# Go with the Flow

BY PAUL CHUNG, P.E., AND JASON FANG, P.E., PH.D.

## In car-centric Southern California, a highway overcrossing replacement project allows traffic to flow uninterrupted.

**THERE ARE MORE** than 24,000 automobile bridges in California supporting one of the world's most vibrant economies and linking the nearly 45,000 miles of pavement.

Just over a year ago the first steel state highway bridge designed to the AASHTO *LRFD Specification* with Caltrans (California Department of Transportation) Amendments was installed in California, using the accelerated bridge construction (ABC) approach. The project, the widening of an Interstate 10 (I-10) segment that connects central Los Angeles to San Bernardino County, replaced a reinforced concrete overcrossing in the town of Baldwin Park.

The existing Baldwin Park Overcrossing, constructed in 1956, was a two-span cast-in-place reinforced concrete box girder bridge. Its total structural length was 220 ft and it was supported by a four-column (retrofitted by an infilled shear wall) reinforced concrete bent and closed-end cantilever abutment on spread footings.

The new overcrossing, a four-span steel I-girder bridge with a total structural length of 478 ft, adds two high-occupancy vehicle (HOV) lanes and auxiliary lanes in the eastbound and westbound directions to meet increased traffic in the area. The four spans are 89 ft, 160 ft, 153 ft and 91 ft, and the bridge alignment matches the former structure. The new bridge profile is elevated to raise the vertical clearance from the existing 15 ft to nearly 17 ft to meet Caltrans' *Highway Design Manual's* required minimum 16.5 ft of vertical clearance. The assembly, which uses 690 tons of structural steel, consists of six 5.875-ft-deep steel I-girders, spaced at 12.33 ft apart, topped with a 9.45-in. cast-in-place concrete slab with a 1.5-in. hunch, providing an overall structural depth of 6.8 ft.

The steel superstructure is continuously connected and sits on reinforced concrete drop bent caps supported by four 4-ft-diameter columns founded on 6-ft cast-in-drilled-hole (CIDH) pile shaft substructures. The end spans are also supported by seat type abutments on CIDH pile foundations. The use of pile shafts helped avoid conflict with existing foundations and minimized the substructure work space so that four freeway lanes could be operational during construction.

The original crossing, a two-span cast-in-place concrete box girder bridge built in 1956.

The replacement span under construction.

All images: Caltrans

The new Baldwin Park Overcrossing is a four-span steel I-girder bridge with a total structural length of 478 ft.

## No Closure

The existing bridge served as a gateway to the Kaiser Permanente Hospital in Baldwin Park, and a full closure of the existing bridge during construction was not permissible since it serves as the main access to the hospital. The steel plate girder bridge type was selected because it was the only feasible option to satisfy the minimum temporary and permanent vertical clearance criteria (15 ft and 16.5 ft, respectively) required by the Caltrans *Highway Design Manual*. Cast-in-place (CIP) pretressed concrete box girders were not feasible because the minimum temporary vertical clearance could not be maintained due to the depth of falsework beams. Prestressed precast Bulb-T girders were also not feasible as they would have required a deeper structural depth and thus would have reduced the permanent vertical clearance to less than the minimum requirement; furthermore it was very difficult for a precast girder bridge to match the curved bridge profile and maintain the desired look.

The new LRFD specification with California Amendments called for increased truck live loads on the bridge, thus requiring heavier plate girders. The bridge is on a constant high 48° skew and thus

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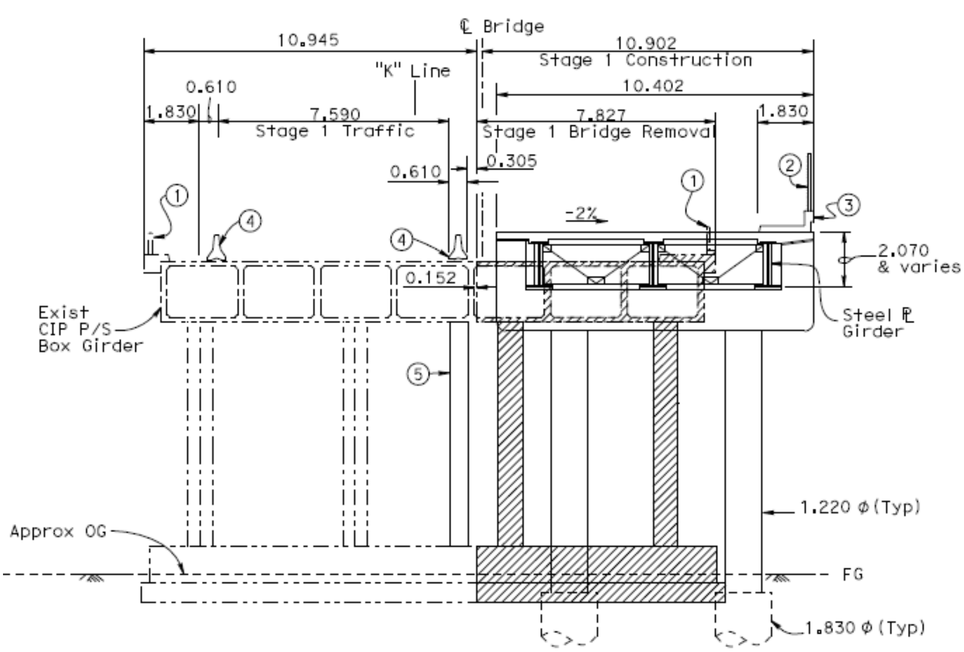
vertical load distribution (especially live load) can have irregular load path patterns. A 3D grillage finite-element model was generated in the MDX bridge design program, and the model was analyzed and checked for all LRFD vertical load limit states. The 3D MDX model consisted of girders, cross frames and supports reflected in the design so that realistic load distribution could be used to optimize the girder design by incorporating variable plate sections and matching the plate thicknesses to resist the force/stress demands.

### Seismic Design Considerations

The bridge site is located in a seismically active region of Southern California and close to a number of faults that are active or potentially active. Based on the Caltrans California Seismic Hazard Map (CSHM, 1996), the magnitude of the maximum credible earthquake (MCE) is 7.5, and the design median peak bedrock acceleration (PBA) is approximately 0.6g. The seismic design of the bridge is based on the *Caltrans Seismic Design Criteria* (Version 1.4, 2006). In the transverse direction, the shear keys were provided to transfer lateral seismic force to the substructure during an earthquake. In the longitudinal direction, the seismic force would transfer to both ends of the bridge, where the earthquake energy can be dissipated by combined action of the back wall and soil.

Given the 48° skew, the bridge has the potential to yield an irregular and complex seismic response. In order to accurately predict the response, another 3D grillage finite-element model was generated—this one in CSI SAP2000—and the model was analyzed using elastic response spectrum methods. Earthquake motion spectrum was applied to the model from a range of sources in different directions to ensure that the seismic performance of the bridge met the Caltrans seismic design criteria. The steel girder structure allowed for a relatively smaller (and more cost-effective) substructure than a comparable concrete structure and foundation, which was especially helpful in a region with the potential for high peak ground acceleration.




TYPICAL SECTION – STAGE 1
1:100

▲ The new bridge raises the vertical clearance from 15 ft to nearly 17 ft to meet current Caltrans requirements.

▼ The crossing stayed open to traffic during expansion.

### Construction

The new bridge was built in two halves (lengthwise) to allow unobstructed traffic flow across the I-10 freeway during the construction period, which lasted nearly seven months. Temporary sheet piling was installed at the median of the new and the existing abutments to retain the roadway embankment used in both stages, and temporary supports were provided at the bent caps of the existing bridge after each half was removed; during each construction stage, the existing half of the abutments and wing walls were removed.

The successful design and construction of the Baldwin Park Overcrossing—again, the first California state highway project built in accordance to the AASHTO *LRFD Specification*—provide an excellent ABC case study in high-seismic region. As owners and contractors continue to meet increasing demands for faster, less disruptive and efficient construction, it is expected that the steel girders will continue to be used in future ABC projects statewide. MSC

### Owner and Structural Engineer

California Department of Transportation

### General Contractor

Flatiron West, Inc., San Marcos, Calif.