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.

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.

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.

POSITIONING OF THE SECOND WIDE-FLANGE PRECAST CONCRETE GIRDER FOR PLACEMENT AT THE RIEGO ROAD OVERCROSSING. PHOTO: BRANDI MATTEONI.
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 ½-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,

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.
Overcrossing. Photo: Brandi Matteoni.

The first of the California wide-flange girders arriving at the project site of the Riego Road Overcrossing. 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 girder shape is shallow and rotates 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, electrolyers, 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. A

Sue Hida is with the Division of Engineering Services for the California Department of Transportation in Sacramento.

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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.