Searching for a practical solution

ANGELES CREST BRIDGE 1

by Jose Higareda, California Department of Transportation

Heavy runoff along with sliding debris overwhelmed drainage systems and caused major damage to the roadway along scenic Route 2 northeast of the city of Los Angeles within the Angeles National Forest. Much of the damage occurred during the spring thaws of 2006 and 2007.

Transportation officials with the California Department of Transportation (Caltrans) looked for economical and more durable repairs for the route. At the Angeles Crest Bridge 1 location where the roadway was washed out, they were faced with limited practical solutions. From the onset, the steep and loose terrain made it difficult to perform adequate subsurface investigations. Geologists were confined to work within the reach of their drill rig and from where the roadway was sturdy enough to support the equipment.

The girders were shipped to the site in three segments and spliced together on the ground.

Several alternatives were considered but ultimately, Caltrans opted to use 208-ft-long spliced precast, prestressed concrete girders to bridge the gap in the roadway. The girders were shipped to the site in three segments and spliced together on the ground near the bridge location. This avoided the need to construct temporary bents on the unstable slope in order to splice the girders in place. The long-span girders allowed the structure to bypass the area of geotechnical uncertainty. The abutments were placed away from known fracture planes in the rock and were founded on stable ground. The intent was also to create a gap between the structure and the natural chute of sliding debris allowing the debris to slide under the structure.

The single-span, simply-supported structure provides the added benefit of not having intermediate supports that could transmit earth loads to the structure during a seismic event. This is important given that the bridge location is situated in a high seismic area (peak ground acceleration of 0.7g and maximum credible earthquake of 8.0). Engineers needed only to confine the structure laterally at the abutments and provide sufficient seat length to prevent the girders from being dislodged.

Construction Logistics

Caltrans felt it was essential to consult with the precast concrete industry early on to study the construction challenges that this type of structure presented. The industry was represented by the Precast/Prestressed Concrete Manufacturers Association of California (PCMAC) who provided assistance with feasibility studies.

Two of the chief concerns were the transportation and erection of the girders. The girders spliced and fully loaded with rigging weigh nearly 180 tons each. PCMAC confirmed that erection was feasible if cranes could be staged at each abutment. It was determined that to install the girders, a 500-ton-capacity hydraulic crane at 91% margin and a 330-ton-capacity conventional crane at 88% margin would be required.

It was not, however, feasible for either crane to reach across from one abutment to the other while lifting one end of a girder. The swing radius for the cranes had to remain as short as

The Angeles Crest Bridge 1 northeast of the city of Los Angeles within the Angeles National Forest. Photos: Caltrans.

profile

ANGELES CREST BRIDGE 1 / LOS ANGELES COUNTY, CALIFORNIA

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

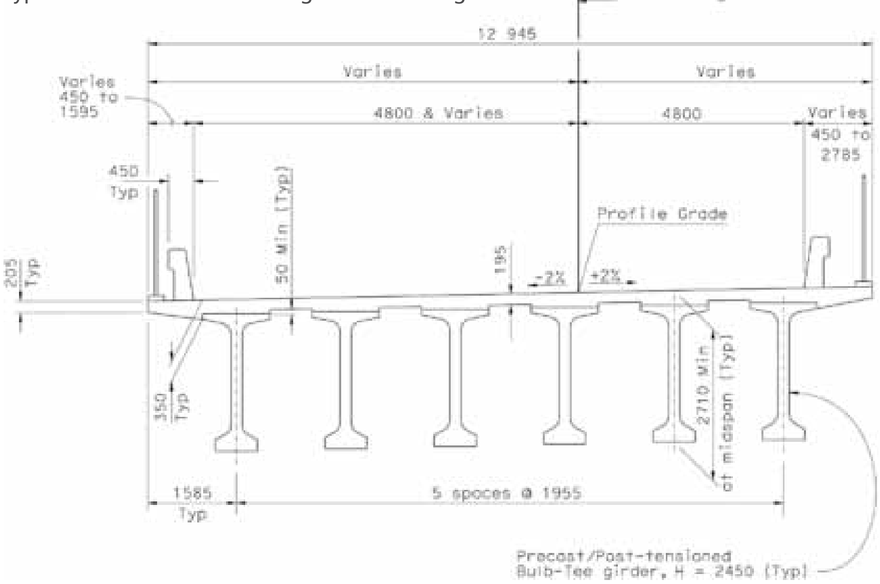
PRIME CONTRACTOR: Griffith Company, Brea, Calif.

PRECASTER: Pomeroy, Perris, Calif., a PCI-certified producer

CONCRETE SUPPLIER: Cornerstone Materials, Palmdale, Calif.

AWARDS: *PCI 2009 Design Award for Best Bridge Project (Spans More than 150 ft)*

Typical cross section of the Angeles Crest Bridge 1.



The girder is shown in the Pomeroy casting yard prior to installing the steel side form. All three segments for one girder were cast at one time.

possible. This meant the girders needed to be either spliced adjacent to the bridge location one at a time, launched across the gap on a truss positioned on both abutments, or hauled close enough to both abutments so they could be lifted by the cranes from each end. Finally, a plan was developed to temporarily shore up what remained of the existing roadway just enough to be able to haul the assembled girders close to both abutments.

A staging area was established less than a mile downhill from the bridge site to receive the individual girder segments that arrived from the precasting yard.

At the staging area less than a mile downhill from the bridge, girder segments were aligned and forms placed for the closure joints.

Here the girders were braced on supports, aligned, and spliced. When concrete in the splices cured to the specified strength, the girders were loaded onto specialized equipment used to move the assembled girders from the staging area to the bridge. A Goldhofer six-line, single-wide hydraulic platform trailer was used to support each end of a girder. A prime mover (tractor) pulled the girders up the hill with 55,000 lb of force. Using hydraulics, the trailers were individually controlled to keep the girders plumb and as level as possible during transport.

At the bridge site, the abutments were constructed and one end of each partially buried to allow the haul truck to drive over them and move the girders into position near the cranes. The girders were unloaded onto the abutment seats with flanges nearly touching one another. After placing all the girders on the exposed portions of abutments, the buried portion was cleared. Next, the temporary haul road which occupied the same space as part of the abutments and superstructure was removed. Finally, the cranes spaced the girders in their final positions along the abutments.

The first stage post-tensioning was done in the staging area. The bottom tendons needed to be stressed simultaneously from opposite ends of the girder to prevent eccentricity.

Structural Components

The bridge measures 208 ft long by 42 ft wide with a structure depth of 8.9 ft. It has a 2% cross slope and 5.4% longitudinal slope. A cast-in-place, composite concrete deck was placed over the six bulb-tee girder lines.

The abutments are each founded on a single row of 4-ft-diameter, cast-in-drilled-hole (CIDH) piles. Recognizing that the abutments would need to be constructed in cut and in rock, the footprint of the abutment was minimized to limit the amount of excavation by allowing the stem of the seat-type abutment to act as a cap for the CIDH piles.

SINGLE-SPAN, PRECAST, PRESTRESSED CONCRETE SPLICED BULB-TEE GIRDER BRIDGE / CALIFORNIA DEPARTMENT OF TRANSPORTATION, OWNER

POST-TENSIONING CONTRACTOR: DSI, Long Beach, Calif.

BRIDGE DESCRIPTION: A simple-span bridge with 208-ft-long, precast, prestressed concrete bulb-tee girders spliced together from three segments at a remote site in the Angeles National Forest

BRIDGE CONSTRUCTION COST: $2,376,192; $272/ft^2 of deck area

A special tractor and trailer were required to transport the girders from the staging area to the bridge site through several sharp turns.

An assembled spliced girder is shown being driven over Abutment 1.

The bridge clear span length of 204 ft warranted a structure depth of about 10 ft using the guide depth-to-span ratio of 0.05 for a simply-supported bulb-tee girder structure. The girders should ideally have had a depth of about 9 ft. However due to the weight limitations, 8-ft-deep girders were used instead. The use of a shallower girder resulted in reducing the spacing between girders to support the design loads.

Shallower girders required a concrete compressive strength of 8500 psi (at 56 days). The concrete strength requirement of 8000 psi (at 56 days) for the closure pours was higher as well. Achieving this strength is typically not a problem. However, the structure is located at an elevation of 6500 ft above sea level in a freeze-thaw environment so there was the additional requirement for 6% (±1.5%) air entrainment. Air entrainment reduces the strength of high strength concrete. While it was not an easy task, both the committed precast concrete manufacturer and the general contractor managed to provide the required concrete for the girders and closure pours.

The individual girder segments were pretensioned for transportation. The assembled spliced girders were post-tensioned in two stages. The first stage of post-tensioning took place after the closure concrete achieved the required strength at the staging area. During the first stage, four of the six ducts per girder were stressed to 2330 kips total. Final stressing took place once the girders were on the abutments and securely braced. The final force was 3560 kips per girder. End diaphragms and intermediate diaphragms were cast after stressing was complete.

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Jose Higareda is a senior bridge engineer with the California Department of Transportation, Sacramento, Calif.

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The temporary haul road crosses the uphill end of the abutments to allow delivery of materials including the assembled girders.

The temporary haul road crosses the uphill end of the abutments to allow delivery of materials including the assembled girders. Note the braced forms and bridge over the forms. Once girders were delivered, the road was removed and the full abutment unearthed.

Cranes were positioned over abutments and lifted the girders from trailers that were pulled across the temporary haul road.