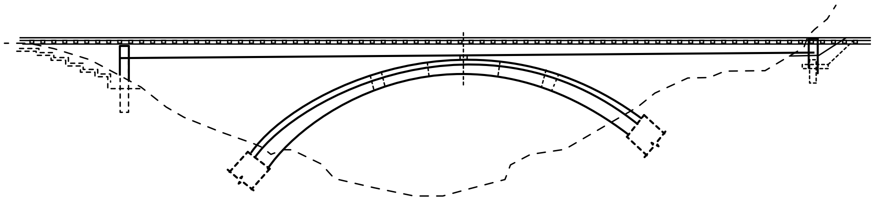
A TIME TO REPLACE—Constructing a Safer Tomorrow

by Raymond W. Wolfe and Ali Asnaashari, California Department of Transportation, and Bill Jahn, city of Big Bear Lake

The Big Bear Bridge nears completion.



All photos and drawings: California Department of Transportation.

The San Bernardino Mountains have long provided a key recreational outlet for the millions of residents populating the valleys and coastlines of sunny southern California. Big Bear Lake is situated approximately 100 miles east of Los Angeles in the San Bernardino National Forest at an elevation of 6752 ft. It is an idyllic mountain resort community and a major destination for year-round recreation. Fishing, boating, hiking, and camping are abundantly available during the warmer seasons, while skiing and other snow related activities are a real favorite of winter enthusiasts.

Big Bear was established as a local resort destination in 1884, after construction of the first dam and the subsequent establishment of a lake in a valley surrounded by picturesque mountain peaks. A larger capacity dam, impounding a 73,000 acre-ft lake, was constructed in 1912 and still stands today.

History of the Bridge

San Bernardino County completed a concrete highway bridge crossing the dam to provide access directly to the resorts from the San Bernardino valley floor in 1924. The 351-ft-long, 21-ft-wide bridge carried two lanes of traffic with one narrow sidewalk. The bridge comprised 12 spans of four girders each. The girders were haunched concrete T-beams resting atop arched ribs attached to the face of the concrete dam. The girder depth varied from 2.5 ft at the center of the spans to 3.5 ft at the simply supported ends.

During the Great Depression, the highway network crossing the San

profile

BIG BEAR BRIDGE / SAN BERNARDINO MOUNTAINS AT BIG BEAR LAKE, CALIFORNIA

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

PRIME CONTRACTOR: Flatiron West Inc., San Marcos, Calif.

CONCRETE SUPPLIER: Robertson's Ready Mix, Corona, Calif.

POST-TENSIONING CONTRACTOR: AVAR, Fremont, Calif.

ABUTMENT BEARINGS: D.S. Brown, North Baltimore, Ohio

. . . replacement [was] the only true viable option.

Bernardino Mountains was transferred to the State of California. The highway crossing the dam was designated as State Route 18 (SR 18).

An Aged Bridge

Nearly 60 years after it was opened to traffic, widespread deterioration was reported during an inspection and a replacement was deemed a high priority. The report identified numerous locations of concrete spalls and corroded reinforcing bars. The bearing pads at each of the dam's arch spandrels had suffered significant damage from years of deicing salts applied to the bridge deck. Temporary measures were instituted while a replacement was planned.

Finally, the configuration of the highway at the bridge as well as the narrow width of the structure played an important role in its demise. The orientation of the dam relative to the approaching highway forced traffic to turn left at a stop sign just west of the old bridge to remain on SR 18 toward their destination in Big Bear. The narrow width among other factors led to a "Functionally Obsolete" classification. The "Sufficiency Rating" or overall health indicator of the bridge as of March 2003 was 19.6 (out of 100 possible), with ratings less than 80 considered deficient. Key factors in computing these values such as deck geometry were such that they could not be enhanced through rehabilitation, leaving replacement as the only true viable option.

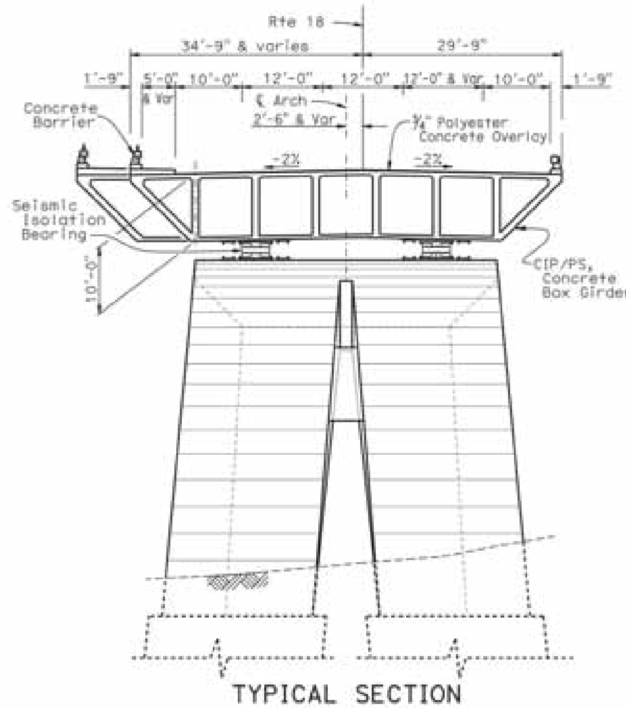
Creating a Dramatic Defining Community Landmark

Designers worked closely with the appropriate regulatory agencies at the federal, state, and local levels, as well as the local community to develop replacement alternatives. The bridge replacement project was required to meet both federal National Environmental Protection Act and California Environmental Quality Act environmental statutes. The final environmental document, begun in 1984, was signed in 2007, with construction commencing in late 2008.

Several alternatives were developed during the environmental phase of the project, with environmental impacts including potential mineral pollution of the lake water from an alignment directly over the lake as well as general aesthetic impacts. The final alignment diverted south of the existing dam, creating a new bridge crossing Bear Canyon. This alignment afforded a dramatic canvas to create a signature bridge capturing the spirit of the community while integrating with the steep jagged ravine.

A Concrete Solution

A 474-ft-long arch bridge with two 237-ft equal spans of post-tensioned, cast-in-place concrete box girders now graces the pristine landscape, as if it were leaping from one rock face of the ravine to the other effortlessly. The bridge is on a tangent alignment at Abutment 1, changing to a 501-ft-radius curved alignment near Abutment 5. The profile grade of the bridge is at 0.8% with a 2% cross slope. The superstructure is supported on polytetrafluoroethylene (PTFE) spherical bearings at the abutments and two 6.5-ft friction pendulum isolation bearings at the



The belvedere or overlook permits pedestrians a vista of the lake. The dam and existing bridge are at the left.

POST-TENSIONED, CAST-IN-PLACE CONCRETE ARCH SUPPORTING CAST-IN-PLACE BOX GIRDER / CALIFORNIA DEPARTMENT OF TRANSPORTATION, OWNER

SEISMIC ISOLATION BEARINGS: Earthquake Protection Systems, Vallejo, Calif.

BRIDGE DESCRIPTION: A 474-ft-long structure with two 237-ft equal spans of post-tensioned, cast-in-place concrete box girder. The 10-ft deep box girder superstructure rests on a cast-in-place concrete arch. The arch cross-section is hollow, trapezoidal in shape, with a depth that varies from 10 ft at the crest to approximately 15.5 ft at the base. The arch splits into two legs that are combined at the crest with a width of 45 ft. Each leg is 22.5 ft wide at the base.

BRIDGE CONSTRUCTION COST: $35.5 million

Falsework and forming for the arches.

The Big Bear valley . . . is underlain with numerous faults, including the south branch of the San Andreas Fault.

crest of the arch. Each isolation bearing carries 4600 kips and has a longitudinal movement capacity of 18 in. Two 72-in.-diameter, cast-in-drilled-hole piles support each corner of the abutments. These piles along with isolation bearings provide the necessary lateral strength required to meet the seismic demand of the bridge.

The exterior webs of the girders are sloped at a 45-degree angle. The 12-in.-thick interior webs are spaced at 9-ft centers. The top slab thickness is 8 in. and the soffit slab is 6¼ in. thick. The design concrete compressive strength is 5000 psi. All of the top slab reinforcement including the reinforcement for the barrier railings is epoxy coated.

The superstructure is post-tensioned with 4200 kips of force in each web for a total jacking force of 33,600 kips. A typical group of tendons has three 4-in.-diameter ducts and one 4³/₈-in.-diameter duct. The 4-in. ducts contain twenty-two, 0.6-in.-diameter strands while the 4³/₈-in. duct has twenty-seven, 0.6-in.-diameter strands. All of the ducts were fully grouted after the structure was stressed.

Cast-in-Place Arch

The arch consists of two cast-in-place reinforced concrete legs separated at the two bases and connected at the crest of the arch. The arch cross-section is hollow and has a trapezoidal shape with a depth that varies from 10 ft at the crest to approximately 15.5 ft at the base. From the crest, it splits into two legs. The top width of each leg of the arch is 22.5 ft at the base and 45 ft combined width at the crest. The bottom width of each leg varies. There are four circular continuous reinforcement cages at each corner of each half of the arch connected with 18-in.-thick reinforced concrete top and soffit slabs and 24-in.-thick webs. The specified concrete compressive strength of the arch ribs was 3500 psi.

Seismic Safety

The new bridge meets current seismic design criteria, lending a dramatic improvement over the old structure. The Big Bear valley and surrounding landscape is underlain with numerous faults, including the ominous south branch of the San Andreas Fault. The latter is presumed capable of a maximum credible event exceeding 8.0MMS on the Richter scale. The other lesser faults in the region may produce events ranging from 6.0 to 7.5MMS.

Capacity, Operations, and Maintenance

The new structure provides one 12-ft lane in each direction for traffic, a right-turn lane for westbound traffic heading onto SR 38 around the west side of Big Bear Lake, and two 10-ft shoulders. The shoulders facilitate snow removal by accommodating temporary snow storage. A black-tinted polyester concrete deck overlay reduces icing potential, thus minimizing the need for damaging deicing chemicals.

A dramatic improvement over the old structure.

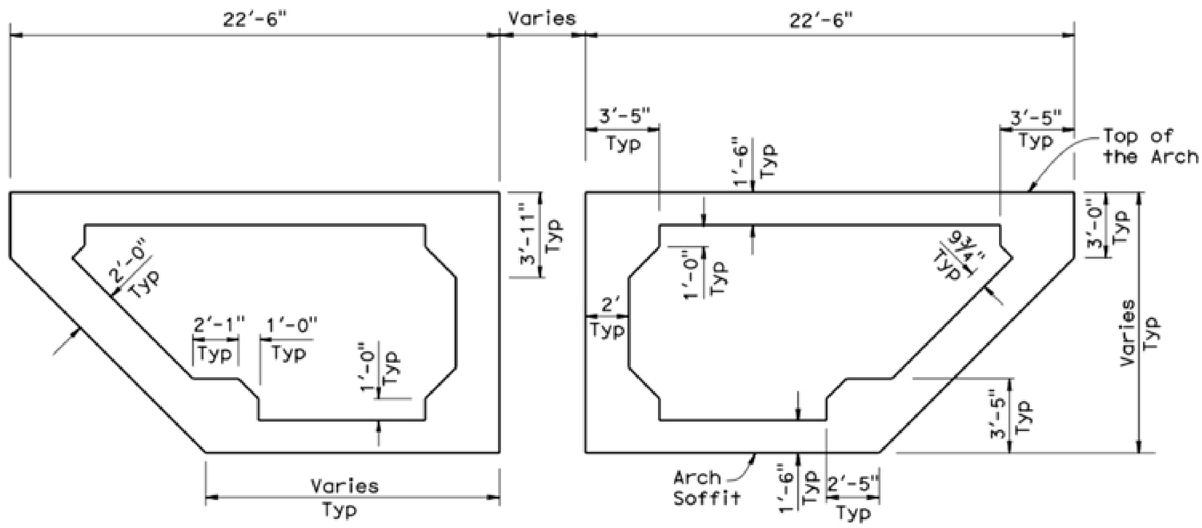
A Community Identifier

The new bridge is a testament to a road well traveled. When visitors ascend SR 18 and reach the entrance of Big Bear Lake, the site of the new bridge tells them they have arrived, that they have made it to Southern California's only four-season resort. The opening of the bridge was accomplished with great fanfare on June 24, 2011. The bridge has created a resurgence of pride in the local community as its aesthetically pleasing architecture is certain to win accolades and draw tourists and bridge enthusiasts for the next century to this pristine alpine resort community. The timing of its opening during a protracted recession is certain to help revive the local economy.

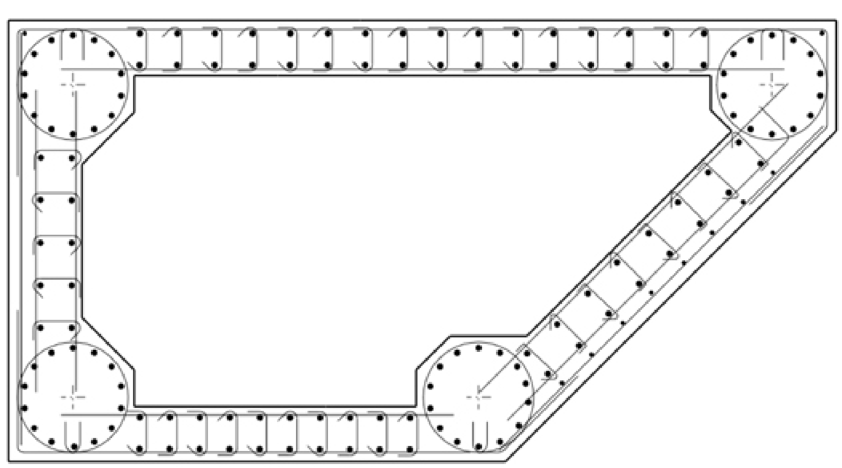
Raymond W. Wolfe is the District 8 director for the California Department of Transportation in San Bernardino, Calif., managing operations throughout San Bernardino and Riverside Counties; Ali Asnaashari is a senior bridge engineer for the California Department of Transportation in Sacramento, Calif., and the designer of record for the bridge; Bill Jahn is the mayor of Big Bear Lake, Calif.

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

The Big Bear Dam and existing bridge.



Cross Section Through Arch



Reinforcement in Arch

All but the bottom form for the arches have been removed while forming begins for the box girder.

The new and old Big Bear Bridges in Big Bear Lake, Calif.

Finishing work proceeds on one of the concrete arches.

A special open concrete barrier affords views of the dam to the north and the ravine to the south.