

**2017 PROJECT OF THE YEAR: THE RITZ-CARLTON
RESIDENCES WAIKIKI BEACH, PHASE 1**



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Waikiki. The Ritz-Carlton. The former is one of the world's premier vacation destinations and the latter is synonymous with luxury development (Fig. 1). The union of these two is The Ritz-Carlton Residences Waikiki Beach. Constructed in two phases, this project is the largest, most recent new resort development and includes approximately 900,000 ft² (84,000 m²) in two complementary 38-story towers, each 350 ft (107 m) tall. Phase 1 of this luxury hotel and condominium project

opened to the public in July 2016 and has become one of Hawaii's most sought-after luxury residential addresses, offering the ultimate in resort-style living with unobstructed views of the Pacific Ocean, world-class design, and access to legendary amenities and services provided by one of the world's best hoteliers.

The project site posed many challenges. With severe site constraints, building height and envelope restrictions, and a desire to maximize views and sellable



Fig. 1—The Ritz-Carlton Residences Waikiki Beach, Phase 1.

space, structural simplicity was not a priority. Baldridge & Associates Structural Engineering (BASE) rose to the occasion, using post-tensioning throughout the project to create innovative solutions to the structural challenges.



Fig. 2—PT slab under construction.



Fig. 3—Major building transitions.

The resulting building required the following features:

- Optimized thin post-tensioned slabs (Fig. 2);
- Eighteen unique floor types;
- A post-tensioned transfer slab with upturn beams at the roof supporting 32 hanging steel columns;
- Over 50 major wall and column transitions (Fig. 3);
- Seventeen transfer girders;
- One hundred twenty ft (37 m) long post-tensioned concrete truss;
- Sloping W-shaped columns cupped with a post-tensioned restraint beam (Fig. 4 and 5);
- Concrete-wide-flange steel composite columns; and
- Most critical to the occupants, unobstructed views of the Pacific Ocean.

HEIGHT RESTRICTIONS

Squeezing 38 floors into a 350 ft (107 m) height limit was no easy task, especially considering additional floor height requirements for public and premium levels and mechanical transitions at the transfer floors. To meet all of the project requirements, the slab system needed to be as thin as possible while still maintaining acceptable sound transmission, vibration, and deflection characteristics (Fig. 6). The only way to achieve this was through the use of post-tensioning. The majority of the slab areas are 7 in. (175 mm) thick at parking and residential levels.

One unexpected benefit of the height restriction is the structural efficiency created by the use of a thin post-tensioned floor system. Overall structural weight was reduced by as much as 30%, reducing column, wall, and foundation requirements. As seismic load is proportional to the structure's weight, the lateral load requirements were also reduced.

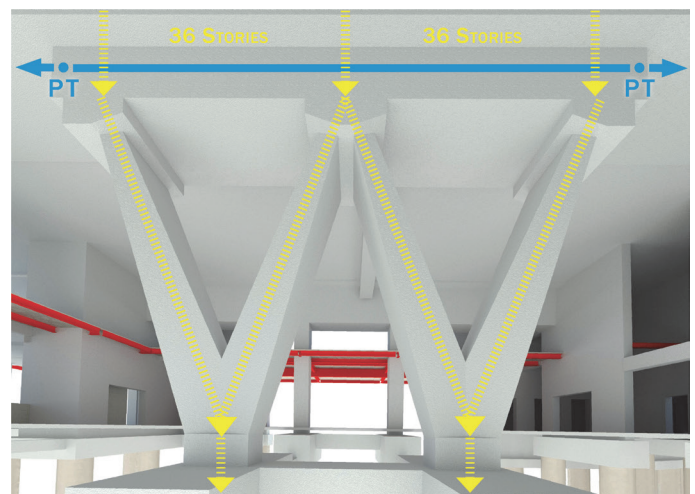


Fig. 4—Load transfer through W column.

GRAVITY SHIFT

Encompassing nearly 500,000 ft² (46,500 m²), the Phase 1 building contains five floors of parking; one floor with back-of-house space; two floors with amenities such as pools, restaurants, and a spa deck; and 30 floors of condominium units for a total of 38 levels plus a usable roof deck. This diverse use leads to a total of 18 structurally unique floors.

As is typical with vertical mixed-use projects, the optimum column and wall layouts for each use rarely match the supporting levels below. Offset foundations and columns, as well as sloping columns, were incorporated throughout the project to shift support locations through varying floor layouts. In this tower, more than 50 major transitions were required for the vertical elements, with no columns going to the ground in their original location and some elements shifting in plan several times throughout the height of the building.


Adding to the challenge was a lack of structural depth, which in many cases prevented the use of conventional

transfer girders except at the podium floors, where 17 post-tensioned transfer girders in both downturn and upturn (Fig. 7) conditions were used to reposition tower-level columns and walls to work with an efficient parking layout and to create a large open space at ground level for the drop-off area located directly below the tower. The ground-floor loading dock space created a major challenge from a structural standpoint due to a number of constraints that would not allow the podium vertical elements over the loading dock to extend down to the foundation level. These constraints included very tight spaces for trucks to maneuver, city utility easements, and access requirements for an adjacent retail loading area. This meant that an area of the building with spans of 50 to 120 ft (15 to 37 m) had to be column-free (Fig. 8). To support the seven floors of podium structure above, four post-tensioned transfer

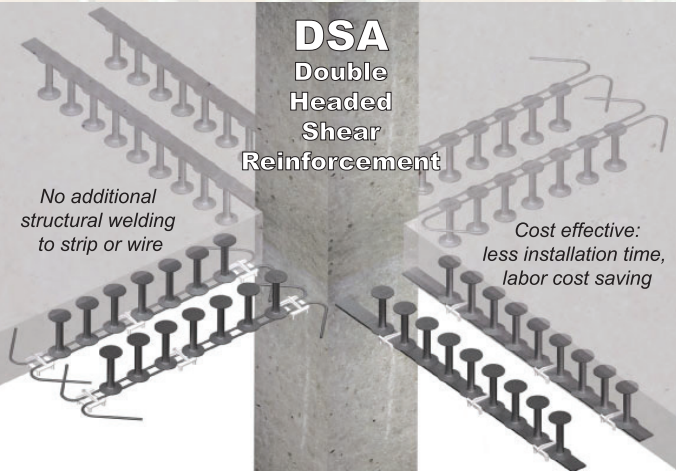


Fig. 5—W column under construction (top) and completed (bottom).

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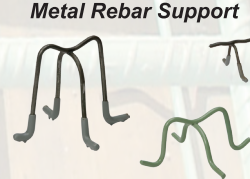
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girders and a two-story post-tensioned concrete truss was designed to span the full 120 ft (37 m). Post-tensioning was used in the top and bottom chords of the truss to help control deflections and vibrations (Fig. 9 through 11).

At the top of the tower, the penthouse units were designed with spectacular double-story atrium spaces

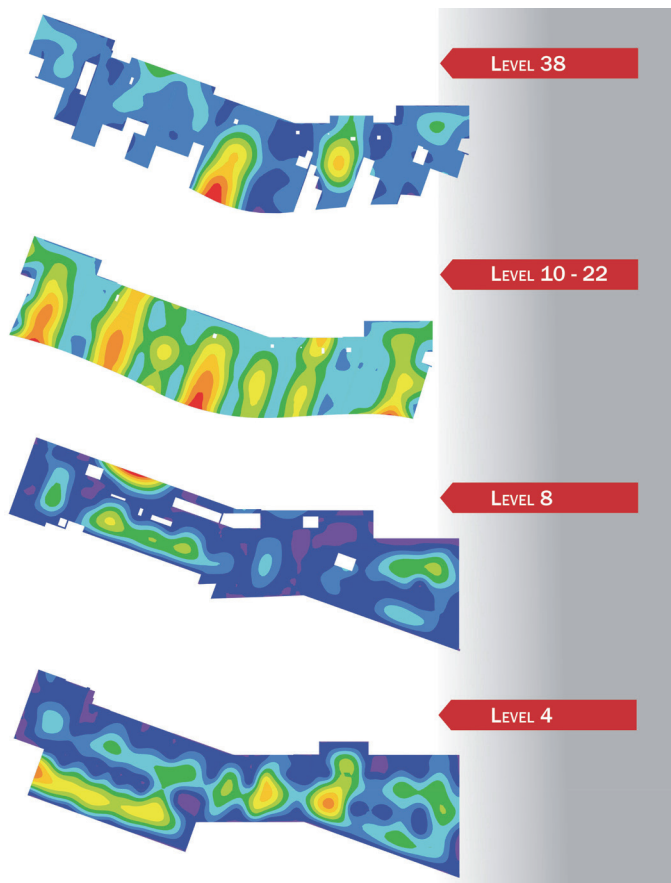


Fig. 6—Ritz Phase 1 deflection plans.



Fig. 7—PT upturn transfer girder.

(Fig. 12). These were achieved by hanging the penthouse post-tensioned slabs with 32 steel “skyhook” columns from the roof transfer slab (Fig. 13). The roof not only had to support the loads from the hanging columns but also

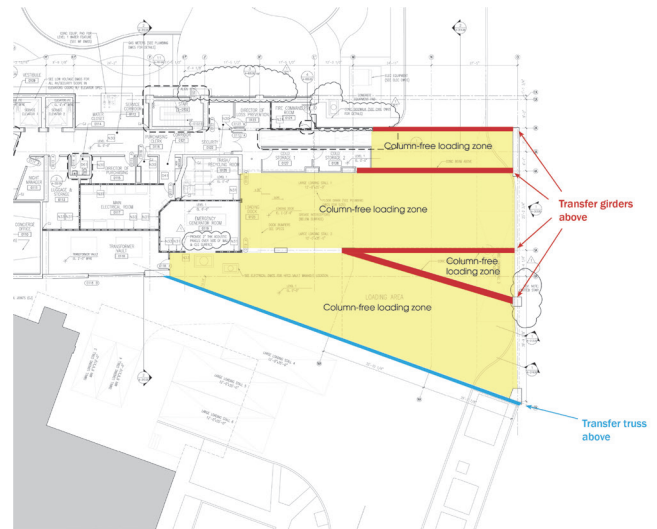


Fig. 8—Drawing indicating four PT transfer girders and 120 ft (37 m) PT concrete truss.

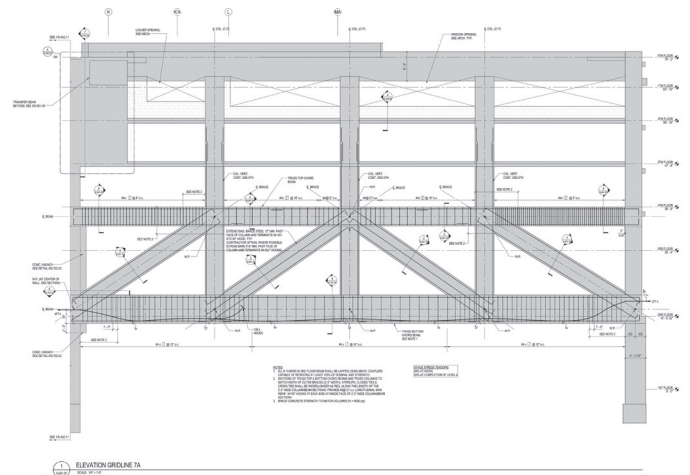


Fig. 9—PT concrete truss drawing (top) and completed truss (bottom).



Fig. 10—PT concrete truss under construction.



Fig. 12—Rendering of double-story penthouse atrium unit.

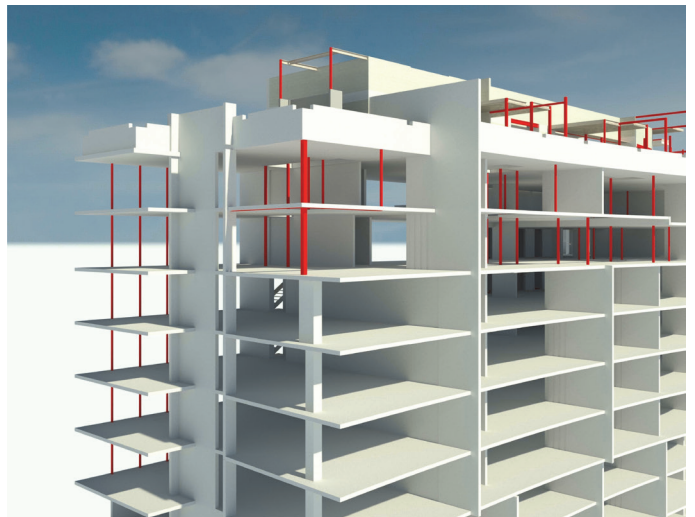


Fig. 13—Revit model of hanging penthouse slabs, PT slabs, and roof PT transfer slab.

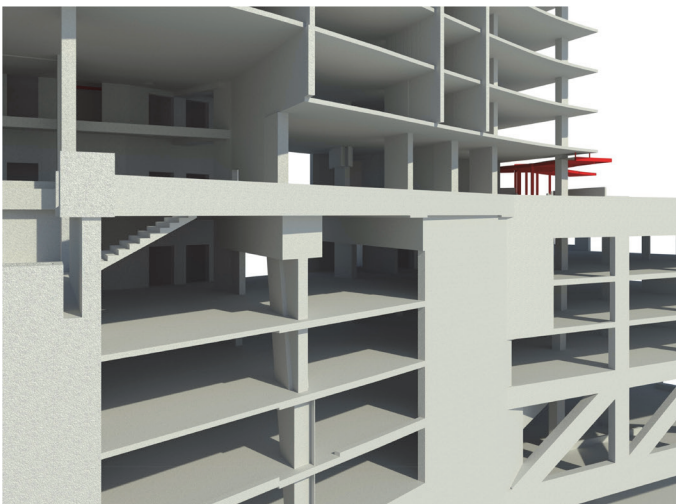


Fig. 11—Rendering of PT transfer girder.



Fig. 14—Penthouse unit rooftop pool and terrace.

the loads from heavy mechanical loads in the center and loads from rooftop terraces on the perimeter (Fig. 14). This was achieved by using a post-tensioned concrete slab with post-tensioned upturn concrete beams.

To maximize views for the premium units in the upper floors, more glazing and less concrete wall had to be incorporated into the design of the north (back) face of the tower at levels 30 through 38. A series of small HSS 5 x 3 steel columns were designed to replace a solid concrete wall found in the lower floors. The HSS columns were designed to be hidden in the glazing mullions so as to give the appearance of 40 ft (12 m) long glass walls at each side of the elevator core.

BASE started working on the conceptual design of the Phase 2 tower just as construction commenced on the Phase 1 tower. The Phase 1 and Phase 2 towers share common spaces at the podium floors but are separated by seismic expansion joints. During the initial Phase 1 design, BASE collaborated with the architect and contractor to ensure that the expansion joint was designed and built with corbels along the floor edge beams and columns to support the future Phase 2 tower, even though its design was only in its very early stages. This proactive approach avoided the need to provide new columns and new foundations along the expansion joint that might appear to be an afterthought or retrofit to support the final Phase 2 building configuration.

LATERAL SYSTEM CHALLENGES

The project is located on the island of Oahu, HI, a moderate seismic zone subject to hurricanes. The size, shape, and significance of the project justified a more rigorous approach to determining both wind and seismic

loads on the structure. A wind tunnel study modeling the surrounding area, with and without the Phase 2 tower, was performed by RWDI Consulting Engineers & Scientists to determine the impact of both normal trade and hurricane winds on the building. Unique soil conditions found at the site justified a more in-depth seismic shear wave velocity test that was performed by the geotechnical engineer to determine seismic Site Class classification.

With the height restrictions on the building, shear wall link beams typically used as part of the lateral system needed to be rather shallow, reducing their effectiveness. BASE developed composite link beams using standard concrete link beams combined with embedded strengthening steel plates. These plates were configured to allow slab post-tensioning to be placed through the links along with embedded conduit and pipe sleeves.

Due to the height of the structure, the relatively light weight of the post-tensioned floor system, and the results of the seismic shear wave velocity testing, seismic forces were reduced to the point where wind forces governed the design of nearly every lateral element, creating a very balanced and economical lateral system considering all of the vertical transfers in both gravity and lateral load-resisting elements.

CONCLUSIONS

Construction on The Ritz-Carlton Residences Waikiki Beach, Phase 1, was completed in April 2016. Through the use of post-tensioning, along with the hard work and innovation of the architect, the structural engineer, and the contractor, Waikiki now has an iconic structure worthy of both name and location.

Location: Honolulu, HI

Submitted by: Baldrige & Associates Structural Engineering (BASE)

Owner: PACREP, LLC

Architect: Guerin Glass Architecture

Engineer: Baldrige & Associates Structural Engineering (BASE)

Contractor: Albert C. Kobayashi, Inc.

PT Supplier: Suncoast Post-Tension

Other Contributors: Associated Steel Workers, Ltd. (PT Installer)

Jury Comments:

- The designers were able to use post-tensioning to mitigate the height restrictions by using thinner post-tensioning slabs and transfer girders.
- This building is a wonderful example of the advantages of post-tensioned concrete in tall buildings.
- Without post-tensioning, this building would be much taller, much heavier, much more expensive, and would present many more architectural challenges.