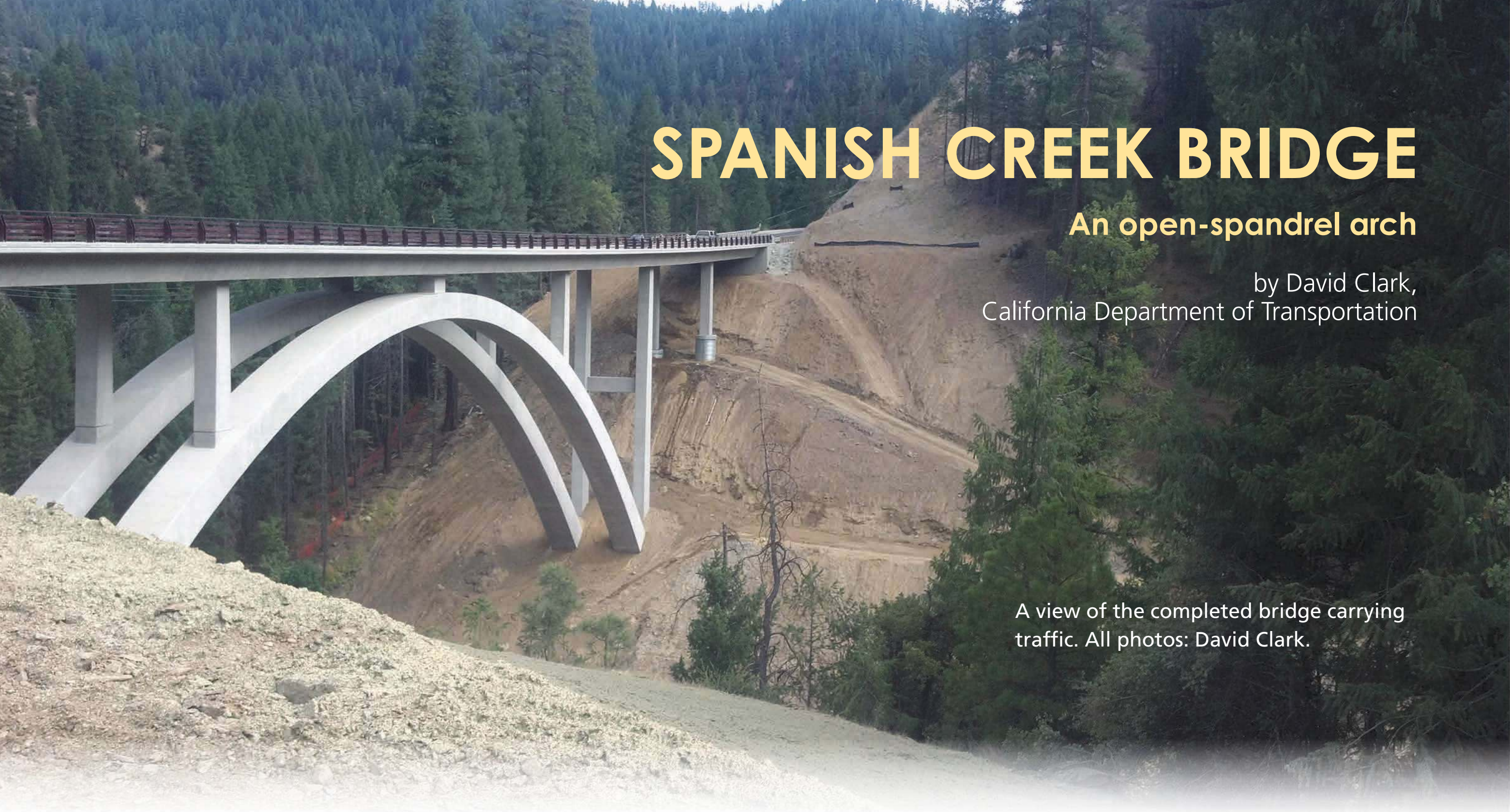
SPANISH CREEK BRIDGE

An open-spandrel arch

by David Clark,
California Department of Transportation



A view of the completed bridge carrying traffic. All photos: David Clark.

A new, open-spandrel arch bridge located in the Sierra Nevada mountains of California now becomes the latest major structure to be constructed in the Feather River Canyon. This rugged and scenic canyon has been designated a historic district as well as a National Scenic Byway. It is the home to numerous railroad and highway bridges, tunnels, retaining structures, and hydroelectric facilities, many of which are also designated historic structures.

The graceful lines of the new Spanish Creek Bridge will do well to complement this setting. The Spanish Creek Bridge and State Highway 70 provide a primary route in and out of Quincy, a logging town 10 miles to the south of the bridge. Because there are few alternative routes in this area of the Sierra Nevada Mountains, the Spanish Creek Bridge is critical to local traffic and the economy.

New Bridge Needed

The Spanish Creek Bridge cost approximately $29 million dollars to build and marks the 11,000th transportation project funded by the American Recovery and Reinvestment Act of 2009. It replaces a bridge that was built in 1932, which had two 12-ft-wide lanes with no shoulders. After 80 years of service, the existing bridge was beyond its expected service life and was becoming increasingly expensive to maintain. It was located in an active seismic area but it did not meet modern seismic criteria.

The new structure is on a tangent with a grade sloping downward to the north at just over 2%. It is a conventionally reinforced concrete box girder capable of supporting oversized loads up to 360,000 lb, whereas the load limit for the old bridge was set at 80,000 lb. Rising to a height of approximately 170 ft over Spanish Creek, the bridge length is 630 ft. The 350-ft-long arch span is one of the longest conventionally reinforced spans in California. The bridge deck is 43 ft wide, which includes two 12-ft-wide traffic lanes and two 8-ft-wide shoulders.

The solid twin arches are approximately 8 ft square at the base and taper gradually in depth to 5.5 ft at the crown. The spandrel columns are solid with outside dimensions of 4 by 5.8 ft and tapering to 4 by 4 ft at their tops. They vary in height from 83 ft at the ends of the arch to 10 ft at the center of the arch. The superstructure consist of cast-in-place multicell (five-cell) reinforced concrete box girders with span lengths of 74 to 95 ft.

profile

SPANISH CREEK BRIDGE / KEDDIE, CALIFORNIA

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

PRIME CONTRACTOR: C. C. Myers, Rancho Cordova, Calif.

OTHER MATERIAL SUPPLIERS AND CONSULTANTS: Foundation report, Kleinfelder, Sacramento, Calif.; Temperature monitoring system, Engius IntelliRock, Stillwater, Okla.; Concrete cooling system design, CTLGroup, Skokie, Ill.; Piling contractor, Drill Tech Drilling and Shoring Inc., Antioch, Calif.; Tieback contractor, Neil's Controlled Blasting, Newcastle, Calif.

PROJECT DESCRIPTION: 630-ft long, seven-span, open spandrel arch supporting a conventionally reinforced, cast-in-place concrete, box girder

Environmental Impact

Spanish Creek has been recognized as a temperature-sensitive fish habitat and has been monitored over the years to support the study of this environment. A result of these studies is that there is extensive temperature data available for Spanish Creek. Data recording the diurnal temperature changes of Spanish Creek were used to determine that cooling water could be pumped directly from the creek to cool the concrete and then returned to the creek after it was heated by the concrete without making a significant impact on the water temperature.

The natural diurnal temperature change of the water was close to 10°F at the time of year when the concrete was placed. The temperature increase due to the returned cooling water was estimated to be less than 2°F.

An additional concern was that of increased pH value in the creek caused by the possible introduction of alkalis from the concrete into the creek. The system was designed so that the cooling water remained in the cooling tubes and never directly contacted the concrete. Thus the pH of the creek was not affected.

Environmental clearances were obtained to implement the cooling system and the Spanish Creek waters were used to cool the hydrating concrete at a significant cost savings compared to using conventional chillers. Wireless temperature sensors were employed to monitor the temperature changes of the water in the same way the concrete temperatures were being monitored.

A concrete bucket on a crane was used to keep the deck placement progressing when a concrete pump truck moved to a new position.

The box girder cells have a depth of 5.2 ft and a width of 7.2 ft. Top and bottom flange thicknesses are 8 and 6 in. respectively. The web thickness is 8 in.

The superstructure contains epoxy-coated reinforcing steel, while all other structural elements were constructed with non-coated steel bars. An additional measure to reduce corrosion and extend the service life of the deck was to apply a 0.75-in.-thick polyester concrete overlay to the new 8-in.-thick concrete deck. The overall bridge is designed for a 75-year service life. Concrete compressive strengths vary by structural element with concrete for the arches and piers 2 and 6 being specified at 6.0 ksi, the thrust blocks at 4.0 ksi, and all other structural elements at 3.5 ksi. All specified compressive strengths are at 28 days.

This picture shows some of the installed micropiles in the foreground and drilling in the background.

Site Necessitated Mass Concrete

The geologic material that the bridge is founded on consists largely of highly fractured and foliated phyllite and metasandstone. The ends of the arches are founded on seventy-seven 7-in.-diameter micropiles,

CALIFORNIA DEPARTMENT OF TRANSPORTATION, OWNER

STRUCTURAL COMPONENTS: Conventionally reinforced concrete box girders, open spandrels, twin concrete arches, 250 yd^3 concrete thrust blocks, micropiles, and cast-in-drilled hole piles

BRIDGE PROJECT COST: \$29 million (\$1075/ft^2)

AWARDS: 2013 *Engineering News-Record* "Best of the Best" Highway/Bridge Project Award; 2013 *Engineering News-Record* Best Highway Bridge Project, Northern California; 2013 Excellence in Transportation – Major Structures Award; 2012 California Transportation Foundation, Finalist—Structure Project of the Year; 2012 & 2013 Caltrans Partnering Success In Motion (2 Gold Awards); 2013 International Partnering Institute – John L. Martin, Partnered Project of the Year Award (Ruby Award); 2013 Associated General Contractors of America (AGC) – California Excellence in Partnering, Projects under \$50 Million; 2013 Associated General Contractors of America (AGC) Meeting the Challenge of a Difficult Job – Heavy Engineering Classification Constructor Award, AGC-California (C.C. Myers, Inc.); 2012 Caltrans Safety Award; and 2013 American Society of Civil Engineers Sacramento Chapter-Geotechnical Project of the Year each grouping capped with 250 yd^3 concrete thrust blocks. These large concrete elements meet the criteria for mass concrete.

These large concrete elements meet the criteria for mass concrete.

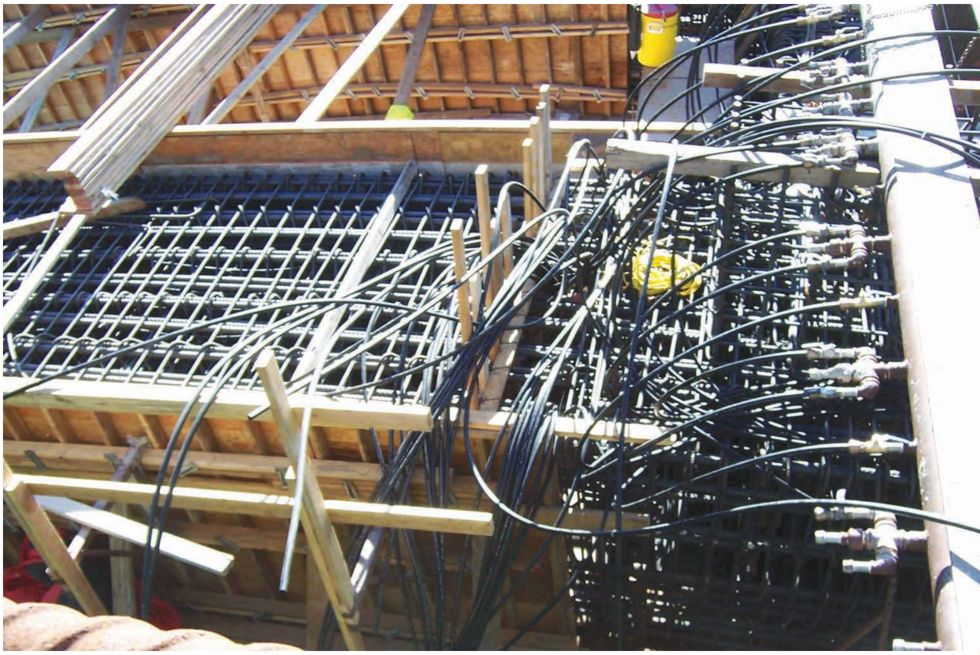
Contract specifications required the implementation of a concrete cooling plan to remove some of the heat generated within the concrete while curing and help prevent excessive temperature differentials that could lead to cracking. It would also reduce the possibility of secondary ettringite formation, a chemical reaction that is deleterious to the service life of the concrete.

The concrete for the arch was placed in a series of five ascending segments. Each of the arch segments had cooling tubes installed throughout their reinforcing bar cages to cool the hydrating concrete from within. The segments were also fitted with temperature sensors that were wirelessly connected to an internet-based monitoring site. The site was remotely accessible with the data being available in real time to those people given the pass code.

Segments were also fitted with temperature sensors that were wirelessly connected.

This temperature monitoring system allowed the efficient placement and removal of thermal blankets and space heaters as needed to control temperature differentials.

This photo shows the strand jacks mounted on the completed arches lowering the first stage arch formwork.



The polyethylene cooling water tubes are shown coming out of a manifold assembly and entering one end of an arch section, which is ready for concrete placement.

Falsework was constructed on top of the completed arch; it supported formwork for the superstructure.

Construction

Falsework used for this bridge was built in two stages. The first stage supported just the arch. Once the concrete for the arch was placed and cured, the first stage falsework was removed and a second tier of falsework was erected on top of the arch to support the superstructure formwork.

Summary

This was a challenging structure to build in many respects, but the result of overcoming the challenges is a new structure that fits well in the canyon it traverses, both aesthetically and with its improved capacities.

David Clark is a structure representative and resident engineer for structure construction, Division of Engineering Services, California Department of Transportation (Caltrans) in Chico, Calif.

For additional photographs or information on this or other projects, visit www.aspirebridge.org and open Current Issue.

AESTHETICS COMMENTARY

by Frederick Gottemoeller

It is great to see that arches are making a comeback. Too often, structural type decisions are influenced by assumptions that what was economical somewhere else will also be economical here. In recent years, we have seen many concrete segmental box girders and even continuous bulb-tee bridges in this span range, even in locations like this one that seem ideally suited to an arch. The fact that this elegant bridge was also economical to build shows that each site needs to be looked at with a fresh eye. The conventional wisdom might be wrong.

If you ask a non-engineer to sketch a bridge it will almost always look like an arch. The form is in our collective memory. When an arch is placed in a steeply sided canyon, such as this one, the visual interaction of the arch and the canyon walls directly evokes the forces at work. Anyone can intuitively understand what's happening, even if they can't express it in words. That's what makes arch bridges so memorable.

The elegant simplicity of this bridge makes it more memorable than most. The Swiss do this kind of arch very well; this bridge reminds me of the best of their bridges. The simplicity begins with the decision to use a box girder for the deck. This keeps the spandrel spans the same as the side spans, establishing a constant span rhythm all of the way across the bridge and reducing the lines of spandrel columns to a mere three. The full-width box girder also conceals all of the diaphragms and webs that would otherwise make the upward view of the bridge complicated and distracting. The spandrel columns are also simple rectilinear shapes. Finally, the taper of the arch ribs adds a subtle grace note that makes the ribs look less massive than they are.

It is clear that Caltrans is proud of their work here. They have constructed an overlook where visitors can view and appreciate the bridge. It is well worth the money.