



Courtesy of Hawaii Department of Transportation

Maui's Kahului Airport ConRAC

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The new \$340 million Consolidated Rent-A-Car (ConRAC) facility at Kahului Airport is part of an ambitious airport modernization program with the goal of upgrading the state's airports to increase operational efficiency and improve the traveler experience. The Kahului Airport ConRAC accomplishes this goal by consolidating most of the rental car companies within one state-of-the-art structure and connecting to the main airport terminal via tram.

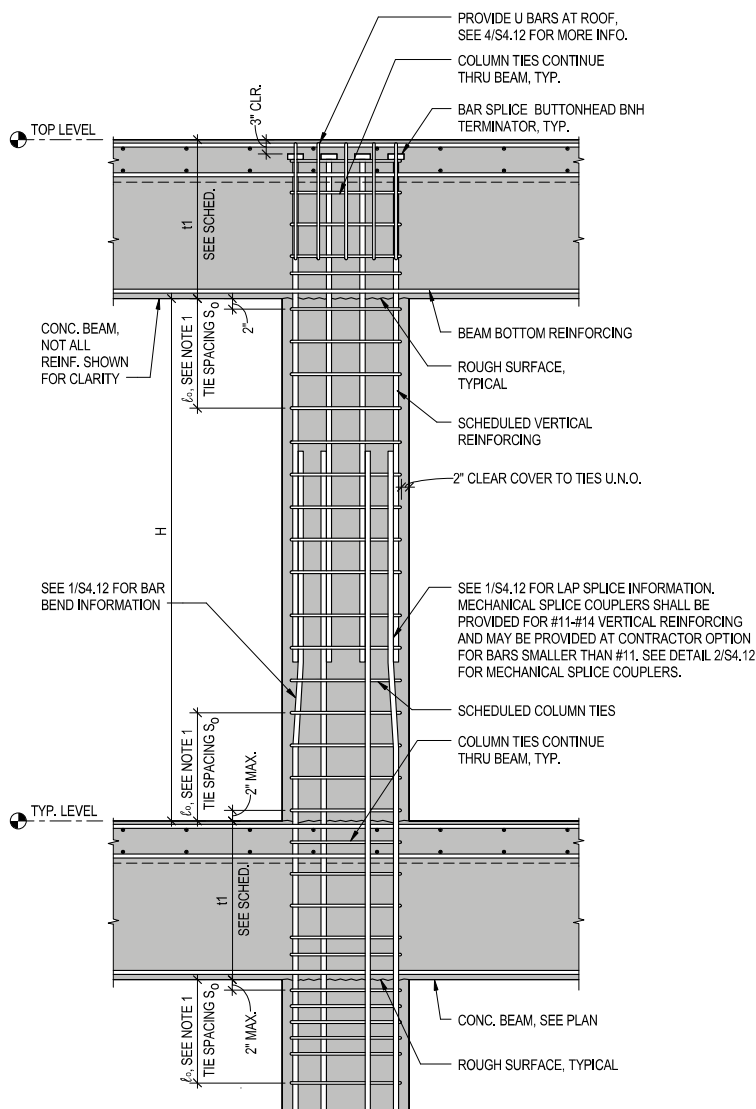
The ConRAC facility is a three-story structure, including a partial basement area and small enclosed roof structures for stair egress and elevator access to the roof parking areas. The building has an overall area of approximately 1.9 million square feet, measures nearly a quarter-mile from end to end, and includes more than 3,700 parking stalls dedicated to the rental car companies and an additional 700 stalls for employee parking. There are also 72 fuel positions, 12 carwash bays, and 11 maintenance and mechanic stations for rental car servicing.

The main structure was built using cast-in-place concrete with columns supporting post-tensioned beams and girders that span 60 feet by 40 feet, respectively. The beams were spaced at 20 feet on-center, providing a regular and repetitive framing system to simplify formwork. The structural slab consists primarily of a one-way post-tensioned slab, typically 5

inches in thickness, and spans 20 feet between the beams. In addition to the requirements of the building code, the garage was also designed to meet the recommendations provided in ACI 362.1R-12, *Guide for the Design and Construction of Durable Concrete Parking Structures*, which designated the Kahului Airport ConRAC as being within

Coastal Chloride Zone I due to its location between half a mile and three miles from the Pacific Ocean.

The Hawaii Department of Transportation and the architect of record both wished to maintain an open floor plan for the main structure to maximize ventilation, circulation, and flexibility. No interior bearing walls were provided, and the structure was designed as a moment frame to accommodate this desire. Due to the high seismicity present on Maui ($S_s = 0.989g$, $S_1 = 0.254g$), the moment frames were designed as special reinforced concrete moment frames with a response modification factor, R , of 8. As the state of Hawaii was still operating under the 2006 version of the *International Building Code* (IBC), a variance was successfully sought to allow the structure to be designed in accordance with the relatively newer ACI 318-08, *Building Code Requirements for Structural Concrete*, which was the first instance of that code to include or allow for the effects of post-tensioning in special moment frames. The effects are limited,



Typical column detail.

however, as ACI 318 prohibits utilizing more than 25% of the post-tensioning strength capacity to resist seismic loads. However, in accordance with the strong column-weak beam capacity design philosophy, ACI 318 still requires the engineer to account for 100% of the probable moment capacity, including the full effects of post-tensioning, when designing the columns and joint regions.

The structural design of the horizontal framing endured many iterations to balance the beneficial impacts of post-tensioning on the performance and durability of the gravity system and the detrimental effects of post-tensioning on the demands placed on columns and joints to maintain strong column-weak beam behavior. The result of this iteration yielded non-frame beams typically 30 inches high by 16 inches wide with approximately 360 psi of post-tensioning, moment frame beams typically 36 inches high by 16 inches wide with approximately 300 psi of post-tensioning, and girders typically 42 inches high by 28 inches wide with approximately 260 psi of post-tensioning. Moment frame beams are typically increased in size near building edges to resist higher forces due to the inherent and accidental eccentricity of the building; however, perimeter frames were designed to not contribute to lateral resistance due to a lack of joint confinement.

While smaller columns were sufficient for gravity design, the typical interior column size was increased to 36 inches square to improve ductile behavior, decrease the amount of reinforcement required, prevent the use of expensive #18 rebar, and alleviate congestion. All joints were designed to meet the joint shear limits of ACI 352R-02, *Recommendations for Design of Beam-Column Connections in Monolithic Reinforced Concrete Structures*, in place of the less stringent requirements of ACI 318. The design of the post-tensioned slabs, beams, and girders were all carefully coordinated to allow reinforcement and post-tensioning to be placed with



Moment frame column cage during construction



PT beam/column picture during construction.



Soffit view of the typical floor framing.

minimal conflicts, and to limit the amount of unnecessary “throw-away” or “feel good” reinforcement that can inadvertently inflate the capacity of the horizontal framing elements and thus detrimentally affect strong column-weak beam behavior.

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The location and length of the main building required it to pass over an existing 70-foot-wide box culvert that could not be relocated. To avoid loading the culvert as it ran under the building, a post-tensioned transfer slab was provided over the culvert to transfer column loads across an approximately 75-foot span between lines of 52 auger cast-in-place pile foundations located on either side of the culvert. The concrete transfer slab is between 36 and 42 inches thick, with typically 2,500 kips of post-tensioning forces under each column that was stage-stressed to avoid overbalancing the transfer slab before the structure above the culvert was built. To ensure that no column load was imparted onto the existing culvert, cardboard void forms were provided between the

top of the culvert and the bottom of the transfer slab to support the self-weight of the transfer slab during its construction. Once the transfer slab cured and was stressed and self-supporting, the cardboard void forms were injected with water to dissolve them, leaving a void space between the top of the culvert and the bottom of the transfer slab.

At the central service bay where the tram exits and all rental company counters are located, a series of 80-foot-long open web structural steel trusses and glass canopy were incorporated to provide an airy, column-free lobby and unique structural feature that is highly visible to the public. The trusses cantilever 40 feet with a 40-foot back span and are just over 8 feet tall at their deepest point. The trusses are com-

prised of hollow structural section (HSS) chord-and-web members and utilize all welded connections to provide a clean and architecturally appealing solution. The HSS trusses are spaced at 60 feet on-center with steel wide flange girders spanning between the trusses and HSS purlins located at 10 feet on-center supporting the glass canopy and spanning between the girders. To maintain a column-free area over the tram station, the cantilever portion of the canopy was designed as a horizontal moment frame to distribute earthquake and wind forces back to the remainder of the canopy and the primary lateral force resisting system.

The Kahului Airport ConRAC opened to the public on May 15, 2019. Through careful coordination and attention to constructability, this state-of-the-art facility was completed on-time and under-budget despite numerous challenges. Maui's primary airport now has a facility worthy of its distinction as one of the world's premier vacation destinations and is ready to welcome the millions of domestic and international travelers who visit the Valley Isle annually. ■



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Project Team

Owner: Hawaii Department of Transportation
Structural Engineer of Record: BASE
Architect of Record: Demattei Wong Architects
General Contractor: Hawaiian Dredging Construction Company

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Dog Creek Bridge Seismic Retrofit

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