PROJECT

RIEGO ROAD OVERCROSSING

Lessons learned on challenging bridge project north of Sacramento

by Sue Hida, California Department of Transportation

Positioning of the second wide-flange precast concrete girder for placement at the Riego Road Overcrossing. Photo: Brandi Matteoni.

Sometimes the California Department of Transportation (Caltrans) builds square bridge spans; spans that are as long as they are wide. Such was the case for the Riego Road Overcrossing over Highway 99 just north of Sacramento. New residential areas, high traffic volume to the airport and into the city, and a limited vertical clearance all had to be accommodated in the new bridge design.

Design

Fourteen lines of 5.5-ft-deep, spliced, wide-flange precast concrete girders were selected for the 156-ft 4-in.-wide, two-span, 295-ft-long overcrossing. The overall 6-ft 5-in.-deep superstructure is supported on seat-type abutments and an integral pier cap. The cap is supported on five 6-ft-diameter columns that are approximately 26 ft in height, fixed at the top, and pinned at the bottom. The columns and abutments rest on precast-concrete-pile-supported footings.

The precast concrete wide-flange girder was developed for its stability during transportation and erection. The shape is so efficient that, had bulb-tees been used on this project, the girders would have to have been 6 in. deeper. The top and bottom flanges are 4.1- and 3.8-ft-wide, respectively, and the web is 8 in. wide to accommodate 4-in.- diameter post-tensioning ducts. For the Riego Road Overcrossing, end-blocks for post-tensioning anchorage and 9 ksi concrete are used to satisfy shear requirements. Caltrans requires design for a 15-axle, 200-ton design permit vehicle.

Lesson-learned #1

Use *AASHTO LRFD Bridge Design Specifications* Table 3.5.1-1 expression for concrete unit weight when calculating dead loads; these girders exceed 150 pcf.

Splicing of the girders at the bent was required to keep the superstructure as shallow as possible. Splicing not only provides continuity of the spans, but also stiffens the integral bent cap joints with the column tops. Integral bent caps are used in most Caltrans' bridges for clean lines and context sensitivity. The detail also ensures desired seismic performance by limiting displacement and forcing damage to occur in the column top, that is, plastic-hinging.

profile

RIEGO ROAD OVERCROSSING / SACRAMENTO, CALIFORNIA

BRIDGE DESIGN ENGINEER: California Department of Transportation, Sacramento, Calif.

CONSTRUCTION INSPECTION ENGINEER: California Department of Transportation, Sacramento, Calif.

GENERAL CONTRACTOR: Teichert Construction, Roseville, Calif.

SUB-CONTRACTOR: MCM Construction, North Highlands, Calif.

PRECASTER: Kie-Con, Antioch, Calif.—a PCI-certified producer

The Riego Road Overcrossing was built using two-stage post-tensioning:

- two tendons with a total of 29 strands (1274 kips/girder) in Stage 1
- one tendon with 15 strands (659 kips/girder) in Stage 2

The first stage of post-tensioning controls stresses due to primarily self-weight of the girders and the deck, and the second stage is needed to carry additional super-imposed dead loads and all live loads.

Compared to one-stage post-tensioning, two-stage post-tensioning is better for

- reducing the total prestressing force required,
- reducing the concrete strength requirements, and
- controlling deflections.

Based on experience with post-tensioned box girders, Caltrans shifts from one-stage to two-stage post-tensioning when span lengths exceed approximately 140 ft.

Straight pretensioned strands are used along with draped post-tensioning tendons. The 150-ft-long girders for span 1 have 36 pretensioned 0.6-in.-diameter strands, and the 137-ft-long girders for span 2 require 30 pretensioned strands. One-third of the strands are debonded for 15 ft at each end, and four ⅜-in.-diameter top strands (tensioned to 5 kips/each) were added to reduce tensile stress in the top flange at the girder ends. Caltrans permits slightly more debonding than the current 25% limit per the *AASHTO LRFD Bridge Design Specifications*.

The AASHTO LRFD specifications limit the duct diameter to 40% of the gross web width in Article 5.4.6.2. The limitation seems to have come from early segmental bridge design practice. From experience in California, the duct diameter can be up to 50% of the gross web width. LRFD Article 5.8.2.9 requires that 25% of a grouted duct diameter be deducted from the web width considered in evaluating shear resistance, and LRFD Article 5.8.6.1 calls for 50% of the grouted duct diameter be deducted. Until definitive research recommendations are available, Caltrans is capping the deduction at 1 in. for post-tensioned, grouted spliced girders.

Construction

Falsework towers were erected to support the girder ends at the bent caps. Girders were placed on the towers and abutments at night using two 300-ton cranes, one of which was on rolling outriggers. In hindsight, the team wishes it had known how the camber, post-tensioning, and haunch thickness along the length of the girder would have played out.

The end diaphragms, which connected girders at abutments, and the bent cap,

The girders are connected to the pier cap with extended strands at the bottom and post-tensioning at the top. The girders frame into a 7-ft-wide integral bent cap, reinforced with 10 and 12 bundles of two No. 11 bars bottom and top, respectively, and No. 7 double- and triple-U-stirrups adjacent to the columns. Photo: Jim Ma.

Lesson-learned #2

Triple-check abutment and beam-seat elevations knowing the deck elevations; question any excessive minimum haunch thickness requirement. This can significantly increase the quantity of concrete required.

Removable formwork was used for the cast-in-place deck. Photo: Brent Bullard.

CALIFORNIA DEPARTMENT OF TRANSPORTATION, OWNER

POST-TENSIONING CONTRACTOR: Dywidag Systems International USA Inc., Long Beach, Calif.

BRIDGE DESCRIPTION: Two-span, 295-ft-long, spliced precast, pretensioned and post-tensioned girder bridge

STRUCTURAL COMPONENTS: Fourteen precast, pretensioned 5-ft 6-in.-deep girders in each span; 8¼-in.-thick, cast-in-place concrete deck and integral pier caps; cast-in-place columns and abutments supported on precast pile footings

BRIDGE CONSTRUCTION COST: $\$125/ft^2$

Setting the first of 14 California wide-flanged girders into the second span. Extensive shear reinforcement is required for the girder-slab connection adjacent to the bent cap so that the integral bent cap behaves as desired during a seismic event. Photo: Brandi Matteoni.

which contained splices for the post-tensioning ducts, were formed and concrete was placed in the next step. The end diaphragm at each abutment is 3 ft thick and made continuous transversely with three 6-ft-long, No. 8 bars going through each girder and three bolt inserts on the interior face of the exterior girders. At the bent, the girders extend 6 in. into the 7-ft-wide bent cap. Strands extend from the bottom flange into the bent cap to develop positive moment resistance in the joint.

Top and bottom longitudinal bars of the integral bent cap consist of bundled No. 11 bars. Extensive joint shear reinforcement is required in accordance with both the *Caltrans Seismic Design Criteria v1.4* and the *AASHTO Seismic Design of Highway Bridges Guide Specifications*. After concrete placement, a minimum strength of 3.5 ksi is required prior to the first stage of post-tensioning. After the first stage of post-tensioning, the falsework towers were removed and formwork was placed for the deck.

The girders are made composite with a cast-in-place concrete deck by extending all girder shear reinforcement into the deck and bending it in the field. For Riego Road Overcrossing, which uses 11-ft 3-in. girder spacing, Caltrans requires an 8.25 in. deck thickness, and No. 5 transverse top and bottom deck reinforcement alternating every 2.75 in. for an overall spacing of 5.5 in. The standard design is controlled by serviceability.

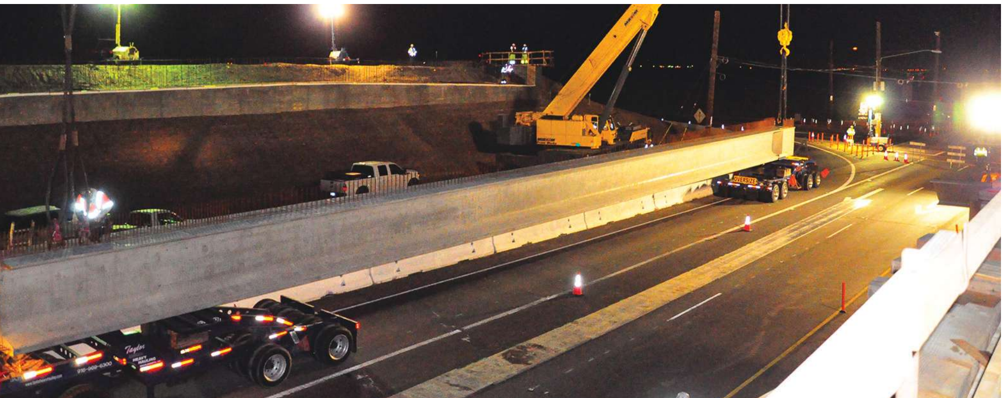
In the longitudinal direction, No. 4 bars at 18-in. spacing support the top transverse reinforcement; alternating No. 5 and No. 4 bars are provided below and above the bottom transverse reinforcement. At the bent cap, an additional eight 60-ft-long No. 10 reinforcing bars are placed in the deck over each girder. These bars further enhance the bent cap joint performance during a seismic event and help resist negative bending due to long permit vehicles with multiple axles. The climate is temperate and conventional 60 ksi, ASTM A706 reinforcing steel is used in the 5 ksi concrete deck.

Within a few weeks of placing concrete for the deck, cracks emerged parallel to and diagonal from the bent cap area. The cause of the cracking is thought to be rotation of the girder ends. The new girder shape is shallow and rotates more than the girder shapes currently in wide-spread use in California.

Stage 2 post-tensioning took place 10 days after the deck concrete was placed. For the bookkeeping of prestressing-force losses in the pretensioned girders and post-tensioned spliced girders, Mathcad was used to calculate the design with the LRFD equations. The final post-tensioning did not close the deck cracks enough to satisfy serviceability concerns. The deck was sand-blasted and a methacrylate resin treatment applied. Caltrans frequently uses this process on bridge deck rehabilitation projects.

An elevated median barrier, sidewalks on both sides, electroliers, and decorative chain link railing were added. The bridge opened to traffic on August 16, 2014, but the ribbon-cutting ceremony was performed on December 2, 2014.

The first of the California wide-flange girders arriving at the project site of the Riego Road Overcrossing. Photo: Brandi Matteoni.



Lesson-learned #3

Deck placement sequence may need to be considered and rethink removal of falsework prior to casting the deck and completion of post-tensioning. The composite strength of the girders is important.

Lesson-learned #4

The "seismic" bars added over each girder for continuity are also needed for service loads and should be spread out more into the area between the girders—or additional bars should be used. Whether or not intermediate diaphragms would have helped decrease the deck cracking is open for debate.

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EDITOR'S NOTE

Measuring as-cast camber while stored in the precast plant prior to the field casting of the beam seats can allow haunch thickness adjustment. The engineer of record, contractor, and specialty engineer (with the data from the fabricator) need to collaborate to avoid the casting of excessive haunches. This simple step of a field adjustment can also avoid bottom mat of steel conflicts that may occur when excessive camber exceeds the minimum build up dimensioned in the plans. See page 38 to learn more about the variability in camber.