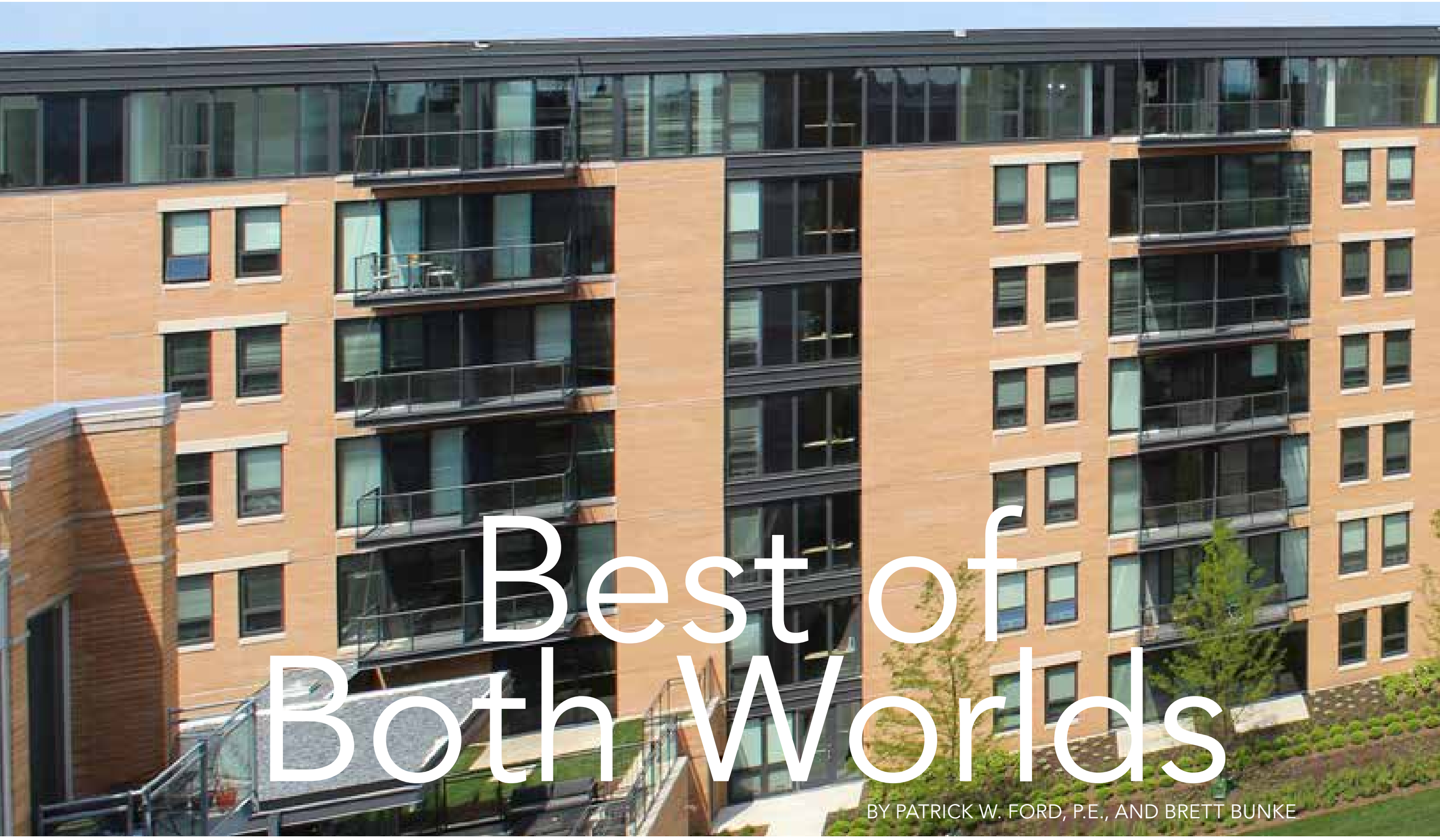
The design-build team gets the floor-to-floor height it wants using the framing system it wants, thanks to an innovative hybrid deck system.



Best of Both Worlds

BY PATRICK W. FORD, P.E., AND BRETT BUNKE

EVANSTON HAS grown up.

Over the last several years, the Chicago suburb (home to Northwestern University) has been gradually filling its downtown core with modern multi-story residential buildings, a sharp contrast to its multitudes of large, historic single-family homes.

One of the newest additions to the area is 1717 Ridge, an eight-story, 175-unit luxury apartment building above two levels of sub-grade parking. The site was originally intended for Phases 3 and 4 of a previous condominium complex that was subsequently acquired by Focus Development and Atlantic Realty. The steel-framed building is approximately 251,000 sq. ft, with a footprint of approximately 24,500 sq. ft. In addition to the main apartment building, a one-story steel and glass amenity pavilion is constructed over the existing Phase 1 parking garage and contains a fitness center and terrace lounge. A new outdoor pool is located next to the amenity pavilion as part of an elevated terrace that was originally to be built for the Phase 1 and 2 buildings of the complex.

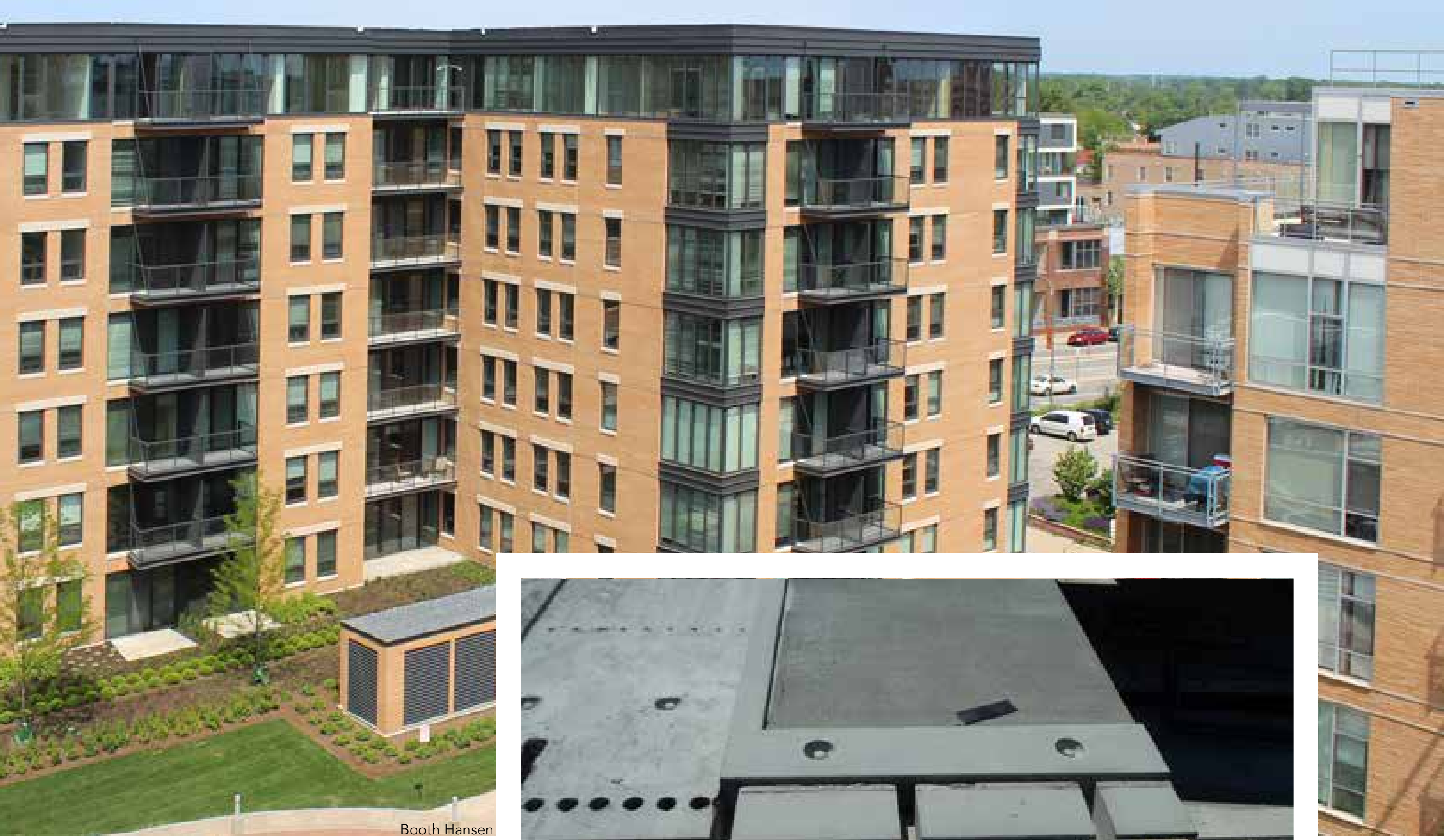
Integration and Support

First, it's important to note that this is not a typical project, due to the choice to reuse sitework from the previous project plan. As a result, two significant challenges of the project were 1) integrating the east column line of the building with the column line of the existing parking garage and elevated terrace and 2) supporting the amenity pavilion at a portion of the same level originally designed for only residential loads.

Since the original columns and foundation at the junction of the new construction were fairly robust, instead of building a new column line adjacent to the existing parking garage grid line the new building shares the same grid. This resulted in some transfer beams and a few column reinforcements in the existing garage, but also significantly less work and material than adding all new supports. Bracing of the transfer beams and reinforcement of the columns became a critical aspect of the design, especially after dimensional offsets were discovered in the locations of the new transfer loads from the existing grid lines.

The amenities pavilion area had to be reinforced beneath the existing precast hollow-core plank on steel beams. The original hollow-core plank had enough extra load capacity to carry the heavier amenity terrace loads, and the columns had significant extra load capacity since they had initially been designed for an additional eight residential stories above. However, the steel beams had been designed for only residential live loads and had to be reinforced for the heavier live loads, as well as some small transfer loads from the amenity pavilion frame itself.

For the main framing of the new building, several structural systems were investigated based on an aggressive construction schedule, tight project budget, restricted site and strict limitations on the building height. The design team considered several systems: cast-in-place concrete; precast



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▲ 1717 Ridge is an eight-story, 175-unit, 250,000-sq.-ft luxury apartment building.

➤ The flooring system allowed for the desired number of stories.

concrete beams, columns and hollow-core floors; and traditional steel framing with open-web steel joists floors.

Based on the preliminary estimates, cast-in-place concrete proved to be too expensive and time-consuming for the construction schedule and would have required increased sizes in the foundations—not to mention created a significant foundation issue at the shared column lines. An entirely precast concrete solution presented similar load issues, along with more structural difficulties with connections and tie-ins to the existing steel grid. An open-web steel joist system was the lightest and overall most economical choice, but with the strict overall height and clear ceiling limits it would have resulted in fewer apartment floors and less rentable square footage.

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Steel framing for the first floor, including the D-beams.

A New Solution

Still, given the advantages of the steel system, the design team was determined to find a way to make it work and looked into alternative flooring systems, eventually deciding to use the Girder-Slab system. This system is a steel and precast hybrid using precast hollow core slabs with an integral steel girder to form a monolithic structural slab assembly. The relatively lightweight assembly develops composite action, enabling it to support ordinary live loads at moderate spans, mimicking a flat-plate concrete design in several critical aspects. Applications include floor and roof slabs, which are supported by a steel column frame that resists all gravity and lateral loads. Wide-flange beams are typically used at spandrels, shafts and other conditions.

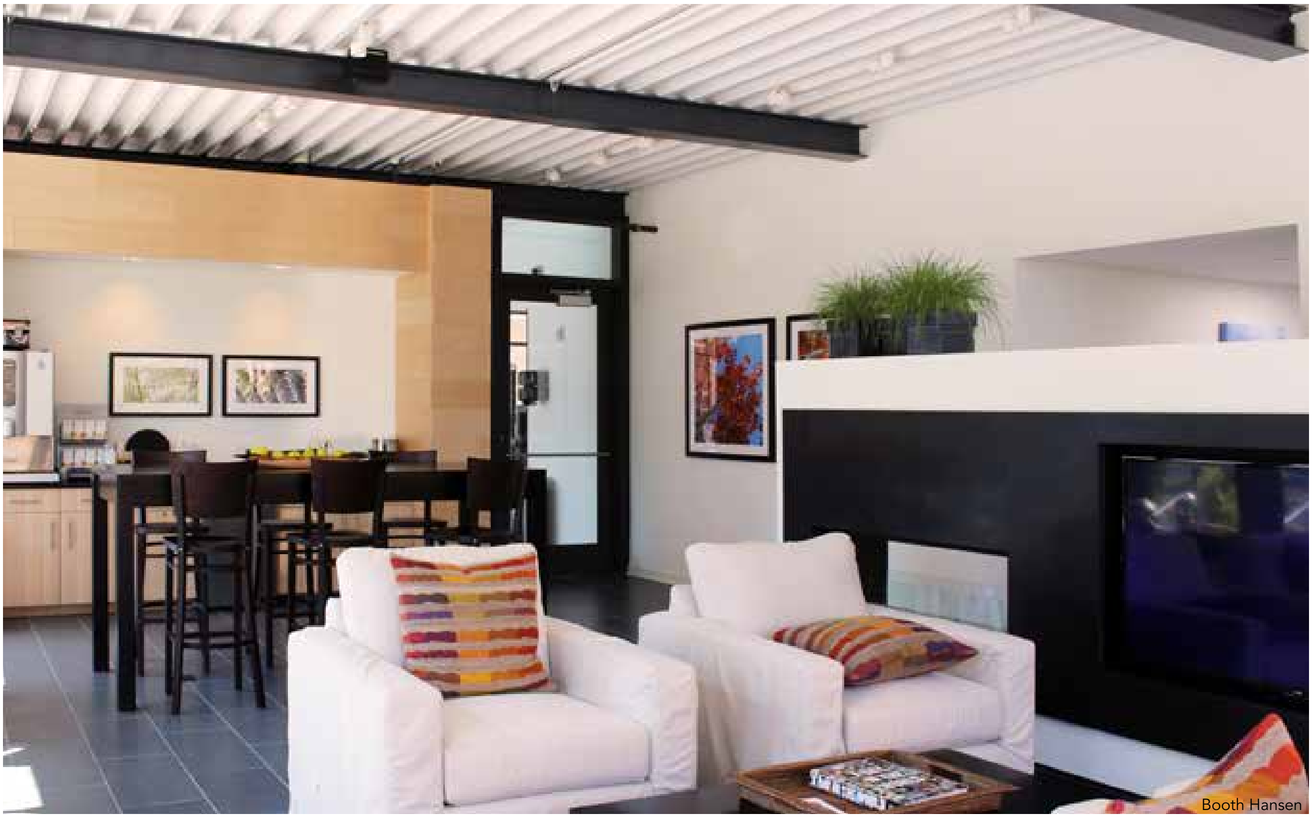
For 1717 Ridge, the system offered simpler design and detailing of the steel grid connections to the existing steel structure, cost advantages versus the cast-in-place option (in the range of $5 per sq. ft) and an overall weight closer to the lighter bar joist assembly—and it allowed for 10-ft story heights with 9-ft finished ceilings in the apartment units, thus negating the original concern about fewer floors. The design team ended up using the system at the above-grade levels, with conventional steel post-and-beam framing supporting precast plank at the parking and first levels.

A special steel beam is used as an interior girder supporting the precast slab on its bottom flange. The beam is cut from a donor wide-flange into the shape of a WT section, except for its castellated web, and a heavy rectangular bar is welded back onto the high points of the castellation to create a replacement top flange. The web and top flange are concealed within the plane of the precast slab. The whole system consists of the interior girder (known as an open-web dissymmetric beam or D-Beam) and prestressed hollow-core concrete slabs, connected across girders by cementitious grout with short lengths of reinforcing bar placed in the opposing cores at regular spacing. Grouting is done after slabs are set in place, at the same time as the hollow core keyway grouting is done, and the grout flows through the D-Beam web openings into the precast cores. There are two basic D-Beam girder sections available for use with 8-in. precast slabs. The DB-8 is used for typical assemblies while the DB-9 is used for 2-in. concrete-topped assemblies. 1717 Ridge used DB-8s throughout.

The D-Beams themselves (prior to grouting) can typically carry the plank dead loads for span lengths of 18 ft to 19 ft, often limited by pre-composite dead load capacity. The difference with the bay size is made up with a "column tree," which is an engineered WT bracket, modified as required and cantilevered off the column several feet to a field bolted splice connection to the D-Beam. The columns are subject to an increased moment due to this configuration and must be checked for live loads in alternating bays, which in some cases would cause the worst case bending and axial interaction. On 1717 Ridge, it was estimated that the columns increased only one weight per standard depth over an ordinary concentrically loaded condition.

Lessons Learned

As this was our first experience with the Girder-slab system, we made several observations. The D-beams are often made



The interior of a residential unit, with exposed steel framing.

to identical designations on the project regardless of specific strength requirements. This is based on ease of fabrication and economy of donor sections (two D-beams are cut from each wide-flange donor beam). Shoring requirements and pre-camber of the D-beams should be carefully checked for the typical bridge beam conditions. Measured dead load deflections at cases with shear plate connections are very close to calculated deflections, as opposed to end plate connected beams or conventional framing sections, and pre-cambering of the sections is easily done in the fabrication shop.

Also, column tree sections are more radically affected by the applied eccentric moments of the system, and weldments of the modified WTs can be a significant fabrication undertaking. Non-composite dead load limitations are often critical to the design, especially for the decision of shoring or not shoring. For example, the composite section can be nearly twice the strength and over twice the stiffness of the D-beam itself.

Thanks to our decision to employ what was a new deck system for us, we were able achieve the desired story heights and design the building with a structural steel frame. MSC

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