Honolulu Rail Transit Project (Segments 1 and 2)

Improving the quality of life in a highly congested urban area

by Jose Rodriguez, FIGG

Rendering of typical urban section of Honolulu Rail Transit Project (Segments 1 and 2). All Renderings and Photos: FIGG.

The Honolulu Rail Transit Project is a 20-mile elevated rail line on the island of O'ahu that will connect west O'ahu with downtown Honolulu and the Ala Moana Center via the Honolulu International Airport. The system features state-of-the-art, electric, steel-wheel trains that will travel the entire route through 21 stations in 42 minutes. Trains will travel on steel rails and will be powered by a third rail. The $5.16 billion project will provide approximately 10,000 direct and indirect jobs per year.

Honolulu Authority for Rapid Transportation (HART) developed the project to improve mobility, enhance reliability, and address the island's increasing congestion. By 2030, the rail system will handle approximately 120,000 trips per weekday, reducing roadway traffic by about 40,000 vehicles. This will reduce overall commuting times and costs and enhance the quality of life for the residents of O'ahu. The western-most 10 miles of the project's guideway system are being completed through two design-build contracts.

Project Alignment

O'ahu's mountainous landscape and congested roadway system in this project segment make it difficult to build a new guideway. The project requires erection of the guideway on the shoulder or in the limited-width median of the existing 2- or 3-lane roadway for 7.5 miles. The route includes intersecting roads and left-turn pocket lanes in the median. The guideway alignment consists of various straight and curved sections with a minimum radius of 1100 ft for precast concrete sections and 800 ft for cast-in-place concrete sections. The maximum vertical profile grade is 5.5%. The contractor is using a plinthless design for the rail support, connecting the rails directly to the top of the guideway deck with fasteners and requiring superelevation in curved alignments.

Structural Solutions

To solve the challenges of material delivery, mobility, and erection of the structure that are posed by the project's congested, urban location, the guideway was designed to be built from above using precast concrete box girder segments. The contractor is precasting the segments at a site approximately 5 miles away while also building the substructure elements on site. The project consists of 438 total spans, 430 of which are made of precast concrete and range in length from 68 to 151 ft. The remaining eight are made of

profile

HONOLULU RAIL TRANSIT PROJECT / HONOLULU, HAWAII

BRIDGE DESIGN ENGINEERS: Segmental Superstructure: FIGG Bridge Engineers, Tallahassee, Fla., and Substructure: HNTB, Lake Mary, Fla.

PRIME CONTRACTOR: Kiewit Infrastructure West Co., Vancouver, Wash.

POST-TENSIONING SUPPLIER: Schwager Davis Co., San Jose, Calif.

OTHER MATERIAL SUPPLIERS: Formwork: EFCO Corp., Des Moines, Iowa, and Bearings: D.S. Brown Company, North Baltimore, Ohio

PRECASTER: Kiewit Infrastructure West Co., Vancouver, Wash.

CONSTRUCTION DRAWING PREPARATION: FIGG Bridge Engineers, Tallahassee, Fla.

cast-in-place concrete with span lengths ranging from 204 to 342 ft.

The substructure consists of typical 30-ft-tall single columns that are 6 to 7 ft in diameter and have flared capitals. The columns are supported by single drilled shafts that are 7 to 8 ft in diameter. There are some locations that require offset piers or straddle bents to clear ground-level obstructions. There are also hammerhead piers at station locations. Both the drilled shafts and columns use a typical 4-ksi compressive strength concrete. Because of design considerations, some of the reinforcement in the substructure consists of Grade 75 steel, while the majority used Grade 60.

At each station location, artistic diagrams are added to columns using formliners. These celebrate the local culture by providing a visual representation of the history of the community. Each diagram is a pictorial description of the cultural history of the surrounding community.

The typical guideway superstructure consists of a precast concrete trapezoidal box girder section that is 30 ft wide and 7 ft 2 in. deep. Some areas require a section that is 17 ft 3 in. wide and 7 ft 2 in. deep. The cast-in-place sections are also 30 ft wide but vary in depth from 17 ft at the piers to 7 ft 2 in. at the ends. The top slab deck varies in thickness from 8 to 15 in.

The 11-ft length of the precast concrete segments utilizes the maximum legal transporting limits on the roads, eliminating almost 10% of the precast concrete segments that would have been required were typical 10-ft lengths used. The precast concrete segments are made of 6.5-ksi compressive strength concrete that allowed for quick stripping of the forms so that production was maximized. Epoxy-coated reinforcing steel was utilized in portions of the superstructure.

Precast concrete segments, 30 ft wide and weighing 36 tons, were cast in a facility that was approximately 5 miles away, then delivered to the site for erection on underslung girders.

The precast concrete spans are longitudinally post-tensioned typically using 3 or 4 external tendons that consist of twelve to twenty-seven 0.6-in.-diameter strands. The tendons are anchored in the expansion joint segments and all deviate in the span at about the third points of the span. The cast-in-place spans are longitudinally post-tensioned using internal tendons with twelve 0.6-in.-diameter strands. The top slab is transversely post-tensioned using tendons with two and four 0.6-in.-diameter strands.

Formliners were used on station columns to create a pictorial celebration of local neighborhood folklore.

HONOLULU AUTHORITY FOR RAPID TRANSPORTATION (HART), OWNER

ERECTION GIRDER DESIGN: Somerset Engineering Group, Bellingham, Wash.

GEOTECHNICAL CONSULTANT: Shannon & Wilson Inc., Seattle, Wash.

GENERAL ENGINEERING CONSULTANT: Ch2M Hill, Englewood, Colo.

CE&I WEST: PGH Wong, San Francisco, Calif.

BRIDGE DESCRIPTION: Ten-mile-long, mainly span-by-span precast concrete segmental box-girder superstructure with external post-tensioning

STRUCTURAL COMPONENTS: Segmental box girder superstructure, cast-in-place columns, and drilled shafts

BRIDGE CONSTRUCTION COST: $850 million

All tendons are inside air-tight tested plastic ducts that are grouted using prepackaged thixotropic material to provide a durable system.

Construction Challenges

The eastern-most 7.5 miles of the first two project segments are required to be erected in the middle of roadways that either have a small median or no median at all. To ensure all roadway lanes are open during peak hours, the roadways were widened to the outside to provide a work zone in the median that allowed for the drilling of shafts and constructing the substructure.

To maximize safety and mobility while rapidly constructing the project, the 5238 segments were precast while the road widening and substructure construction were in progress. The segments are erected using the span-by-span method with underslung girders supported on temporary pier brackets that rest on the top of the columns and are leap-frogged forward as the girders are launched. The structural system uses simple spans of match-cast segments that only require epoxy at the joints.

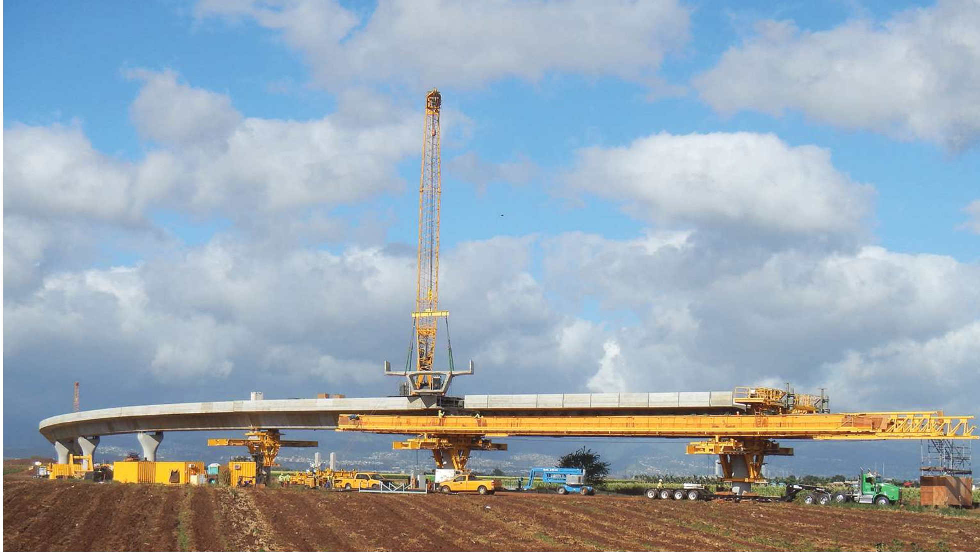
The structure is designed to support a crane to eliminate any traffic disruption due to this equipment use. The segments are typically delivered on the ground at night, lifted by the deck-mounted crane, and placed onto the underslung erection girders. Then, the external post-tensioning is installed and stressed, the temporary girders are launched to the next span, and the crane moved forward to begin the erection of the next span. This operation is typically a 1- to 2-day cycle per span.

The longer spans over the highway are being built in balanced cantilever using cast-in-place concrete placement on form travelers. Most of these spans take advantage of integral twin-wall piers to eliminate temporary falsework. This overhead construction allows uninterrupted traffic flow below.

Project Status

As of April 2015, the precast yard was using at least 13 casting cells, which are being turned every day. The concrete mixture proportions allow for stripping of the forms every day to cycle the segments as quickly as possible. Currently, about half of the segments have been cast and are either erected or in storage at the casting yard. Approximately 110 spans (25%) have been erected by the span-by-span erection method. Construction of the balanced cantilever spans has recently begun, with three pier tables built and the first few typical segments cast on one pier.

These first two project segments, totaling 10 miles, are scheduled to be completed and in operation by the end of 2018, and the entire 20-mile system is slated to be completed by 2020.



First 110 spans completed in the East Kapolei section of the project were built using the span-by-span erection method with a deck-mounted crane.

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Jose Rodriguez was the on-site aerial structures design manager for FIGG.

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