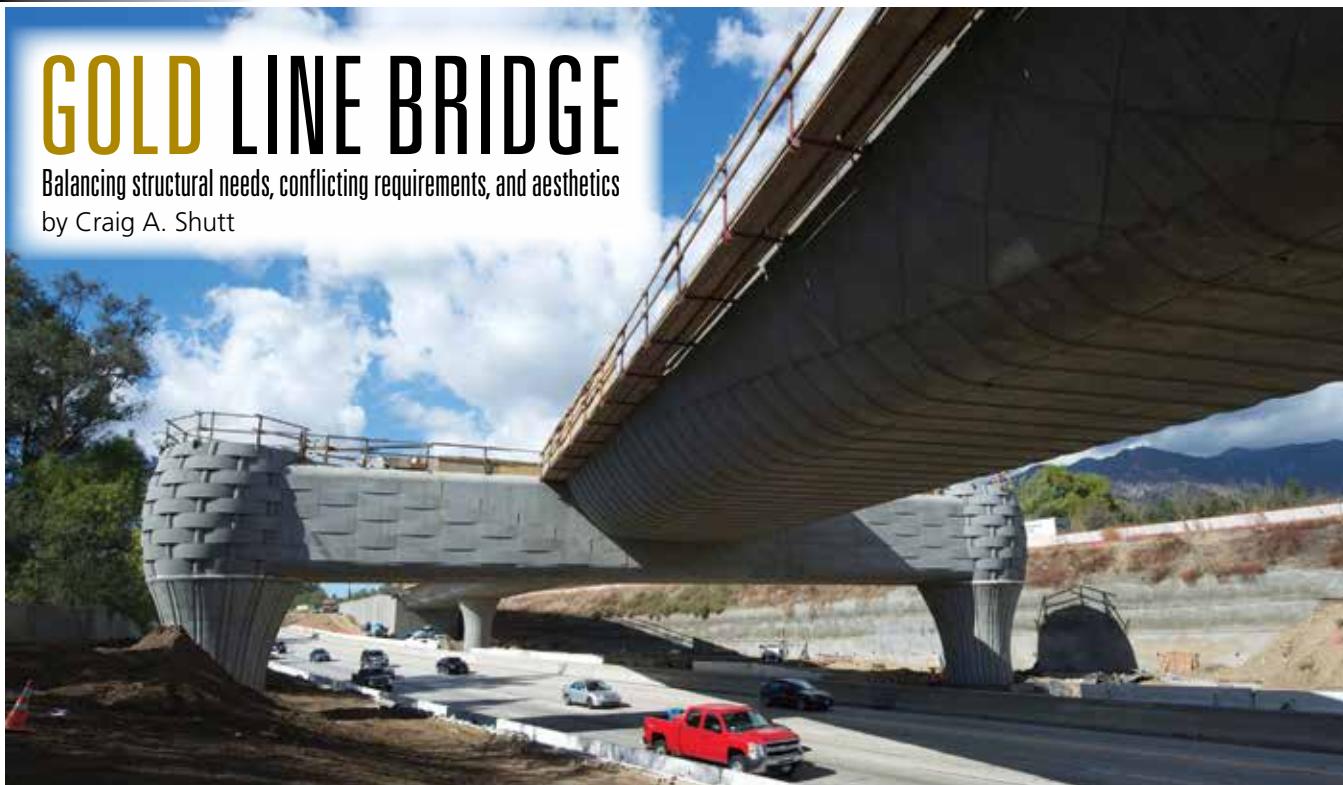


PROJECT

GOLD LINE BRIDGE

Balancing structural needs, conflicting requirements, and aesthetics
by Craig A. Shutt



The \$18.6-million Gold Line Bridge in Arcadia, Calif., features a variety of structural innovations to go with its dramatic aesthetic look. All photos: Metro Gold Line Foothill Extension Construction Authority.

Ensuring that all needs are satisfied on complex bridge projects creates challenges that can be difficult to meet. With the \$18.6-million Gold Line Bridge in Arcadia, Calif., designers not only faced meeting the needs of several overlapping governmental bodies, but also incorporated a number of innovative design techniques for the first time in the state. They accomplished those goals while producing a dramatic aesthetic appearance that reflects the area's heritage.

"This was a truly collaborative process," says Habib F. Balian, chief executive officer of the Metro Gold Line Foothill Extension Construction Authority. "We

learned that much can be accomplished, very economically, with early planning, the right team, and the community's support."

The 584-ft-long, dual-track bridge, which spans the eastbound I-210 freeway, kicks off a \$735-million, 11.5-mile light-rail project from Pasadena to Azusa. The bridge connects the existing Sierra Madre Villa station in Pasadena and the future Arcadia station—the westernmost of six planned stations.

The bridge features three spans of 8-ft 10-in.-deep cast-in-place, post-tensioned, three-cell, concrete box girders, with span lengths of 144, 220,

and 220 ft. The deck is 33-ft 11-in.-wide to accommodate two light-rail tracks and a center emergency walkway. The superstructure is supported by an outrigger bent cap that spans I-210, a single column bent, and the abutments at each end. The project required 6500 yd³ of concrete, and 1,300,000 lb of reinforcement. Total post-tensioning force for the superstructure exceeded 30,000 kips.

Visually arresting, the bridge's superstructure features a rounded underside, with a serpentine design along its length consisting of grooves and hatch-marks visible from I-210. Column tops were constructed of

profile

GOLD LINE BRIDGE / ARCADIA, CALIF.

BRIDGE DESIGN ENGINEER: AECOM, Los Angeles, Calif.

DESIGN CONCEPT ADVISOR/ARTIST: Andrew Leicester, Minneapolis, Minn.

PRIME CONTRACTOR: Skanska USA Civil West, Riverside, Calif.

CONCRETE SUPPLIER: National Ready Mix, Irwindale, Calif.

PRECASTER: Moonlight Molds, Gardena, Calif.; placement of precast units performed by Masonry Concepts, Santa Fe Springs, Calif.

POST-TENSIONING CONTRACTOR: Dwydag Systems International, Long Beach, Calif.

OTHER MATERIAL SUPPLIERS: Reinforcement—CMC Rebar, Fontana, Calif.; Spherical Bearings—D.S. Brown, North Baltimore, Ohio; Expansion Joint Seal Assemblies—American Sheet Metal, Anaheim, Calif.; Formliners—Fitzgerald Formliners, Santa Ana, Calif.; and Prefabricated Wood Forms—Squires Lumber, Colton, Calif.

precast concrete modules to resemble woven baskets connected with a horizontal support and decorated with reed patterns extending upward.

"The Construction Authority set the mandate to create a unique gateway that reflected aspects of the San Gabriel Valley region," explains Andrew Leicester, design concept advisor. "I drew inspiration from two sources: the region's cultural history and its architecture."

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The Metro Gold Line Foothill Extension Construction Authority, an independent agency, coordinated the planning, design, and construction. It followed specifications created by the Los Angeles County Metropolitan Transportation Authority (Metro), which will operate the rail line. But because the structure spans the eastbound lanes of I-210, the California Department of Transportation (Caltrans) also has jurisdiction. That required meshing differing, sometimes conflicting, requirements.

"Whenever required, the stricter of the two criteria were always adopted," explains Patrick Nicholson, project manager for AECOM, the lead architecture and engineering firm. "When contradictions occurred, we carefully assessed the conflict and devised the best solution for both agencies."



Lights wash the sides of the bridge at night, emphasizing the basket-like appearance of the column tops and the reed-like texture of the horizontal support.

Innovative Seismic Features

The key divergence arose over seismic design, which resulted in a balanced system and several innovative features. These were necessitated by the structure's third span crossing the active Raymond Fault. "Every component of the design was driven by the seismic criteria," says Lawrence Damore, project executive for Skanska USA, the general contractor.

The key issue centered on differences in seismic design criteria from each agency, Nicholson notes. "Caltrans' seismic criteria are based entirely on displacement, preferring to engage abutment soil as early as possible in a major earthquake, reducing overall displacement demand," he explains. "Metro's criteria, partially force-based, tends to delay the engagement to reduce abutment damage." After an in-depth assessment of both criteria, it was determined that early engagement was favored. "But through thoughtful

detailed, the abutment damage was also mitigated to an acceptable extent."

The structural design also used Caltrans' new methodology for analyzing bridges that cross active faults, which was issued in May 2012. The Raymond Fault makes a 70-degree angle counterclockwise with the third span's alignment. The anticipated surface fault-rupture displacement is 1.65 ft horizontally. "The breakthrough of the new methodology is that it recognizes the dynamic nature of a fault rupture instead of past analyses' emphasis on consideration of the quasi-static fault-offset component," Nicholson says.

Columns Create Challenges

"The Authority's original concept envisioned five piers, three in the center median and two on the south shoulder of the freeway. As we worked through our design, we realized we could offer a more efficient structure with just three

METRO GOLD LINE FOOTHILL EXTENSION CONSTRUCTION AUTHORITY, OWNER

OPERATOR: Los Angeles County Metropolitan Transportation Authority, Los Angeles, Calif.

BRIDGE DESCRIPTION: Three-span, 584-ft-long bridge with cast-in-place, post-tensioned, concrete box girders and precast concrete architectural column panels

STRUCTURAL COMPONENTS: 8-ft 10-in.-deep cast-in-place box girders with a 33-ft 11-in.-wide deck and cast-in-place pier caps, columns, and drilled shafts

BRIDGE CONSTRUCTION COST: \$18.6 million



The structure's third span on the far side crosses the active Raymond Fault.

columns founded on 11-ft-diameter concrete shafts that are 110 ft deep," Damore adds.

The columns are founded on single, large-diameter, cast-in-drilled-hole shafts. "They represented significant design challenges, especially with seismic considerations," Damore says. Single 11-ft-diameter Caltrans Type I shafts are used for each column. Multiple 2-ft-diameter shafts are used under the abutments.



The outrigger column's basket shapes were created with precast concrete modules. Sixteen reeds per basket were used with the same curvature but with varying lengths.

A single 10-ft-diameter column with an integral bent cap is used at bent 2, while double 10-ft-diameter columns, with a hollow prestressed outrigger bent cap having a span of 115 ft are used at bent 3. The post-tensioning force for the outrigger exceeded 30,000 kips. Both abutments feature high cantilever seat-type designs.

The bridge also is the first Metro-approved bridge to have rolling-stock analysis performed. These analyses are commonly required for high-speed rail or long-span bridges. The analysis employed a specialized three-dimensional finite-element program that models the bridge structure, the light-rail vehicle (including its body and primary and secondary suspension systems), and the dynamic effects due to the movement of the vehicle along the bridge. The analysis verified that the dynamic load allowance (or dynamic amplification factor) stipulated in Metro's criteria were sufficient and that riders would not experience excessive dynamic deflection.

Dramatic Aesthetic Design

Structural considerations were complicated by the unique bridge aesthetics. "I had the same reaction as everyone when they first saw it: Wow," says Rivka Night, lead architect at AECOM. "It's very unusual and not at all a traditional design. My immediate thought was, 'Is it really going to be constructed out of concrete?' It seemed that it might be a very complicated construction because of the unusual shapes."

The artist's inspiration for the serpentine superstructure flow was the Western Diamondback rattlesnake, while the basket-like columns represent indigenous Native American handicrafts. The bridge is the first artist-designed transit bridge in the state.

The underside features a curved profile with a longitudinal wave pattern mixed with a transverse rib pattern. It's the first bridge in the state to have these attributes. Creating the serpentine soffit shape required building temporary falsework and using formliners to create the pattern. The cross-hatching detail was accomplished by nailing small pieces of chamfer to the forms.



The bridge superstructure features a rounded underside, with a serpentine design along its length consisting of cast grooves and hatch-marks visible from I-210.

Each formliner was aligned by hand to ensure the proper shape and to align the grooves and hatchmarks.

The outrigger column's basket shapes were created with 60 individual precast concrete modules, which feature 16 reeds protruding 2 to 10 ft from the top. The concrete contained black stone as well as clear, gray, and mirrored glass to create a sparkling effect that responds to atmospheric conditions.

The 60 column basket's modules doubled as formwork for closure pours of the bent-cap prestressing anchorage. The complex weaving patterns matched those of the adjacent bent caps and the column below.

"The architectural elements of the bridge are unique," says Damore. "Nearly everything on this project was specially designed and manufactured for the project and required our crews to install them using detailed craftsmanship unlike any other bridge I have been involved with."

The result of balancing the complex structural needs, conflicting requirements, and dramatic aesthetics has been a signature bridge. "It's something no one in this region has ever seen or done before," says Balian. "Hundreds of thousands of people pass by the bridge daily, and I think they will appreciate the time and attention we gave to its design." **A**

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