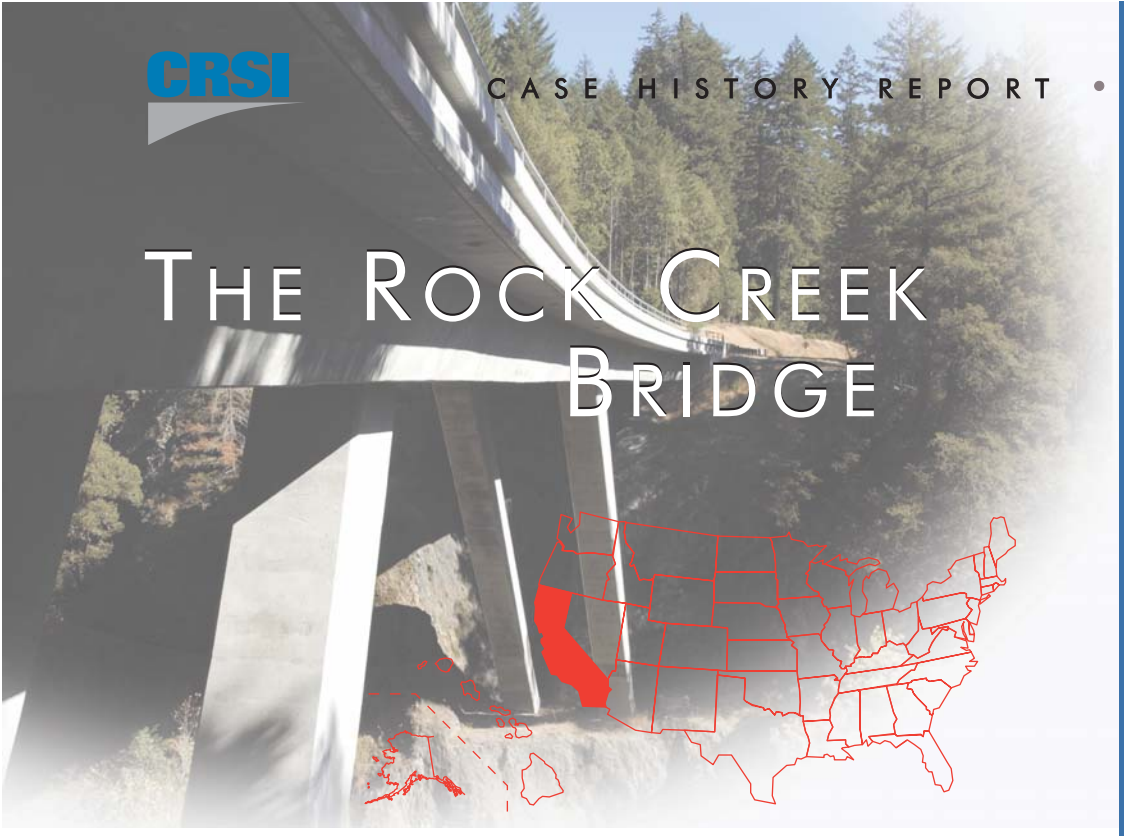
The Rock Creek Bridge



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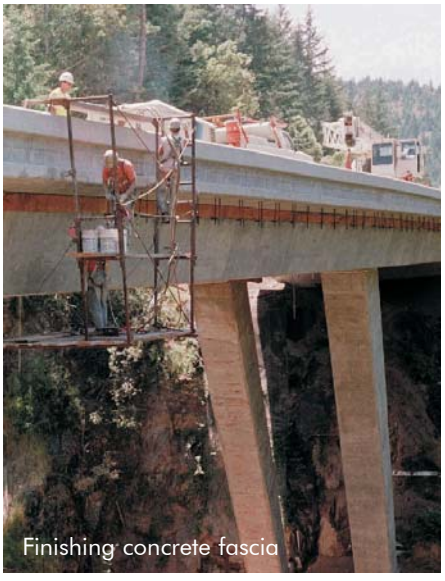
— Carl Huang, P.E.
Caltrans Senior Bridge Engineer and Project Manager

Conventional Reinforced Concrete for an Unconventional Structure

Nearly 1,400 of the more than 12,000 bridges in the California State Highway system have been earmarked for seismic strengthening as part of the $1.05 billion Phase II California Department of Transportation (Caltrans) Seismic Retrofit program. The existing steel Rock Creek Bridge on U.S. Highway 101 in Mendocino County was one of them.

Highway 101 is one of the most important north-south routes in the Redwood Country of Northern California. Tourists and local residents, freight traffic and logging trucks all use the two-lane highway.

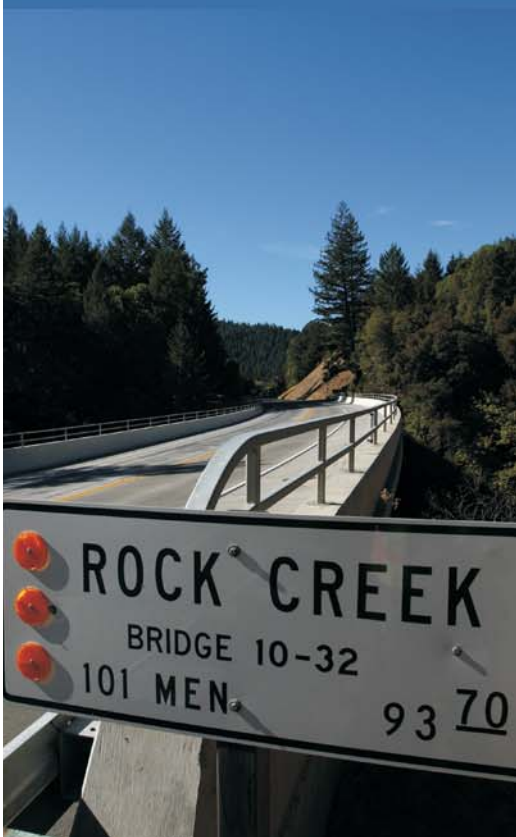


Finishing concrete fascia

In addition to being seismically and functionally obsolete, the existing bridge required periodic labor-intensive painting and maintenance. Caltrans chose to replace the existing bridge with a curved, cast-in-place reinforced concrete box girder supported on slanted legs to cross the steep V-shaped canyon.

"Caltrans has a strong track record with reinforced concrete bridges," says Carl Huang, Caltrans Senior Bridge Engineer and project manager for the bridge replacement. "Reinforced concrete is economical and versatile and was the material of choice for this bridge."

By using a site cast box girder and limiting the span lengths, the conventionally reinforced concrete structural configuration was optimized.



Why Reinforced Concrete?

Different replacement bridge types were considered for the new two-lane Rock Creek Bridge, including steel girder, precast/prestressed girder, and cast-in-place reinforced concrete box. Steel and precast girders were ruled out because it would be difficult to prefabricate members to meet the unique horizontal curvature of the bridge. Furthermore, the remote location of the site would make delivery of large members difficult.

Maintaining traffic flow on two-lane Highway 101 was a major design imperative. This meant that the superstructure and substructure configuration had to allow for staged construction within the existing right-of-way. A bridge with two bents of two columns each and a reinforced concrete box girder superstructure met the project criteria.

Stage One: Under Traffic

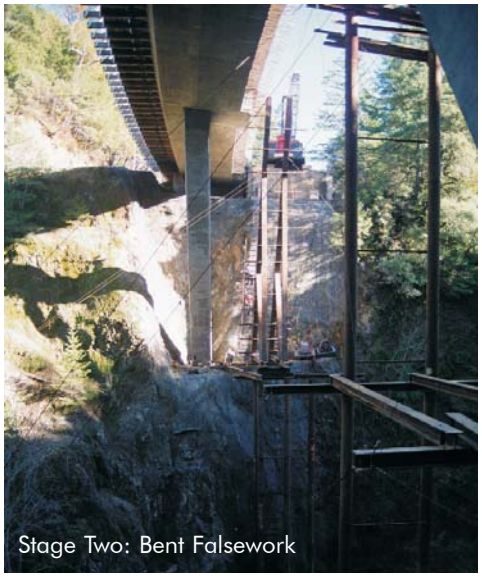
A Twice-Analyzed Bridge

The new bridge was built in two stages to allow traffic to continue across Rock Creek during construction. "Concrete lends itself very well to this type of staged construction," says Huang, "because the two pieces can be readily tied together."

While vehicles continued to use the existing bridge (one lane in each direction), the new northbound lane plus shoulder was constructed on the east side of the bridge.

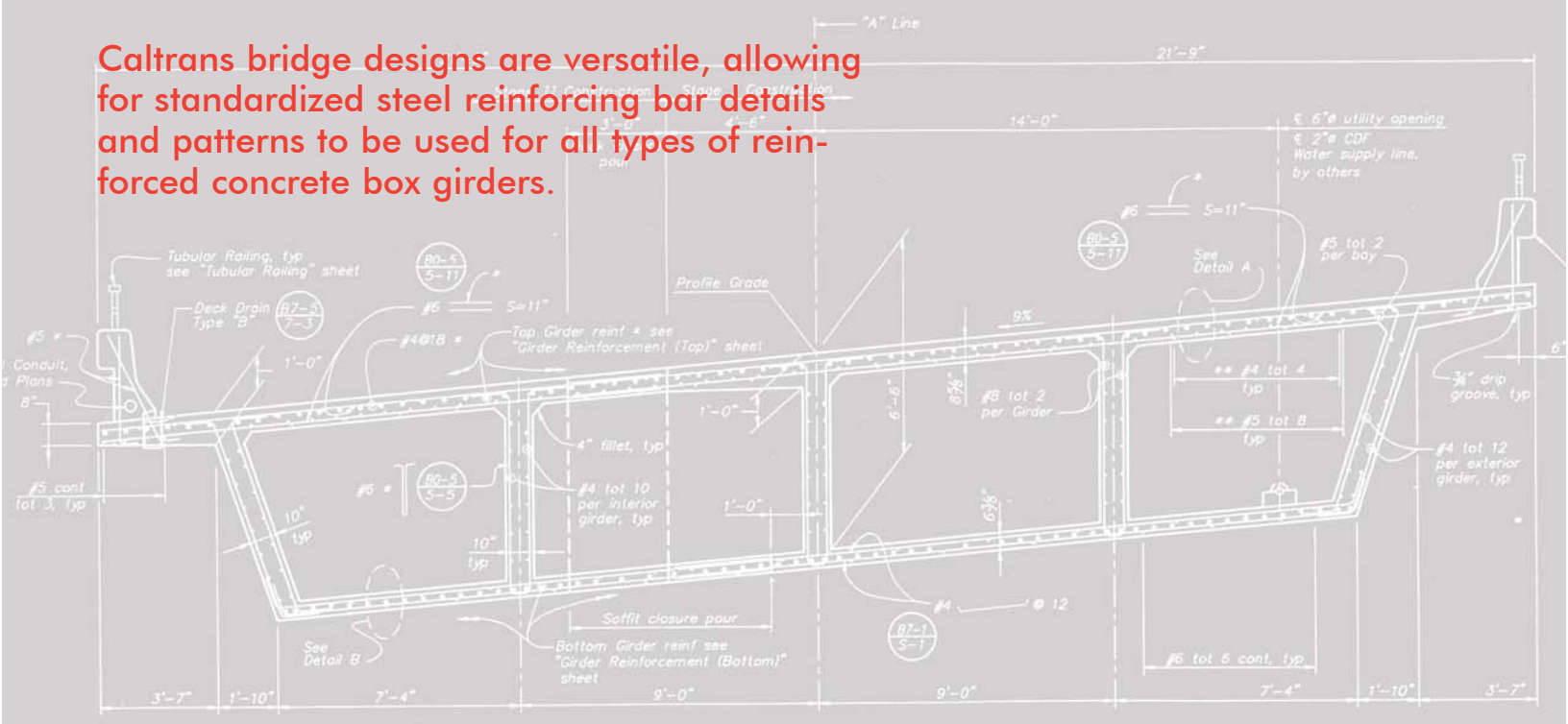
The two-way traffic was then diverted onto the new eastern portion, using flaggers to allow one direction of vehicles at a time. Once the existing bridge was demolished, the new southbound lane plus shoulder was built. The two parts were connected to complete the project.

Because of this staging, bridge designers had to perform a full analysis of the bridge twice. The first analysis considered the eastern portion as a stand-alone bridge, with loading eccentric to the support columns. The second analysis was performed for the bridge as a whole.



Stage Two: Bent Falsework

Caltrans bridge designs are versatile, allowing for standardized steel reinforcing bar details and patterns to be used for all types of reinforced concrete box girders.



Graceful Tapered Columns

Although the design and construction details for most of the bridge were dictated by Caltrans' standards, the supporting columns are unique. Slanted supports are particularly well suited to bridges over deep canyons, because shorter columns can be founded in the canyon sides—rather than very long vertical columns founded in the canyon bottom—thereby creating a more stable structure.

The fractured bedrock and steep canyon slopes lent themselves to a foundation system consisting of piers—hand-mined into the side of the canyon—that are continuous with the slanted columns. The columns themselves were tapered for aesthetic effect.

Tapered columns founded in canyon wall bedrock.

The maximum cross-sectional area of the columns is 6 feet by 8 feet at the top and the minimum area is 4 feet by 6 feet at the bottom. Reinforcing bars in the column were detailed based on Caltrans' seismic standards.

Another major advantage of using slanted columns is that the length of the spans can be minimized; thus, bending moments within the superstructure can be reduced.
This allowed the bridge designers to use the Caltrans standardized system for a cast-in-place box girder superstructure in earthquake-prone areas.

Hoops and Splices: Advances in Concrete Confinement

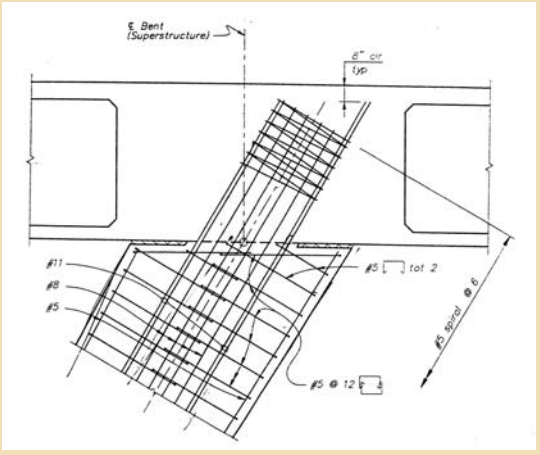
The past decade has seen major advances in reinforcing steel concrete confinement. Observations of structures after the 1994 Northridge earthquake caused some concern about pullout of the confining reinforcing steel. Bridge designers started to rethink spiral confinement, specifically focusing on the use of hoops.

Splicing small-diameter curved hoops can be problematic. In 1992, CRSI member firm Fontana Steel worked with Caltrans to develop a far superior hoop splice: a resistance butt weld. Caltrans now allows bridge designers and contractors to select welded hoops for concrete confinement.

"The resistance butt weld allows the splice to be fabricated in the shop under controlled conditions," says Tom Kaney, General Manager of Fontana Steel in Rancho Cucamonga. "Destructive testing on representative samples gives us more confidence about the integrity of the weld and the quality of the product."

CRSI worked closely with the Caltrans Reinforced Concrete Committee to develop the Ultimate Butt Splices Specification, in which, during loading, the reinforcing bar itself will fracture before the weld or splice breaks. The resistance butt weld conforms to this Caltrans specification.

Double reinforcing bar spiral hoops increase seismic toughness by increasing column ductility. Today, Caltrans allows welded reinforcing bar hoops for concrete confinement.



Top of tapered column

The new Rock Creek Bridge with three spans, 85–, 114–, and 95–feet long, soars 130 feet above Rock Creek.

Connecting the Pieces

Caltrans has standard details for connecting two bridge parts together. This procedure is relatively common in California, given the large number of bridge widenings and realignments necessitated by the state's large growth in population and traffic.

For the Rock Creek Bridge, transverse reinforcing bars from the top and bottom of the box girder of the eastern portion of the bridge were left protruding from the edge of the structure. All of the wearing surface reinforcing bars for the deck and stirrups are epoxy coated for corrosion protection per ASTM A934, so long-term exposure to the elements will not be a concern.

As the western portion of the bridge was built, transverse reinforcing bars were spliced with mechanical splicers to the protruding reinforcing bars from the eastern portion. The concrete for the three-foot-wide closure was then poured.

Controlling the camber of the two individual bridge halves—and the combined bridge—became a significant issue during construction. With slant-legged bridges, the columns have a tendency to rotate as the bridge is loaded. This rotation, the eccentric loading during the first stage of construction, the bridge horizontal curvature, and a slight offset in the as-built locations of the columns together created a construction challenge.

A major benefit of cast-in-place concrete is that field adjustments can be made if necessary. During construction, the Rock Creek Bridge designers performed several additional analyses to ensure that the bridge was still in conformance with the design.

Rock Creek Bridge
Leggett, California

Owner:	**California Department of Transportation**
Engineer:	**DMJM+Harris, Sacramento, California**
Contractor:	**MCM Construction, Inc., Sacramento, California**

CRSI

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Curvilinear Beauty . . .

U.S. Highway 101 winds through the mountains and redwoods of Mendocino County, following the natural contours of scenic California. At Rock Creek, the road curves, with a horizontal radius of 1,150 feet, and the concrete bridge curves right along with it.

That is one of the beauties of cast-in-place concrete. "The concrete can be formed to nearly any shape, which lends itself to great versatility in creating an aesthetic bridge," says Bill Fleming, AIA, Caltrans Bridge Architectural Associate.

Although the new bridge had an initial construction cost greater than the cost of retrofitting the existing structure, Caltrans will realize savings through many years of low maintenance service.

The result is a stunning, safe, and modern bridge meeting all current seismic design standards.