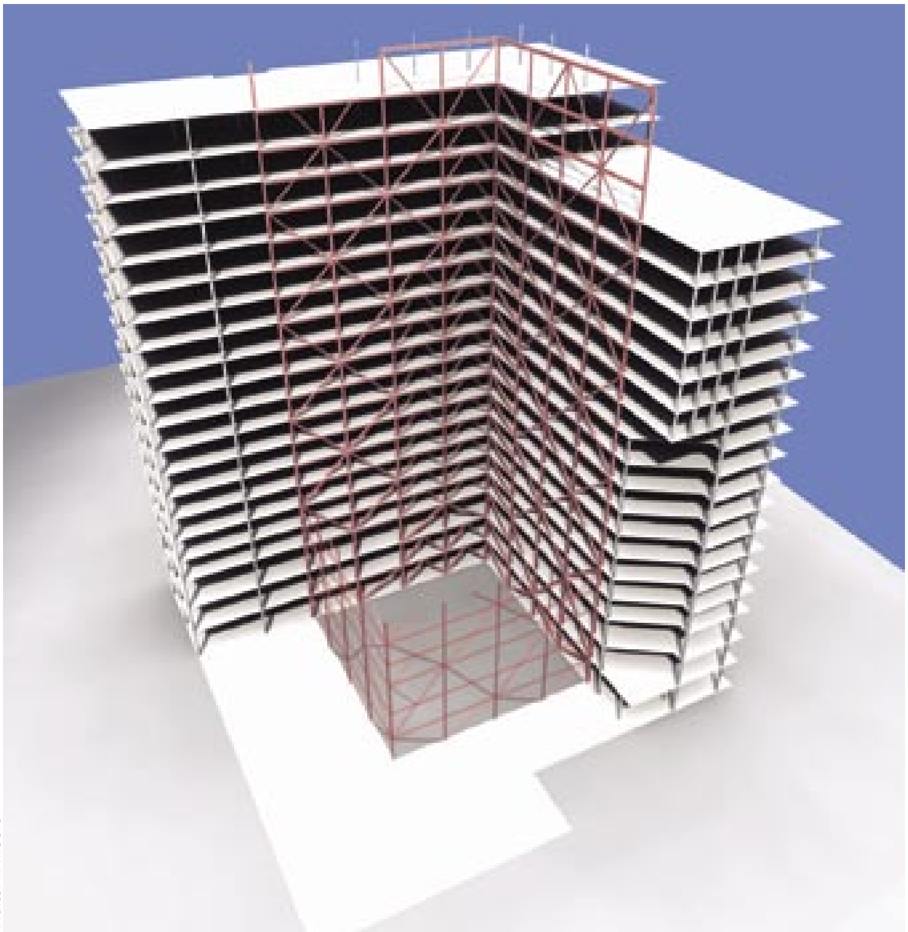
With plan dimensions of 264 ft by 274 ft and a height of 320 ft, this contemporary building takes on a unique, cube-like form and beautifully expresses portions of its structural steel frame. The building is clad primarily with curtain wall, with metal panel accents and a stone base, presenting a robust form that respects nearby downtown architecture. Insets and setbacks combine with varied curtain wall modules and glazing frit patterns to add interest and help reduce the building's scale. The upper two floors are set back from the south side, also helping to reduce scale as well as adding to the atrium clerestory height and introducing even more light into the atrium.

The cube form of the building evolved after evaluating various massing configurations, and taller configurations of up to 40 stories, with smaller floor plates, were considered. But ultimately, the final configuration, with 19 stories and 55,000-sq.-ft floor plates, was selected based on functional and cost considerations. The large floor plates provided a more efficient work area with greater layout flexibility and could accommodate larger departments on a single floor. These plus-sized floor plates, not to mention widened stairways, encourage employee interaction both horizontally and vertically throughout the office space. Additionally, the shorter building configuration was more cost-efficient than a taller building and could be completed faster. Overall, the building's unique form, internal configuration, user-supportive amenities, and architectural expression strongly resonate with Union Pacific's corporate culture.

Structural Efficiency

The structural systems were key elements in helping Union Pacific achieve its goal of a cost-effective, not to mention flexible, building. Throughout the design, the combination of architectural expression and required functionality was met with structural efficiency. Six concrete and steel structural systems were evaluated during the schematic design phase. Preliminary designs and estimated material quantities were developed for each system and given to several contractors for pricing and scheduling. After meeting with the contractors to evaluate the benefits of each system, a structural steel frame was selected as the optimal system, based on both cost and schedule considerations.

The floor slabs are 2-in. composite steel deck plus 3½-in. lightweight concrete, for a total 5½-in. thickness. Composite steel



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Four-story-tall steel X-bracing forms a 120-ft by 120-ft braced tube lateral system. Three sides of the braced tube are exposed to view along the glass walls of the full-height atrium.

Walter P. Moore

Because the brace connection forces were typically significantly larger than the beam force, the floor beams connect to continuous gusset plates, instead of interrupting the gussets.

A Vierendeel frame bridges the 90-ft gap over the recess at the main entry.

Walter P. Moore

beams are typically spaced at 10 ft on center, and bay sizes range from 30 ft by 30 ft to 30 ft by 45 ft. To provide the desired 10-ft ceiling heights, typical floor-to-floor heights in the building are 14 ft, although basement and lower-level floors have 18-in. and 20-in. floor-to-floor heights.

In addition to typical office design loads, each floor also supports a 12–in. raised access floor, and some areas of each floor were designed to support 200-psf high-density file systems. Other isolated areas were designed for 150-psf live load for specific filing and storage needs. High live load areas were concentrated at the smaller 30-ft by 30-ft bays.

The raised access floor economically distributes heat, air conditioning, power, and wiring for voice and data. This strategy, combined with modular furniture, provides Union Pacific with tremendous flexibility to quickly and economically reconfigure offices and work stations. The under-floor air distribution system allows employees to adjust air flow at their individual workstations.

The first-floor framing accommodates an elevated loading dock, executive parking garage, ramps, stairs, escalators, indoor planters, fitness center, and an exterior elevated plaza with planters. Framing for the fitness center was stiffened to accommodate exercise equipment and minimize vibrations. Stiffness of the floor framing at the aerobics area was tuned to approximately 9 hertz, and a spring-isolated floor system was installed to mitigate vibration and sound transmission to other areas of the building.

The four corners at each floor have columns set back, with cantilevered floor framing extending out to the corner, to provide for column-free corner offices. To minimize the cost of the required moment connections, the cantilevered beams were shop-welded to the columns.

The Lateral Challenge

Unlike a more conventional office tower plan, in which elevators and stairs are concentrated in a central building core, the Union Pacific Center vertical circulation is distributed around the large floor plate. Likewise, mechanical rooms and restrooms are also scattered around the floor plate. This challenged the design team from a lateral system standpoint, since the layout did not lend itself to a conventional bracing or shear wall system at a central core. However, the full-height central atrium presented a unique opportunity. Four-story-tall steel X-bracing forms a 120-ft by 120-ft braced tube lateral system, and three sides of the braced tube are exposed to view along the glass walls of the full-height atrium. Ultimately, the lateral bracing system became part of the architectural statement, exposed to view behind the glass atrium walls. The north face of the braced tube system, which is hidden in the walls, incorporates eccentrically braced frames to allow access to the elevator lobby.

With its 120-ft by 120-ft plan extent and resulting slenderness ratio of less than 3, the X-braced tube lateral system proved very efficient and economical. It also reduced the number of bracing members and created an interesting pattern in the atrium. Wind tunnel testing further economized the lateral system. Additionally, with the large plan extent and low slenderness ratio, gravity loads dominated column and foundation design and no net uplift resulted.

Bracing consisted of square HSS members with gusset plate connections to columns. To simplify and economize the bracing connections, gusset plates were welded directly to the columns and extended through the floor framing. The floor beams were then connected to the continuous gusset plates, instead of interrupting the gussets, since brace connection forces were typically significantly larger than the beam forces. This eliminated the need to stiffen or doubler-plate the beam webs.

Capping the top of the atrium clerestory is a steel truss spanning 120 ft to support the roof, lighting, and catwalks. The truss consists of a W14 top chord, double HSS 14×14 bottom chord, and HSS 14×14 webs with welded connections. A lighting catwalk cantilevers from the truss bottom chord. At night, the interior lighting illuminates the atrium clerestory like a lantern.

Bridging the Gap

The main entry, on the building's south face, features a 10-story-tall glass wall dramatically inset toward the atrium. The inset creates a glass-lined, bridge-like walkway adjacent to the atrium at each of the lower floors, and introduces more natural light into the atrium. Supporting six levels of office space spanning 90 ft across the main entry—without compromising the building's transparent outward appearance—was a structural challenge. Deep structural elements or any sort of conventional trusses were dismissed as too intrusive to the clean architectural façade. Instead, a steel Vierendeel frame was used to span the entry. Composed of W24 girders and W14 columns, the six-story-tall Vierendeel frame provides a clean 90-ft span over the entry and blends seamlessly with the rest of the structure.

To simplify erection, the Vierendeel frame moment connections are shop-welded. Frame columns are shop-welded to continuous beams, and columns are field-spliced at mid-height. Construction of this six-story frame presented a significant challenge, since the bottom of the frame is 12 stories above the entry and would not have the capacity to span it until several levels were erected. To aid construction of the Vierendeel frame, the ninth floor was designed to receive temporary shoring struts that propped up the frame until its construction was complete. This strategy eliminated costly shoring and accelerated construction. Cambers and a detailed erection sequence were specified on the structural drawings.

Looking at the building's lower extremities, drilled pier foundations extend approximately 60 ft below the basement level and are socketed into rock. To economize the drilled pier design, an Osterberg Load Cell was used to test pier end bearing and skin friction capacities. Load testing allowed pier capacities to be maximized and reduced foundation costs significantly. As a result, pier sizes ranged from 30 in. to 60 in. in diameter.

Economical, yet Easy on the Eyes

By utilizing an efficient floor framing system and X-braced tube lateral system, the overall structure was both attractive and economical. The project utilized approximately 7,100 tons of structural steel. Even with building insets and setbacks, the Vierendeel frame, and numerous other design features, the structural system totals only 11-psf structural steel overall.

To shorten the overall project schedule, an early foundation and structural frame construction package was issued while the remainder of the design was still progressing. Twenty-six months after foundation construction began, Union Pacific Center was officially opened to the ringing of train bells and the raising of railroad crossing gates. MSC

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