# Above the Rest

BY CHRIS D. POLAND, S.E.

OREGON'S POPULATION HAS BOOMED OVER THE LAST 25 YEARS, AND THE MEDICAL NEEDS OF THE STATE HAVE INCREASED PROPORTIONATELY. Oregon Health and Science University, the state's only health and research college, recently underwent an expansion to meet that demand. The university wanted the expansion to integrate seamlessly into the existing surrounding structures and landscape. With limited site options available for expansion, a new site alongside the existing hospital was created on a steep hill by building underneath the hospital and next to a road. Inventive design and planning placed the hospital's main street within a new, 14-story, 400,000-sq.-foot facility: the Peter O. Kohler Pavilion

Home to 120 hospital beds, 12 new operating rooms, outpatient care space for the Center for Women's Health and the OHSU Cancer Institute's Center for Hematologic Malignancies, as well as a new Radiation Medicine suite, the facility also holds 15,000 sq. ft of garage space, enough for 450 cars.

## A Precarious Perch

This expansion doubled the university's programming space—and created several design challenges. Programming required that the expansion integrate existing facilities with matching floor heights to allow for flexible growth in the future. Additionally, OHSU is classified by the state of Oregon as an essential facility, requiring it to meet strict seismic standards. The new facility had to be designed as usable after a major earthquake to ensure its ability to serve the community in that time of crisis. Additionally, the steep hill and a need to align floors that varied in height from 11 ft to 19 ft required a unique solution for this campus centerpiece.

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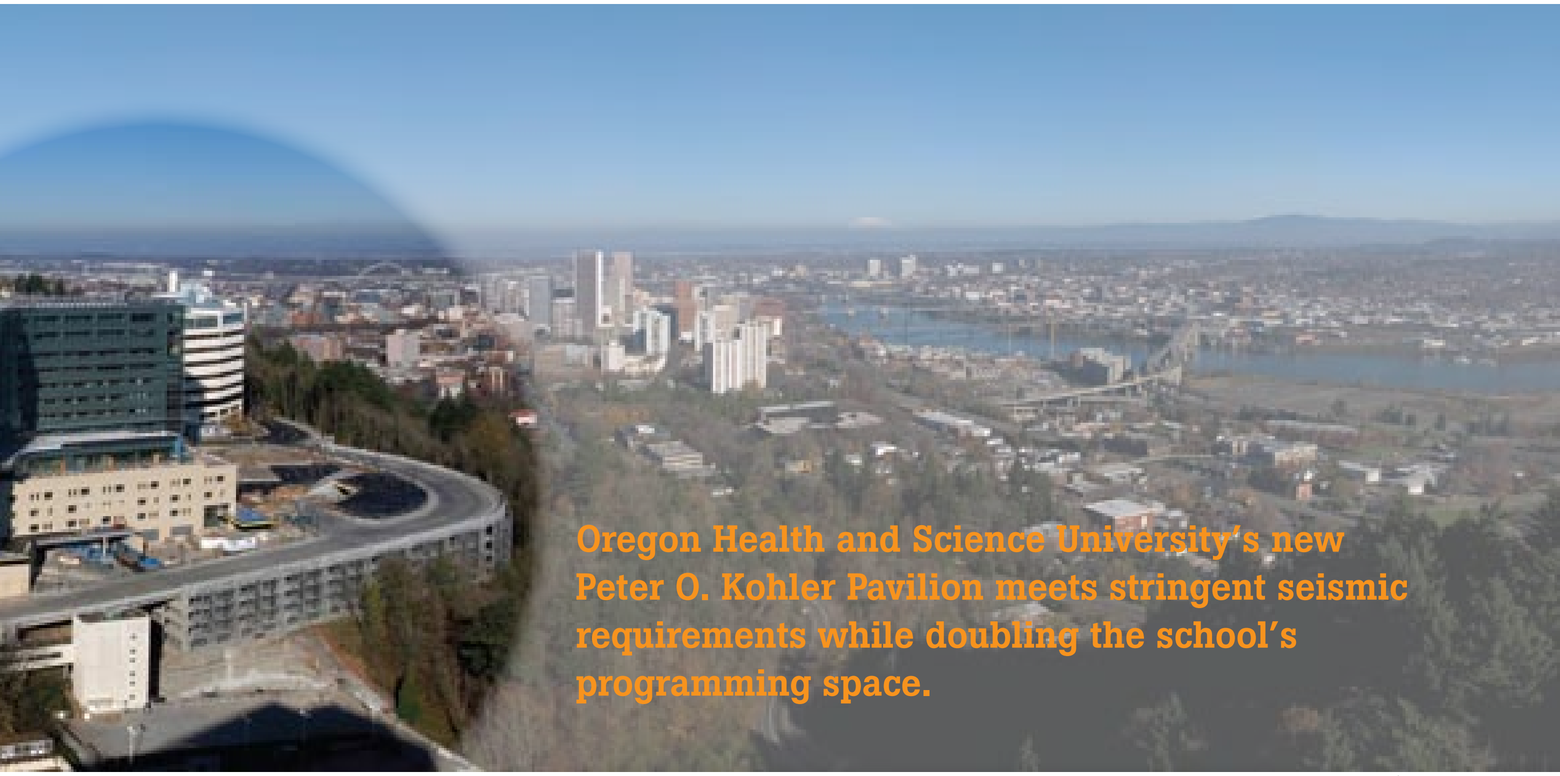
The combination of a steep site and the need to match floor elevations and support the main road while meeting seismic requirements led to a combined concrete and steel structural solution. The resulting dual structural systems provided the best seismic performance in each sector of the project, as well as maximum flexibility in the programming spaces. The engineer was able to make the varied structural systems harmonize with the projected budgets by maximizing design efficiencies. The seven-story base structure served to embed the facility into the hillside, providing the needed parking and support for the structural steel patient tower, which curves to match the hillside and interconnects with the existing hospital.

## Going Hybrid

The shorter story heights within the patient tower could not accommodate the conventional structural depth of steel composite floors and meet the utility system requirements. The engineer designed a hybrid composite steel and concrete flat slab system to address this issue. Though more costly than a traditional floor system, the hybrid floor allowed the new construction to match the floor heights of the adjacent building's existing concrete system, while proceeding with the desired steel framing system. Overall project costs were minimized as a result.

The hybrid system was used on floors five, six, eight, and 10 through 14, where the floor-to-floor heights were 12 ft 6 in. or less. The system utilized 4-in.-deep wide-flange beams spaced at 4 ft on center and spanning to column line girders. Up to three times as many beams were used with the shorter spacing distance to create the same strength as a traditionally spaced beam system.

The metal deck was supported on the



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bottom flange, allowing the concrete to be cast fully composite with the beams to achieve the needed stiffness. The slab-reinforcing steel was interwoven with the steel beams to create a system that met rigorous strength and vibration standards.

The composite system provided for an average ceiling height savings of up to 24 in., creating adequate space for mechanical systems typically found in hospital construction. Additionally, the shallow framing system with intermittent girders created ceiling corridors for placement of equipment and mechanical system lines.

Floor construction at the other levels consisted of a traditional composite metal deck with reinforced concrete fill, supported on composite steel wide-flange beams and girders. Gravity loads are resisted by the hybrid and composite floor systems spanning to steel columns, which are founded on spread footings or pile caps and drilled piers embedded in hard basalt.

## An Essential Facility

Structural steel was further used in one of two seismic systems present in the building. As an essential facility designed to sustain minimal damage and remain operational after a major earthquake, the engineering team designed multiple systems that offered redundancy throughout the expansion.

The parking garage (floors one through


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seven), and the patient tower (floors seven and higher), each had their own unique systems. The lateral resisting systems included steel moment frames for the seventh floor and higher, reinforced concrete shear wall base structures, and rock anchors. The steel moment frames used reduced beam sections and deep columns to minimize the steel tonnage, based on research conducted by AISC at Lehigh University (which involved a series of tests on deep beams with RBS connections to expand the depth to which these connections were considered prequalified). Steel moment frames were selected to complement the hybrid floor system and provide superior lateral force resistance and flexibility for future uses.

The reinforced concrete shear wall base structure provided the foundation for the superstructure while accommodating the steep site. By incorporating the site retaining walls into the main building system and adding additional shear walls to fully support the lateral and earthquake loads, all structural elements were used to their full capability. Further, rock anchors were used over the height of the base structure to pin the base to the hillside and reduce the number of concrete shear walls and the size of the foundation structure. The garage, cast in concrete, served as the foundation structure that supported the hill, the road, and the steel-framed tower. MSC

## Commitment to Goals

At $216 million, the final approved budget reflected the university's commitment to meet its highest priority goals at Kohler Pavilion. The result was a building with state-of-the-art facilities and structural engineering that reflect the university's need for flexibility, shear strength, and sustainability.

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