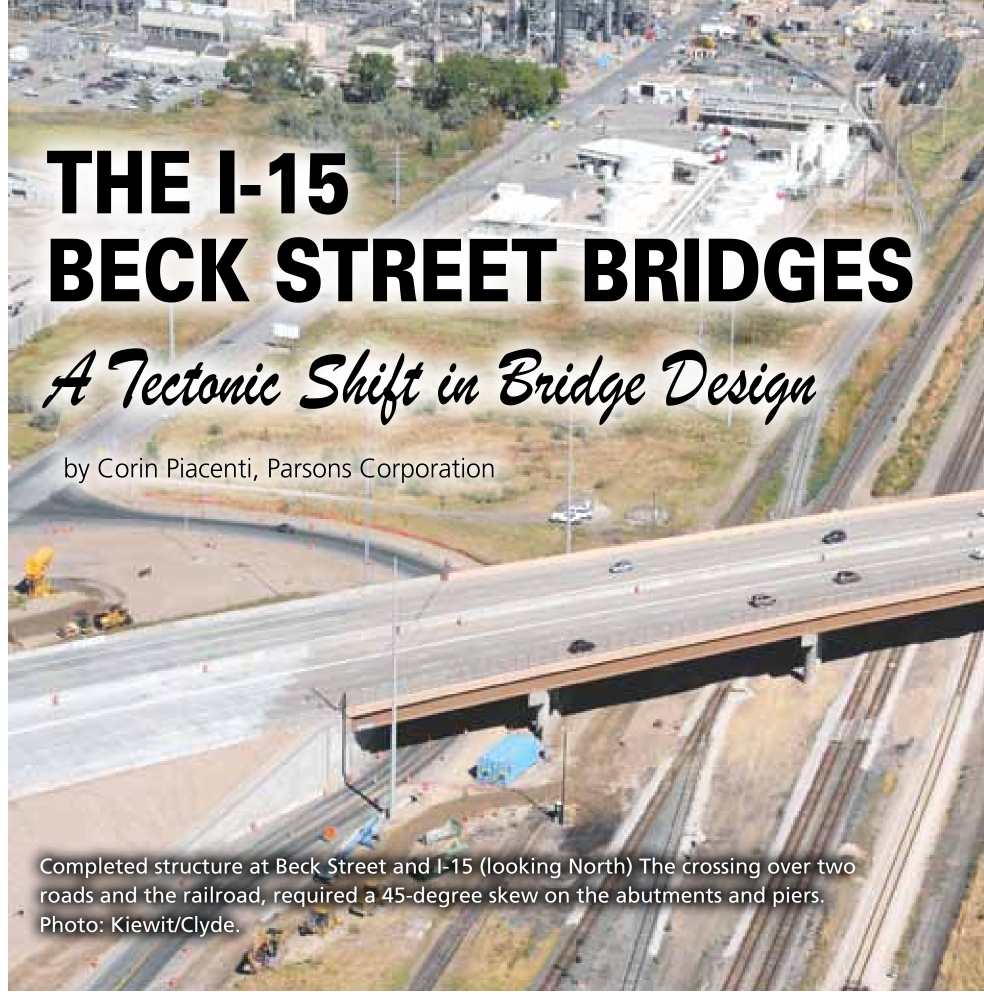
THE I-15 BECK STREET BRIDGES

A Tectonic Shift in Bridge Design

by Corin Piacenti, Parsons Corporation



Completed structure at Beck Street and I-15 (looking North) The crossing over two roads and the railroad, required a 45-degree skew on the abutments and piers. Photo: Kiewit/Clyde.

Designed to remain fully functional after the anticipated maximum seismic event.

The $115 million I-15 widening project from 500 North in Salt Lake City, Utah, to the I-215 junction in Davis County, added 4 miles of northbound and southbound express lanes to I-15. As part of the design-build project, the existing six-lane Beck Street Bridge was removed and replaced with twin, four-span bridges to carry a total of 10 lanes of traffic on I-15. The bridge replacement, including additional lanes, eased the heavily used commuter route.

The northbound and southbound I-15 Beck Street Bridges are the Utah Department of Transportation's (UDOT's) first bridges designed to remain fully functional after the anticipated maximum seismic event. At the time of construction, they also used the longest precast, prestressed concrete girders ever fabricated and erected in the United States.

Improved Layout from Original Concept Plans

The project team redesigned the concept plans for the I-15 Beck Street Bridges to reduce costs and complete the project 3 months ahead of UDOT's initial schedule. Warm Springs Road, the westernmost feature crossed by the I-15 Beck Street Bridges, was realigned 50 ft east, and vertical abutments were used instead of slope protection, resulting in a reduction of the overall length of the bridge by more than 200 ft. The reduction of the overall bridge length and the adjustment of the locations of the bents reduced the maximum span length to just less than 195 ft, allowing the use of precast, prestressed concrete girders rather than steel girders. The project team worked with the precaster during the proposal stage to select the girder section that could handle the long span. At the time, the standard Utah bulb-tee girders were still in development, but the precaster already had the data and the forms available for the metric, 2400-mm (94.5-in.) -deep, bulb-tee girder, which was selected for the project.

The bridges cross Union Pacific Railroad (UPRR) tracks, Utah Transit Authority (UTA) commuter rail tracks, Warm Springs Road, U.S. 89/Beck Street, residential and commercial structures, pressurized natural gas and hydrogen lines, and two 10-in.-diameter crude-oil pipelines, and pass under a transmission power line. The geometric layout required approximately 45-degree skews at the abutments and bents. The bridges are on vertical and horizontal curves and featured a varying superelevation.

The northbound bridge is 591 ft 8.25 in. long between centers of bearings. The approximate span lengths are 114.6, 185.5, 196.5, and 95.1 ft. The bridge width varies from 84 ft 10 in. to 92 ft 11 in. The southbound bridge is 603 ft 7.1 in. long between bearings. Its span lengths are 124.6, 175.6, 196.5, and 107 ft. and its width varies from 72 ft 10 in. to 77 ft 0.25 in.

profile

I-15 BECK STREET BRIDGES / SALT LAKE CITY, UTAH

BRIDGE DESIGN ENGINEER: Parsons Corporation, Pasadena, Calif.

GEOTECHNICAL/FOUNDATION DESIGN ENGINEERS: Dan Brown and Associates PC, Sequatchie, Tenn., and Shannon & Wilson Inc., Seattle, Wash.

PRIME CONTRACTOR: Kiewit/Clyde (a joint venture between Kiewit Western Co., American Fork, Utah, and W.W. Clyde, Springville, Utah)

CAST-IN-PLACE CONCRETE SUPPLIER: Geneva Rock, Orem, Utah

PRECASTER: Hanson Structural Precast, Salt Lake City, Utah, a PCI-certified producer

SHAFT CONSTRUCTION: Malcolm Drilling Company Inc., San Francisco, Calif.

The use of long precast concrete girders was vital in accelerating the schedule, minimizing impact to the railroads, and reducing costs.

Use of Precast Elements

The bridges use 194-ft 5-in.-long bulb-tee girders with shipping weights of approximately 242 kips. The 92 girders have a depth of 7 ft 10½ in. and are flared in the end spans to accommodate a varying roadway width. The center-to-center spacing of the girders varies from approximately 6 ft 9 in. to 7 ft 7 in. Steel was used for the intermediate diaphragms. The girders are heavily pretensioned, using up to sixty-eight 0.6-in.-diameter prestressing strands. The total jacking force was 2988 kips—791 kips in the 18 harped strands and 2197 kips in the 50 straight strands. The engineer used prestress bed capacity information from the precaster to guide the girder designs. The girders required 8500 psi compressive strength concrete to reach the desired span length. The specified strength of the concrete at prestress transfer was 6500 psi. The girder bearings are 5¼-in.-thick reinforced elastomeric pads. The use of the long precast, prestressed concrete girders was vital in accelerating the schedule, minimizing impact to the railroads, and reducing costs.

The girders were shipped 18 miles to the construction site supported on each end by trailers specifically constructed for their transport. They were then lifted from the trailers and walked into place using two 250-ton crawler cranes. The precaster placed three monostrands in each edge of the top flanges of the girders. These helped to improve stability and mitigate tensile stresses in the girders' flanges during stripping, shipping, and erection. The monostrands eliminated the need for external bracing and were cut to detention them following erection.

Keeping with UDOT's commitment to incorporating accelerated bridge construction elements during design, partial-depth precast concrete panels were used in the 8½-in.-thick composite bridge deck. The 3.5-in.-thick, precast concrete panels, ranging from 3 ft 7 in. to 4 ft 7¾ in. wide and from 3 to 8 ft long, span between the girders and serve as stay-in-place forms for the bridges' cast-in-place concrete deck. These allowed the project to avoid installation and removal of forms over the railroad and was estimated to have saved an additional 6 to 8 weeks of construction time. The design compressive strength of the panel concrete was 5000 psi.

Each girder weighed up to 242 kips. Photo: Hanson Structural Precast.

A precast, prestressed concrete bulb-tee girder during transport to the project. At 194 ft 5 in., the girders were the longest used in the United States at the time. Photo: Hanson Structural Precast.

TWIN, PRECAST, PRESTRESSED CONCRETE BULB-TEE GIRDER BRIDGES WITH COMPOSITE, CAST-IN-PLACE CONCRETE DECK ON PRECAST CONCRETE DECK PANELS / UTAH DEPARTMENT OF TRANSPORTATION, OWNER

DEEP SOIL MIXING: Hayward-Baker AGC, Odenton, Md.

BRIDGE DESCRIPTION: Twin, four-span precast, prestressed concrete bulb-tee girder bridges with partial-depth precast concrete deck panels and with cast-in-place concrete piers, abutments, wing walls, and foundations

STRUCTURAL COMPONENTS: Ninety-two 7-ft 10½-in.-deep bulb-tee girders with a maximum girder length of 194 ft 5 in., 48,333 ft^2 of precast 3½-in.-thick deck panels made composite with 5-in.-thick cast-in-place concrete, and twenty-four 9-ft 2-in.-diameter drilled shafts with a maximum depth of 122 ft

AWARDS: 2011 PCI Design Awards, Honorable Mention, Main Spans Greater than 150 Ft, 2011 American Council of Engineering Companies, Utah Chapter, Structural Systems Grand Award; 2010 *Roads & Bridges*, No. 9 Top Ten Road Projects; 2010 Utah Department of Transportation, Urban Project of the Year.

Durability and Maintainability

The project team evaluated and selected material alternatives based on their ability to meet and exceed the project criteria, constructability, cost, aesthetic value, maintainability, and durability. Maintenance-free or low-cost maintenance components and a design that enabled easy access for maintenance crews were prime objectives. The design incorporated several components with specific durability and maintainability benefits, including:

- Precast, prestressed concrete girders that eliminate the need for painting.
- Partial-depth precast concrete deck panels that provide a PCI-certified, plant-produced, dense concrete in the bottom half of the bridge deck.
- Polymer concrete deck overlay that has proven highly effective in Utah's environment for at least 15 years.
- Deck designed with a ½-in.-thick sacrificial wearing layer and design for a 40 lb/ft^2 future wearing surface.
- Expansion joints only at abutments; no expansion joints at piers.
- UDOT maximum amount of fly ash in the concrete mixtures.
- Epoxy-coated reinforcement in all elements except the drilled shafts and piles.

The girders are 7 ft 10½ in. deep and are shown in the fabrication plant. Photo: Hanson Structural Precast.

Seismic Design

The Beck Street Bridges are the first UDOT structures to be designed with the performance level category of "operational" using MCEER/ATC-49 *Recommended LRFD Guidelines for the Seismic Design of Highway Bridges* and the UDOT *Structures Design Manual*. UDOT classifies these bridges as "critical" because north and south mobility is constricted at this location by I-15, U.S. 89, and the UPRR and UTA tracks. The bridges provide a vital connection between Salt Lake County and Davis County.

Structures that UDOT classifies as "critical" must remain operational after the maximum considered earthquake (MCE). The MCE is defined as the earthquake response corresponding to a 2% probability of exceedance (PE) in 50 years (a return period of 2500 years), which is also equivalent to the MCEER 3% PE in 75 years. Per UDOT seismic design requirements, "critical" bridges must meet the displacement and detailing requirements for Seismic Design Category D with a ductility demand equal to the maximum allowed. For a bridge with a performance level defined as "operational," UDOT requires that the damage sustained must be negligible and full service available for all vehicles after the inspection and clearance of debris. Any damage to the bridge must be repairable, without interruption to traffic.

The abutment is isolated from the approach embankment to reduce loading effects from the lateral spread of the embankment in an earthquake. The abutment embankment is protected through the use of deep-soil mixing.

Column reinforcement cage in a 9-ft 2-in.-diameter drilled shaft. Photo: Kiewit/Clyde.

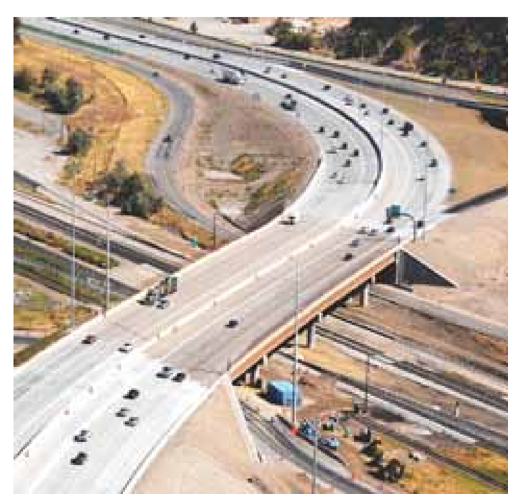
Bridges Open to Traffic

After 6 months of design and 20 months of construction, the I-15 Beck Street Bridges were completed and opened to traffic on August 16, 2010. With the completion of the project, the commute from and to the communities north of Salt Lake City was eased due to the increased capacity of I-15.

Corin Piacenti is a structure design engineer with Parsons Corporation's South Jordan office, near Salt Lake City, Utah.

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

Precast concrete partial-depth deck panels provide a high-performance concrete, stay-in-place form and all of the positive moment reinforcement between beams in the bottom of the 8½-in.-thick composite deck. Photo: Hanson Structural Precast.



Completed twin bridges at Beck Street and I-15 (looking North-East). Photo: Kiewit/Clyde.