PROJECT

Accelerated Bridge Construction over Craig Creek

Every day counts in improving mobility

by Sonny Fereira, Caltrans

The new 108-ft-long, Craig Creek Bridge, built in 2011 with a crack-free deck and a three-day cure. All Photos: Caltrans.

Replacement of the Craig Creek Bridge carrying State Highway 99, near Red Bluff, Calif., began in the fall of 2011 as the California Department of Transportation (Caltrans) undertook its third official accelerated bridge construction (ABC) project under the Federal Highway Administration's (FHWA's) Every Day Counts initiative. This initiative is designed to identify and deploy innovation aimed at shortening project delivery, enhancing the safety of our roadways, and protecting the environment.

The Caltrans project included replacement of an aging, scour-critical, three-span bridge with a single-span structure. Bids were opened on April 20, 2010, with the intent of replacing the old bridge between July 15 and October 15 in two phases, keeping one-lane traffic on each half of the bridge. As bid, this would require temporary shoring for the roadway and temporary bents to support the old bridge while carrying traffic as the other half gets demolished; thereby, allowing the first stage of the new bridge to be constructed.

Traffic would be handled with a combination of temporary traffic signals and flaggers. One-lane traffic would then be shifted to the first stage of the new bridge while the remaining old bridge would be removed and replaced. In order to complete the bridge as planned in two stages within the short construction window permitted by the regulatory agencies. ABC technology using prefabricated bridge elements and systems (PBES) components, was selected over conventional construction methods.

The bridge design comprised 11 adjacent 3.5-ft-deep by 4-ft-wide precast, prestressed concrete box beam units; a 5-in.-thick, cast-in-place concrete deck; precast concrete abutments and wingwalls; and twelve 2-ft-diameter, cast-in-steel-shell (CISS) concrete piles. The designer chose a 4 ksi site-cast concrete deck to provide composite action, in part due to concerns of differential live load deflections between adjacent box beam sections affecting long-term deck durability.

After girders were set in place, five 1$^3/_8$-in. high-strength tie rods were installed, with one at each end diaphragm and the ¼ span points, and the girders were snugged together by stressing the rods to 20% of the total post-tensioning force. After girders were snug, the 18-in.-deep longitudinal keyways were grouted with nonshrink grout and the grout was allowed to reach 5 ksi strength before bringing each rod to the final post-tensioning force of 130 kips. Tie rod ducts were then grouted and exterior bearing plate blockouts were filled with structural concrete and finished to match the rest of the girder.

profile

CRAIG CREEK BRIDGE / RED BLUFF, CALIFORNIA

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

BRIDGE CONSTRUCTION ENGINEER: California Department of Transportation, Chico, Calif.

GENERAL CONTRACTOR: Blaisdell Construction Inc., Anderson, Calif.

PRECASTER: Con-Fab, Lathrop, Calif., a PCI-certified producer

READY-MIX CONCRETE SUPPLIER: A&A Concrete, Chico, Calif.

POST-TENSIONING CONTRACTOR: Schwager Davis Inc., San Jose, Calif.

Preplaced cast-in-steel-shell concrete piles were excavated and cut-off to grade.

Each precast concrete abutment was fabricated in two pieces, with each piece weighing 72,000 lb.

Challenges Provide Opportunities

Delays in the contract award process caused the contract to be awarded late in the 2010 construction window. With shop plans to be prepared and girders to be cast, it was not prudent to begin the demolition and carry traffic on half of the old bridge over the winter and into the next construction season. The decision was made to begin that work during the 2011 summer window. This delay to the start of the project allowed the construction team the time to carefully consider options for completing the project safely, correctly, and quickly.

Contractor Improves Safety, Reduces Cost and Time

The project's general contractor enthusiastically embraced the ABC concepts and furthered the project goals of reducing traffic delays, environmental risks, construction time, and cost by proposing out-of-sequence work and submitting a value engineering change proposal (VECP) to the original plans.

Precast, prestressed concrete box beams that were 106 ft long, weighing 106,000 lb, were set with two cranes from the abutments. Traffic was stopped seven to 15 minutes to make picks from the temporary bridge.

Since the new foundation was beyond the footprint of the old bridge, the contractor proposed to construct the piles outside the construction window. By using steel shells 9 ft longer than required, they could be driven through the existing roadway without first excavating to the bottom of the footing. In four days, the foundation piles were driven, drilled, reinforcing cages installed, and concrete placed. Pea gravel was used to fill the extra length of pile and the tops were paved over. Traffic then flowed uninterrupted for 10 months over the piles prior to being excavated and cut off to grade.

The VECP changed the traffic staging plans by eliminating the timed, one-way signalized control and instead deployed a temporary rented bridge with continuous flagger control diverting the one-lane traffic around the worksite entirely. The temporary rented bridge was assembled and launched in 2½ days and rested on previously placed temporary footings. Construction and paving of the roadway detour took another two days, and once the traffic was off the old bridge, demolition could begin in a single move-in.

Cast-in-place, high-performance concrete deck being placed using a concrete mix containing a shrinkage-reducing admixture and macro fibers.

Rerouting traffic around the footprint of the bridge gave the contractor the opportunity to approach the work in a more efficient manner. Having a larger material storage area was safer and increased production. Accomplishing the work in a single stage reduced direct costs, overhead costs, move-ins of subcontractors, construction time, time traffic was restricted to one lane, and related traffic impact costs. Traffic safety, convenience, and flow through the work zone were increased by utilizing flaggers 24/7 for the detour. Workers provided the ability to be more responsive to the traffic, and a heightened awareness was present as compared to the planned timed signal control. Due to the significant reduction in impacts to the motorists, the contract provides that the contractor is entitled to 60% of the VECP savings, sharing 40% with the state.

Value Engineering Creates Opportunities

With the VECP pending, the next challenge was: "if we could tear down an old bridge and rebuild a new one in its place in three weeks, why can't we

CALIFORNIA DEPARTMENT OF TRANSPORTATION (CALTRANS), OWNER

TEMPORARY BRIDGE: Mabey Inc., Sacramento, Calif.

PILES: E.P. Jarrett Foundation Co. Inc., West Sacramento, Calif.

BRIDGE DESCRIPTION: A single 108-ft-long, precast, prestressed, transversely post-tensioned concrete bridge on cast-in-steel-shell pile foundation

STRUCTURAL COMPONENTS: Eleven 3½-ft-deep by 4-ft-wide, 106-ft-long adjacent precast, prestressed concrete box beams, four precast concrete abutments and precast concrete wingwalls, and composite cast-in-place concrete deck and barrier rail, founded on twelve 24-in.-diameter, 65-ft-deep cast-in-steel-shell piles

BRIDGE CONSTRUCTION COST: \$1,047,000 (\$220/ft^2)

Craig Creek Bridge deck shows no cracking nearly two years after construction completion. Deck concrete contains a shrinkage-reducing admixture and fibers, and was subjected to a shortened curing period.

figure out a way to reduce concrete curing time requirements from the standard seven-day water cure and still end up with a high quality deck?" The week-long moist curing time requirement creates a dead spot in the construction schedule, contrary to the fundamental concept of ABC, and the operational tempo of the contractor's crew is disrupted. A quick literature search did not reveal any current research or methods relating to this need. It was not surprising, since anything less than a seven-day water cure is not typical in the bridge engineering world.

This prompted a 2011 Caltrans construction-evaluated research study, "Bridge Deck Concrete Improvements & Cure Strategies Proposed for Accelerated Bridge Construction," using some of the state's portion of the VECP savings to fund the construction components of the effort. This research study proposed a three-day water cure using previous experience and successes in formulating concrete designs to reduce early-age concrete deck cracking.

Prototype requirements for a high-performance deck and curing specification suitable for ABC were developed and implemented. To allow for future grinding to facilitate the crack investigation portion of the research study, and to make provisions for an additional ordered change to a quiet deck specified by grooving, a sacrificial ½-in.-thick layer was added to the deck thickness.

ABC Deck and High Performance Curing

The 4 ksi compressive strength, ABC high-performance deck concrete with a three-day curing period required a mix design using a shrinkage-reducing admixture (SRA) at a dosage rate of 96 fl oz/yd^3, a water-reducing admixture at a dosage rate of 49.4 fl oz/yd^3, and polyolefin macro fibers at a dosage rate of 3 lb/yd^3 with 705 lb/yd^3 of Type II cement, and a water-cement ratio of 0.39.

Concrete cylinder strengths were 3.2 ksi at at two days, 4.0 ksi at four days, 4.5 ksi at seven days, and 5.9 ksi at 28 days. The newly placed deck was cured using a sprayed-on poly-alpha-methylstyrene white pigmented curing compound applied at 150 ft^2/gal. and the water method. The wet cure was applied for three days using soaker hoses covered with a curing medium. On the third day, another heavier coating of curing compound was applied to the damp deck surface at 100 ft^2/gal. and was allowed to set up for a couple of hours to prevent damage or pick-up from vehicles before being opened to traffic. This helped to seal the concrete so that hydration continued.

Seven weeks later, a diamond drum grinder was used to remove the curing compound and surface paste to aid in finding and mapping cracks prior to grooving for a smooth riding, quiet deck. There were no visible cracks, and there are still no cracks two years later. For an additional material cost of less than \$40/yd^3 (\$18/yd^3 for fibers and \$18.75/yd^3 for SRA) or \$3600 total, a crack free concrete deck was built and cured in less than half the customary curing time.

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Team Delivers Success

By partnering together and creating opportunities from the many challenges that faced the project, the construction team exceeded the goals of the original plans. Utilizing a small construction crew without a lot of long or extra shifts, the contractor was able to remove and replace the old bridge and return traffic to the mainline highway in 29 days without sacrificing quality. By using PBES components, innovative construction methods, and deploying innovative construction approaches, mobility of goods and traffic was improved, safety was enhanced, environmental impacts were reduced, and the project delivery was shortened, all at a cost savings. This project demonstrates how contractors and owners should work together to achieve great things and make advances in the industry. The high-performance deck concrete and curing method used on this project will have applicability on many future projects, making the public the big winner.

Sonny Fereira is a senior bridge engineer with Structure Construction, Division of Engineering Services for the California Department of Transportation (Caltrans) in Red Bluff, Calif.

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