*Finding a Parking Space*

# Portland Airport Expansion

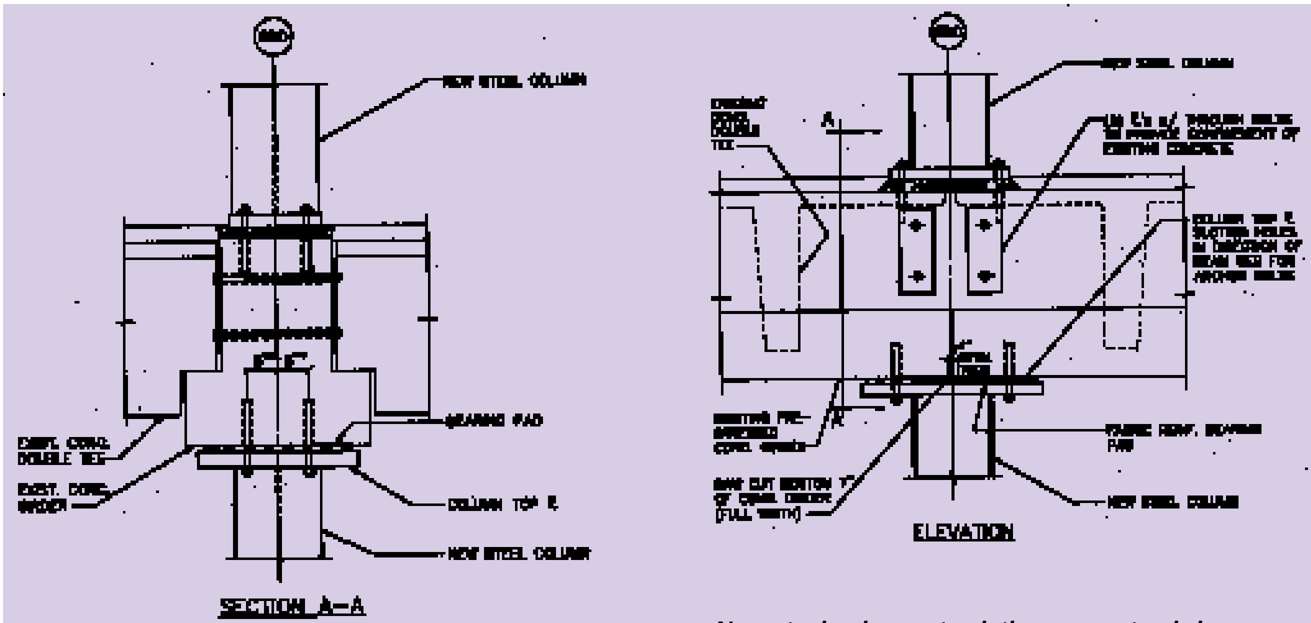
*The addition to the existing parking structure at Portland International Airport included a 95' structure adjacent to the original construction as well as four new floors on top of the existing building.*

**Craig Totten, P.E.**

**During the past decade,** Portland, OR, has seen it's population skyrocket more than 50%, from less than 850,000 in 1990 to more than 1,350,000 in 1998. This rapid—and continuing growth—has significantly increased passenger air traffic at the Portland International Airport, resulting in the need for more terminal space, more parking and better vehicular access.

As part of a major airport expansion and renovation, the Port of Portland opted to substantially expand the airports parking facilities. Not only was an additional 95' of structure added to the west side of the garage, but four entirely new floors were added to the top of the three-level concrete structure. To access the garage, two cast-in-place concrete helixes were constructed on the east side of the garage, one for vehicles entering and one for vehicles exiting the structure. The four existing elevator cores were extended up through the new levels. The two cores nearest the terminal were enlarged from two to five elevators for a total of 12 elevators servicing all levels of the expanded garage. The new garage includes a total of 3,500 parking spaces, plus car rental and other commercial spaces. The existing area of the parking garage was 540,000 sq. ft. and the expansion added an additional 940,000 sq. ft.

In addition to expanding the parking garage, the Port of Portland is also enlarging the main terminal building, adding four elevated lanes to the enplaning roadway in front of the terminal, constructing two pedestrian bridges that connect the new fourth level of the parking garage to




*New steel column at existing concrete girder*

*The massive expansion of the airport's parking structue was necessitated by Portland's rapid population growth. The expansion included an adjacent addition as well as a vertical addition.*

the terminal, and constructing a 220' x 530' steel truss and glass canopy over the roadway between the garage and the terminal.

### Four-Story Expansion

The existing garage, a precast concrete structure supported on precast concrete piles, was constructed in 1988. The structure consisted of 60'-long, prestressed double-tees supported on inverted tee precast beams spanning between precast columns on a 30' x 60' grid pattern.

Structural steel was used for the four-level addition to the garage because it is lightweight, did not need to be fireproofed, was easy to erect, and aesthetically complemented other airport facilities. The expansion required 7,500 tons of structural steel. The use of steel supported the fast-track schedule and was easier to erect than cast-in-place or precast concrete. Structural engineer for the project was KPFF Consulting Engineers of Portland. Steel fabricator was AISC-member Fought & Company (who also did the detailing) and AISC-member Canron Steel Corporation. General contractor was Baugh Construction and architect was Zimmer Gunsul Frasca, Portland.

Erecting additional concrete levels would have required closing the garage during construction due to extensive shoring inside the existing garage, which would have had significant financial impacts on the Port. Steel, however, could be erected above the garage and the existing garage could be kept open through construction. The lighter structural steel frame also reduced both the number of new piles required to support the weight and the lateral seismic design forces of the new structure. Chemical deicers are not commonly used in the Northwest; therefore, steel structures typically develop less corrosion and require less maintenance than they would in harsher winter climates where chemical deicers are more frequently used.

The lateral force resisting system of the existing parking garage consisted of cast-in-place, concrete moment-resisting frames. The lateral system was designed to meet 1985 Uniform Building Code (UBC) Seismic Zone 2B requirements. In 1991, the UBC increased the seismic design requirements of the Portland area to Seismic Zone 3. Therefore, design of the new parking expansion, along with the existing parking structure, was required to meet the higher seismic force levels and more stringent detailing requirements of Zone 3.

The existing parking garage was originally divided into four separate structures by longitudinal and transverse expansion joints running north-south and east-west through the floor levels. Design requirements included reducing floor vibrations in the existing floor slab caused by vehicles driving across these expansion joints. The sudden transfer of vehicle wheel loads from one structure to another sent highly perceptible vibrations across the floor of the garage. As a part of the new design, the existing expansion joints were tied together using cast-in-place concrete diaphragms between the vertical webs of adjacent double tees on each side of the expansion joints.

*The new steel parking structure features large expanses of column-free space, which makes parking easier as well as providing a more open and airy feel for the garage.*

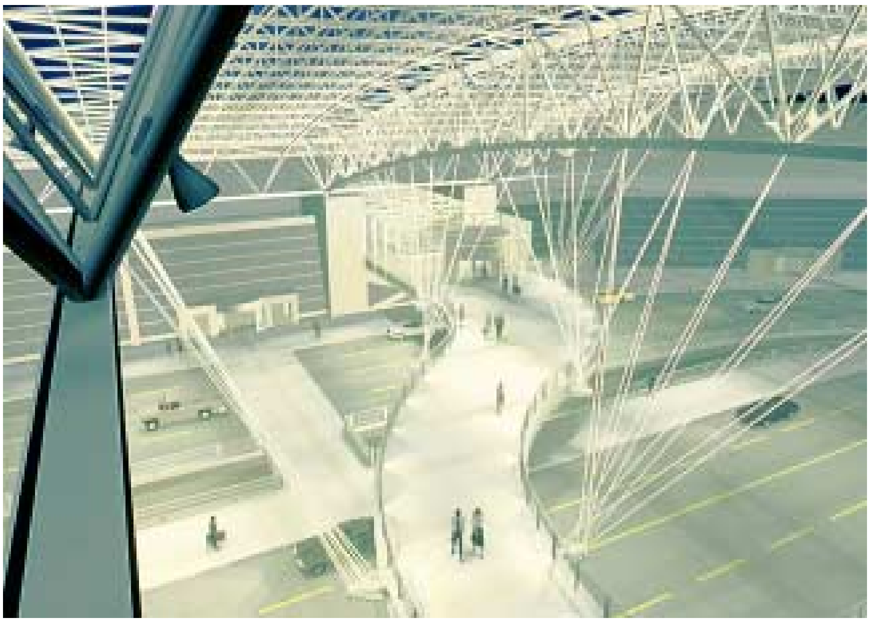
The existing concrete topping slab was also chipped away and re-poured continuously across the joint. This effectively tied the four segments together, reducing the need for internal lateral bracing.

Typical interior floor framing for the expansion consisted of 3-inch composite metal decking with a 3.5-inch concrete topping, which spans 10' between floor beams. G90 galvanized metal decking was used for increased protection against corrosion. As an additional precaution, reinforcing steel was added to the low flutes of the deck to allow the concrete topping slab to span independently of the deck between floor beams in the event that the deck does eventually corrode. W16 x 26 floor beams typically span 30' to W30 x 116 girders with columns on a 30' x 60' grid pattern. The interior steel structure has been left exposed. The structure qualifies as an open parking garage; therefore, no fireproofing was required.

To fully use the capacity of the existing precast concrete piles, and to minimize impacts on parking spaces in the existing garage, the first two levels of the expansion (the fourth and fifth floors) were supported by steel columns bearing directly on top of the existing precast concrete columns. This was made possible by re-supporting approximately half of the existing structure on new steel columns positioned between the existing columns. These columns, at 30'on center, extended to the roof of the garage resulting in a 15'x 60' column grid at the lower four levels and a 30' x 60' grid above the fifth level. These new columns were founded on new pin piles, which were installed inside the existing parking garage, where head clearance was restricted. The pin piles consisted of 100'-long, 7.75"-diameter steel pipe sections that were drilled into the ground in 4-foot sections. Each section had a threaded and counter threaded end, allowing the sections to be connected together during the drilling process.

Where the new steel columns intersected the existing precast concrete beams, the concrete beams had to be re-supported. Existing precast beams were cut at each new column support to form two separate 15' long beams. This was required because the amount of settlement predicted for the new pin-pile caps would have caused a shear failure at the ends of the existing precast beams.

To minimize obstructions caused by the use of interior braces or shear walls, four braced frames were constructed on the full height of each exterior face of the structure. Two additional interior braced frames were also required to strengthen the existing three-level parking garage. Placing frames only at the perimeter of the new 480' x 470' floor levels, and limiting the bracing to four bays, resulted in very high lateral loads in the braced frame members. To resist these loads, heavy W14 column sections were required for brace. Locating the new braced frames at the perimeter of the garage where there was unrestricted overhead clearance, allowed the frames to be supported on conventionally driven piles.



*Shown at top are the long-span steel members supporting the second level drive, while pictured above is an artist's rendering of the new pedestrian walkway connecting the expanded parking garage to the airport terminal.*

The relatively high stiffness of the new braced frames compared to the existing concrete moment frames required that the new frames be designed to carry the entire lateral force. Existing concrete frames were left in place as gravity only supporting members.

## West Expansion

The west expansion of the garage was column free to allow unimpeded access for buses and commercial vehicles. In addition to the practical aspects, the openness of the garage creates a pleasing aesthetic. To create this column free space, W33 x 118 beams at 10' on center span 95' between column lines. This large span required large cambers in the beams. These cambers were varied from beam to beam to provide slope for stormwater runoff.

As with the upper four floors on the vertical expansion, the steel members on the west expansion were left exposed.

## Project Challenges

Traffic topping was used only on the seventh floor (the roof level) of the garage. New floors below this level were bare concrete with a light broom finish. The slabs over metal decking were heavily reinforced to minimize cracking as well as to resist diaphragm shears. Cylindrical, cast-in-place reinforced concrete bases were poured around the base of the new interior steel columns to protect them from vehicle impact loads.

New steel framing around the perimeter of the garage was coated with a four-coat, moisture-cured urethane system for increased weather protection. Inside the garage, a two-coat, latex paint system was used. The underside of the composite metal deck was coated with a moisture-cured, zinc primer to improve the bonding of the latex paint.

*The expansion inlcuded added four levels of steel framing on top of the existing concrete structure.*

Pretensioned cable rails were designed around the exterior of the garage to provide vehicle restraint. Due to the extremely high loading at the cables' anchorage locations, an extensive support structure was required at both ends of the rails.

The perimeter of the garage was clad with aluminum panels to match other existing airport facilities. These aluminum panels were supported on light-gage metal studs attached to the perimeter structural steel framing. Attaching the studs proved to be challenging and required extensive framing and complex connections.

The expansion of the airport's parking garage involved many design challenges. However, the use of structural steel reduced or eliminated many of these challenges and significantly improved several of the project's design features. The use of structural steel minimized on-site construction time. It allowed the project to be constructed while the garage remained open; and it reduced the overall cost and schedule of the expansion. The selection of steel as an alternative to concrete proved to be an excellent choice for everyone involved: the owner, the contractor, and the design team.

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