THE BRIDGE AT PITKINS CURVE

One Less Bend in the Road

by Mike Van de Pol and Pete Norboe, California Department of Transportation

The California Department of Transportation (Caltrans) is currently making improvements to Highway 1 along the rugged Big Sur Coast in Monterey County. The Pitkins Curve project site, located north of Limekiln State Park, is characterized by steep slopes high above the Pacific Ocean and is one of many geologically dynamic sections on this remarkable highway. Noted for its spectacular views of the rocky coastline, the road is both a state scenic highway and a national scenic byway. Seven graceful concrete spandrel arch bridges, rock masonry retaining walls and parapets, and drinking fountains along the 75-mile corridor form memorable features of the Carmel-San Simeon Highway Historic District. Construction of the two-lane highway in the 1920s and 1930s was a remarkable engineering feat; maintaining it in the twenty-first century is another.

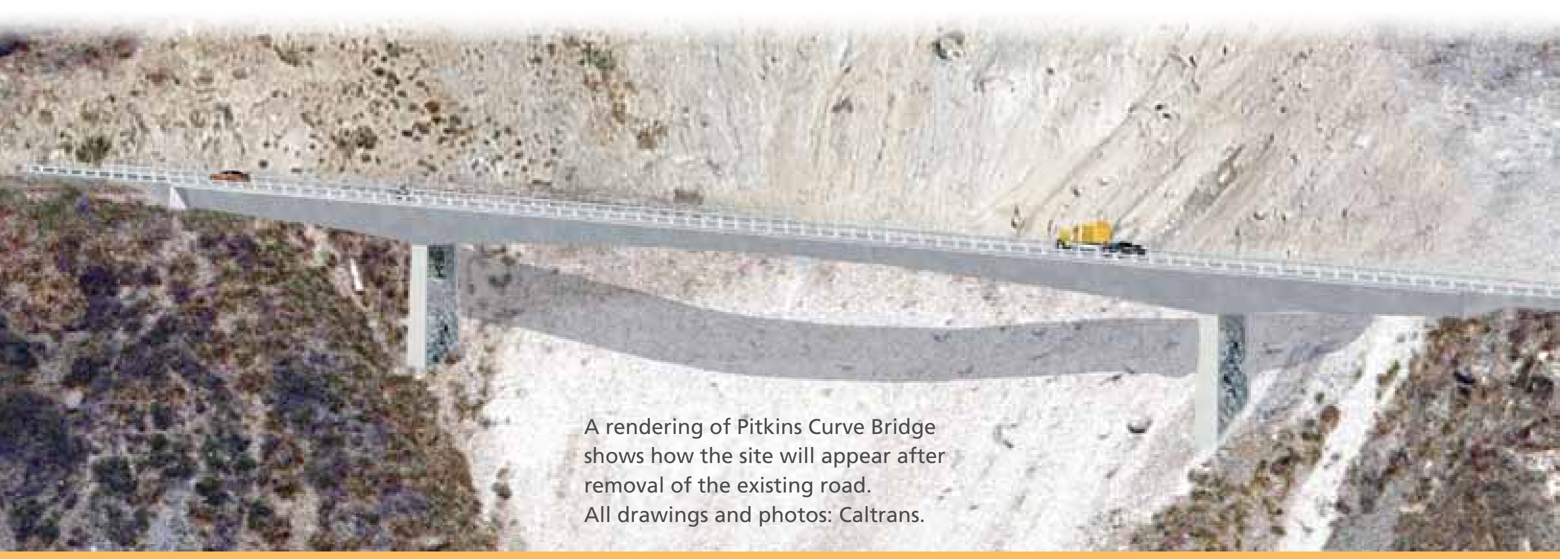
Besides its historical and scenic values, Highway 1 is the only direct link between numerous small communities and isolated residences dotting the Big Sur coast. The Pitkins Curve project will restore highway reliability, decrease maintenance expenditures, and improve safety for motorists and highway workers alike. To accomplish these goals, a new bridge is being constructed that addresses the challenging geologic instabilities found at the site.

Understanding the Risk

Unstable geology and winter storms cause unpredictable and extensive landslides and rock falls at Pitkins Curve, regularly reducing or interrupting travel for months at a time, and creating significant hardship for travelers and the coastal communities. Highway restoration is generally conducted under emergency conditions, which increases the risk to highway workers, elevates costs, restricts the range of restoration methods available, and limits ways to avoid or minimize impacts to traffic movement, the economy, and the environment. Even routine management of landslides at this location is riskier and has higher maintenance costs than other locations on the Big Sur Coast Highway. Caltrans geologists and geotechnical engineers studied the slopes at Pitkins Curve, concluding that the hillside would continue to slide, rocks would continue to fall, and the highway would continue to be damaged and severed repeatedly unless mitigation measures were taken.

The Solution Becomes Apparent

The design selected for the Pitkins Curve Bridge is founded on geologically stable rock formations and spans the unstable slide region. The three-span, 620-ft-long structure carries two-way traffic. The structure has end spans of 154 ft 6 in. and a main span of 311 ft. The structure width at the deck level is 35 ft 6 in., with the roadway section carrying two 12-ft-wide lanes and two 4-ft shoulders. The traveled way is bounded by Type 80 concrete barriers with steel pipe hand railings affixed to the barriers for



A rendering of Pitkins Curve Bridge shows how the site will appear after removal of the existing road.
All drawings and photos: Caltrans.

profile

THE BRIDGE AT PITKINS CURVE / HIGHWAY 1 NORTH OF LIMEKILN STATE PARK, MONTEREY COUNTY, CALIFORNIA

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

GENERAL CONTRACTOR: Golden State Bridge Inc. (GSB), Martinez, Calif.

CONTRACTOR'S CONSTRUCTION ENGINEER: NRV Bridge Design, Gualala, Calif.

FORM TRAVELER AND POST-TENSIONING SUPPLIER: Schwager-Davis, Inc., Calif.

READY-MIX CONCRETE SUPPLIER: Graniterock, Watsonville, Calif.

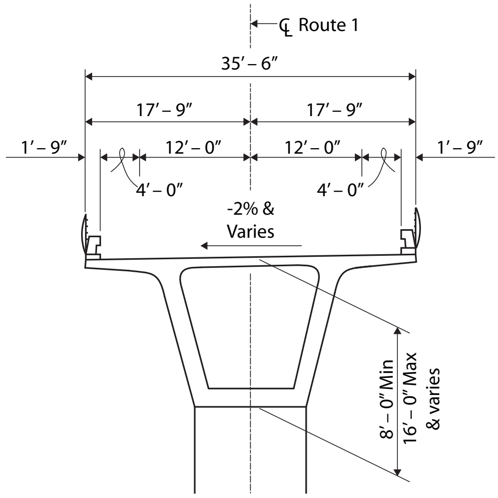
pedestrian and bicyclist safety. Different elements of the barriers have imprinted architectural treatments and all will have staining that includes flecking to match the colors of the local environment.

The Bridge Geometry and Siting

The structure follows a tangential alignment. The vertical change in deck profile grade between one end of the bridge and the other is 39 ft. The profile consists of two vertical curves followed by a straight 7% grade portion. Superelevation of the deck is a constant 2%. Because of the inherent site complexities and geologic instabilities, it was considered not feasible to employ falsework in the main span located over the slide area. Consequently, segmental construction was used. The proximity of the abutments to the main bridge piers and the stability of the geology at these locations did, however, allow the end spans to be constructed on falsework.

Superstructure

The superstructure is a cast-in-place, post-tensioned concrete, variable-depth box girder with inclined webs supported by single-column piers. The main span was constructed segmentally with a single form traveler working from each end. The form traveler was launched from the pier cantilevers that extend 35 ft 9 in. from the centerline of the piers. In addition, there are sixteen 14-ft-long girder segments plus an 11-ft 6-in.-long closure segment in the main span. The variable depth follows a parabolic curve in all spans. The typical box section complies with the American Segmental Bridge Institute standard guidelines for its configuration. Overall box girder depth varies from 16 ft at the faces of pier caps to 8 ft near the abutments and at midspan. Deck overhangs are 8 ft wide, tapering from 1 ft 7 in. thick at the web to 10 in. at the edge. The minimum deck thickness is 10 in. The soffit of the box girder varies in



Girder cross section.

thickness from 24 in. at the faces of the pier caps to 9 in. within the spans.

The superstructure is supported on the abutment seats by two polytetrafluoroethylene bearing assemblies. The superstructure end diaphragms are thicker than usual to act as counterweights against uplift potential due to the short end spans. No vertical tie down anchors are used. The movement expected at the abutments due to thermal and other factors is 4 in. Full-width approach slabs are 30 ft long.

Substructure and Abutments

The piers are slightly tapered rectangular, cast-in-place concrete single columns, varying from 9 ft 0 in. by 12 ft 3 in. at the top to 12 ft 0 in. by 12 ft 3 in. at the bottom. Due to the variation in site and substrata conditions, the columns are 45 and 61 ft tall. The tops of the columns employ slight parabolic flares in two directions. The columns are reinforced with two interlocking circles of No. 14 bundled continuous bars. These bars extend from full footing embedment to full cap embedment. The columns are made integral with the pier cap at the superstructure level. The pier caps are 16 ft deep, 12 ft long, and of variable width to match the box girder sections.

The columns are supported by and integral with concrete footings, which are 8 by 25 by 25 ft, highly reinforced and founded on four, 5-ft 6-in.-diameter, cast-in-drilled-hole piles socketed into competent rock. Vertical tie downs, which are near full pile length, and which have external anchorages at the top of the pier footings, are employed within all pier piles. The tie downs comprise ten 0.6-in.-diameter strands in a single 2¾-in.-diameter duct that are splayed

With the closure segment completed, the form traveler is being removed from the north end of the bridge. Bridge railings remain to be constructed and falsework under the end spans removed.

CAST-IN-PLACE, POST-TENSIONED, CONCRETE BOX GIRDER BRIDGE WITH CAST-IN-PLACE RECTANGULAR COLUMN PIERS, CAST-IN-PLACE FOOTINGS, AND CAST-IN-DRILLED HOLE PILES / CALIFORNIA DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: A 620-ft-long, cast-in-place concrete, variable-depth, box girder bridge with main span of segmental construction and side spans cast on falsework. The side span lengths are 154.5 ft and the main span is 311 ft long. The substructure column piers are 12 ft 0 in. by 12 ft 3 in. at the base and are 45 or 61 ft tall.

BRIDGE CONSTRUCTION COST: $11.5 million

A form traveler was used to cast the 14-ft-long segments. After completing the south cantilever, shown here, the traveler was relocated to the north span cantilever.

at the bottom, each with an anchor head. Permanent steel casings 5 ft 6 in. in diameter are employed at all pier pile locations. Overall pile lengths vary from 69 to 95 ft; steel casing lengths vary from 19 to 35 ft; and rock sockets vary in depth from 50 to 60 ft. Extensive shoring was required to construct the main bridge piers.

The abutments are traditional cast-in-place, concrete seat type abutments, 6 ft thick, and varying from 14 to 18 ft in height. Traditional wingwalls at each end of the abutments are from 24 to 30 ft long. The abutments are founded typically on twin, 5-ft-diameter, cast-in-drilled-hole piles, socketed into competent rock at depths ranging from 32 to 44 ft. The finished grade adjacent to the pier columns and Abutment 1 is contoured for passage of slide debris and rocks dislodged from the adjacent rock shed.

Concrete and Reinforcement

The specified 28-day concrete compressive strengths were as follows:

- Main pier footings and piles, 5000 psi
- Pier columns, 6000 psi
- Integral pier caps and superstructure, 7000 psi
- All abutment components, except the piles, 3600 psi

Due to the size of the pier caps, columns, and footings, mass concrete temperature control systems were designed and implemented. This included plastic tubing with circulated water and a monitoring system that was successful in controlling curing temperatures to prevent cracking.

All nonprestressed steel reinforcement in the concrete barriers, approach slabs, bridge deck, box girder stirrups, pier cap stirrups and top bars, and top reinforcement and stirrups in the abutment diaphragm are epoxy coated due to the marine environment. The remaining box girder reinforcement is uncoated, except for those additional longitudinal bars close to the deck. None of the reinforcement in the columns or abutments is epoxy coated.

Post-tensioning

All post-tensioning used 0.6-in.-diameter 270 ksi strands. The specified concrete strength at stressing was 5500 psi.

In the end spans, three draped tendons in each web extend from the abutment diaphragms through the pier table cantilevers. The force in each of these tendons was 867 kips for a total force of 2600 kips per web. There are approximately 20 strands per tendon and the post-tensioning was done in two stages.

Another group of nine tendons is located within the deck adjacent to the webs. Three tendons extend from the abutment diaphragm and six from deck mounted deviator blocks in the end spans. They extend over the piers and terminate at the various construction joints in the main span. The post-tensioning force was 700 kips per tendon, with approximately 16 strands per duct. One duct per web was designated for additional stressing if needed. These ducts are made continuous over the three spans of the structure. They were not used and were filled with grout, after the closure pour was completed.

The continuity post-tensioning is composed of two groups of six main span tendons, located within the soffit adjacent to each web. These extend between soffit-mounted deviator blocks located at varying distances from the closure segment. The force is 800 kips per tendon using approximately 19 strands per duct. One duct at each web was designated for additional stressing if needed. These ducts were not used and were filled with grout, after the closure pour was completed.

The fourth post-tensioning group is designated for future post-tensioning. Allowance is made for a single 4½-in.-diameter duct adjacent to each web. Internal diaphragms and deviator blocks are employed to provide the anchorage and directional change points for these ducts.

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With segment casting completed on the south cantilever, the form traveler approaches completion of the north cantilever leading to the closure placement to complete the bridge.