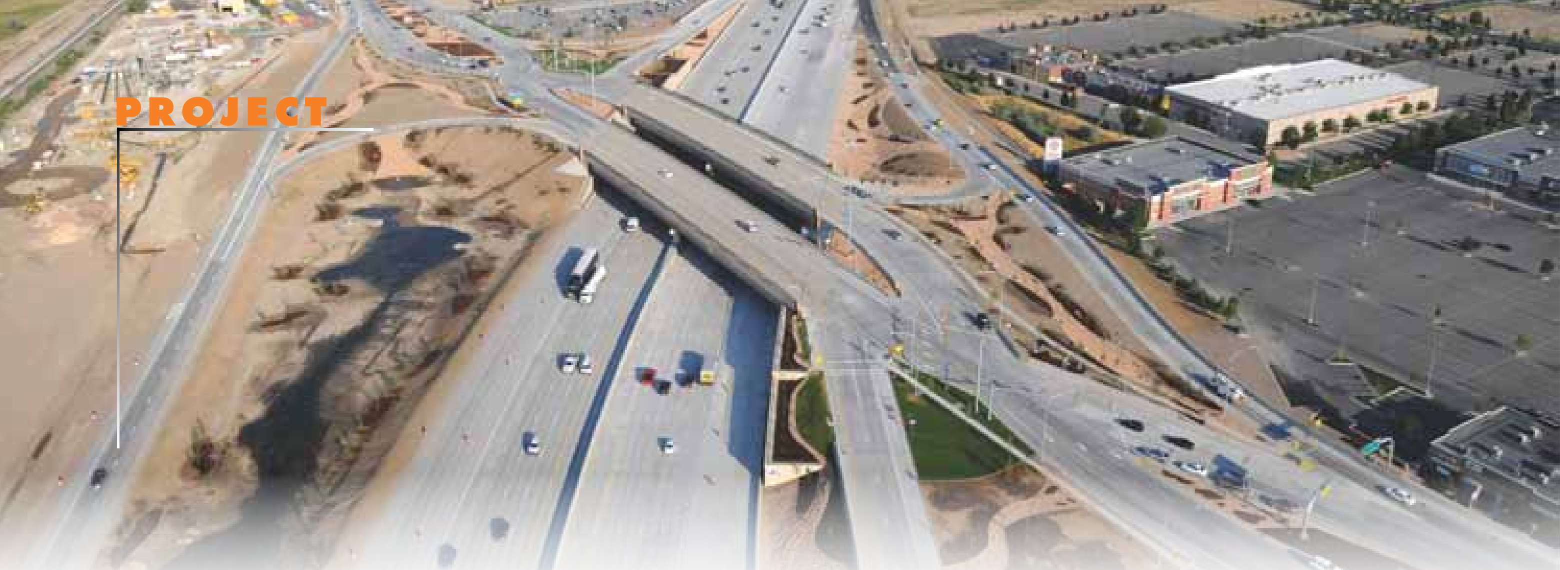


Completed diverging diamond interchange at Pioneer Crossing and I-15, American Fork, Utah. All photos: Kiewit/Clyde, a joint venture, and Parsons.

PIONEER CROSSING

by Steve Haines, Parsons Corporation

A diverging diamond interchange on the move

The $172 million Pioneer Crossing project in American Fork, Utah, comprises 6 miles of new arterial highway between two major development centers in Utah County and 1 mile of reconstruction of I-15, south of Salt Lake City. The new roadway serves a significantly growing community within the cities of American Fork, Lehi, and Saratoga Springs. The jewel of this new connector is its interchange with I-15—a diverging diamond interchange (DDI).

The interchange was originally conceived by the Utah Department of Transportation (UDOT) as a single-point urban interchange (SPUI). The Request for Proposals, however, provided an Alternate Technical Concept (ATC) process that allowed individual design-build teams to develop, gain UDOT approval, and include innovative concepts in their proposals for the project. The winning team submitted the DDI, including necessary traffic modeling analysis to support the concept.

The DDI concept had two main advantages over a SPUI: reduced right-of-way requirements and increased safety for the traveling public. The DDI requires vehicles to briefly cross to the opposite side of the road at crossover intersections. Vehicles go a limited distance over the interstate before they cross back to the traditional side of the roadway. This layout reduces the number of conflict points by eliminating left turns crossing opposing traffic. The team was awarded the contract for the project in the fall of 2008, providing the cost benefit of the DDI and the time advantages associated with accelerated construction techniques.

The DDI includes twin two-span prestressed concrete girder structures that replaced the existing four-span structure over I-15. Traffic was maintained during construction of the DDI by phasing construction of the twin structures. Additionally, the individual superstructure spans were constructed adjacent to the existing interchange and moved into the final location using self-propelled modular transporters (SPMTs). Once in place, closure pours were placed to achieve continuity of the two-span structure.

Layout and Bridge Design

Once the preliminary alignments of the DDI were established, design of the structures began. The final in-place design for each bridge called for nine precast, prestressed concrete bulb-tee beams, each with a depth of 94½ in. and a maximum single unit length of 191 ft 9½ in. Each beam has a top flange width of 4 ft 6 in. and contains fifty-six 0.6-in.-diameter straight strands and eighteen 0.6-in.-diameter harped strands. Beam spacing was 7 ft 9 in. center to center and the geometric layout required a 53-degree skew at the abutments and center bent. The beam design required a concrete compressive strength of 10,000 psi at 28 days and 7,000 psi at prestress transfer. The beams supported an 8½-in.-thick, cast-in-place composite deck.

During design, a specialist in heavy lifting and transport solutions was

profile

PIONEER CROSSING INTERCHANGE BRIDGES, I-15 TO REDWOOD ROAD / AMERICAN FORK, UTAH

BRIDGE DESIGN ENGINEER: Parsons Corporation, Pasadena, Calif.

PRIME CONTRACTOR: Kiewit/Clyde (A Joint Venture between Kiewit Western Co., American Fork, Utah, and W.W. Clyde, Springville, Utah)

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

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

HEAVY LIFT SUBCONTRACTOR: Mammoet, Salt Lake City, Utah

A schematic diagram of the Pioneer Crossing diverging diamond interchange. Drawing: Parsons Corporation

The westbound bridge spans are shown in the staging area located approximately 1100 ft southwest of the final bridge location.

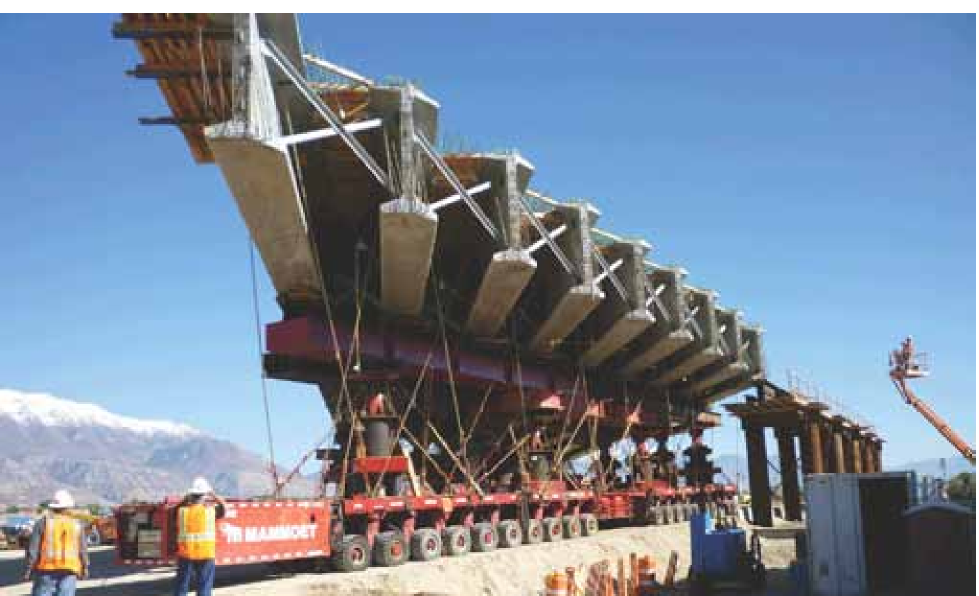
engaged to finalize the location of the SPMTs. The permanent abutments were supported on pipe pile foundations that were enclosed with two-stage mechanically stabilized earth (MSE) walls. Due to this configuration at the abutments, it was necessary to locate the SPMTs at approximately the twentieth points of the spans. This avoided conflicts between the SPMTs and the abutment walls.

Once the SPMT support locations were defined, the superstructure was analyzed for the temporary support conditions during transport from the bridge staging area to its permanent location. The geometric shape of the precast concrete girders was limited by the forms available at the fabricator and the number of prestressing strands was near the upper capacity of the fabricator's bed. The strength of the concrete girders was essentially fixed by the conventional design. If the stresses due to temporary loading during transport exceeded the service limit state, few options other than relocating the SPMTs were available.

The composite behavior of the superstructure allowed the girders to remain in compression during transport. The deck was in tension along the length of the span with the highest tensile stresses over the SPMT support locations. Additional reinforcement was added to the deck to account for these tensile forces and the stress limits in the reinforcement were limited to 30.0 ksi in keeping with the UDOT *Manual for the Moving of Utah Bridges using SPMTs*. To help minimize the tensile stresses in the deck, the concrete end diaphragms were not cast until the spans were in their final locations. Additionally, the concrete deck was not cast over the ends of the girders. This not only reduced tensile stresses in the deck, but facilitated the closure pour at the center-bent to establish live load continuity.

Construction of the Spans

The westbound superstructure spans were constructed in a staging area located southwest of the bridge site and the eastbound superstructure spans were constructed in an area located northwest of the site. The individual spans were constructed on temporary falsework which was supported on large concrete spread footings. Due to existing site conditions, both staging



SPMTs were placed at approximately the twentieth points from the ends of the spans.

TWO PRECAST, PRESTRESSED CONCRETE BULB-TEE GIRDER BRIDGES BUILT WITH CAST-IN-PLACE CONCRETE DECKS IN STAGING AREAS AND MOVED WITH HEAVY LIFTING EQUIPMENT INTO PLACE / UTAH DEPARTMENT OF TRANSPORTATION, OWNER

BRIDGE DESCRIPTION: Twin two-span precast, prestressed concrete girder bridges with a cast-in-place composite deck

STRUCTURAL COMPONENTS: Eighteen 94½-in.-deep bulb-tee girders in each bridge with maximum girder length of 191 ft 9½ in.

AWARDS: Mountain States Contractor, *2010 Project of the Year;* Roads & Bridges, *2010 No. 9 Road Project; American Council of Engineering Companies, Utah Chapter, 2011 Transportation Project Grand Award* areas required extensive geotechnical investigations to determine potential settlement and to provide mitigation.

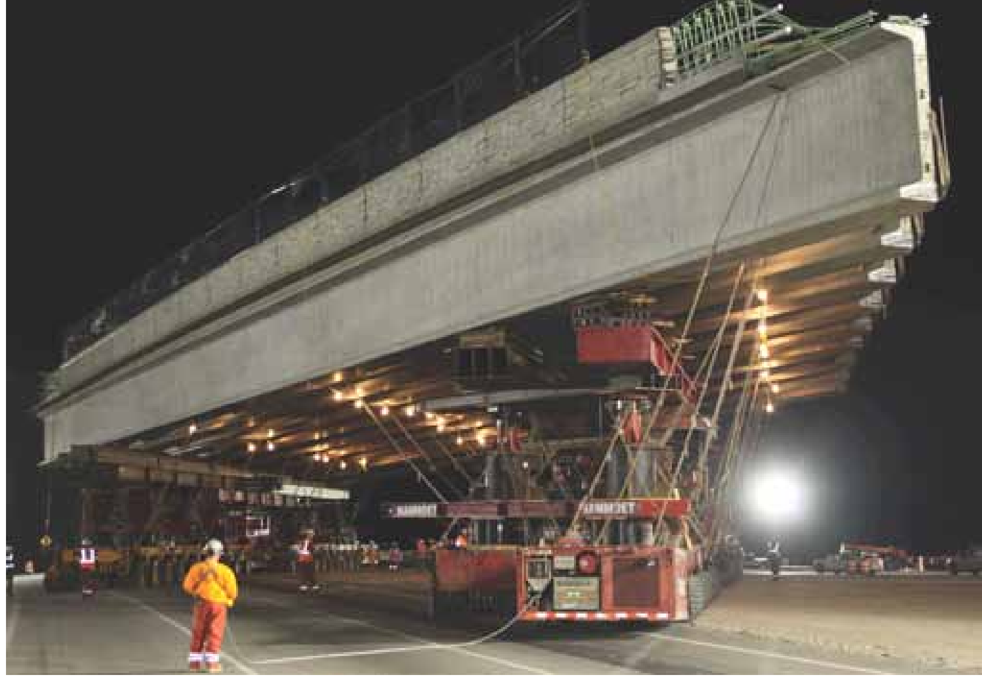
Once the temporary abutments were in place in the staging areas, the construction of the individual superstructure spans progressed much like a conventional superstructure. The most critical item during the construction steps was monitoring the bearing seat elevations of each individual girder. Potential differential settlement of the bearing seats would result in uneven bearing in the final location and would create additional stresses in the superstructure. Bearing seat elevation adjustments were made at the permanent location to compensate for differential as-built elevations.

SPMT Move and Monitoring

The weight of each span was approximately 2300 tons, which represents the longest and heaviest documented precast, prestressed girder spans moved using SPMTs in the United States. Each span was supported at each end with dual SPMTs with 20 axles each, which resulted in each span being supported by 320 wheels. The SPMTs carried cribbing and lateral bracing that supported the spans at the required vertical elevation.

Tapered plywood shims were used between the SPMT cribbing and the girders to account for the longitudinal slope of the girders. The shims were centered under the centerline of the girders to concentrate the load on the bottom flange under the girder web.

The twist tolerance for the superstructure was developed using procedures contained in the UDOT *SPMT Manual*. A 3-dimensional analysis was performed to calculate the allowable superstructure twist. The tensile stress in the reinforcement was the limiting factor.



Bridge span on the move during 8-hour road closure.

The SPMTs' hydraulic systems were controlled to provide four-point support for each span. Strict monitoring of the superstructure was required to prevent excessive torsion. A simplified string line system was adapted from the UDOT *SPMT Manual* to monitor twisting during transport. This consisted of a base string line set along one diagonal of the bridge at a constant offset from the top of the deck. A dual string was mounted along the opposite diagonal. At one end of the duel diagonal, both strings were set at the same constant offset from the top of the deck. At the opposite end, one string was set at the constant offset plus the twist allowance dimension and the other was set at the constant offset minus the twist allowance dimension. The result was the ability to visually monitor the twist in the center where the strings crossed. The string lines were monitored during transport by personnel on the span and adjustments were made hydraulically to the supports as the move progressed. This resulted in a very efficient and simple method to control twisting.

Final placement of the spans required the precise elevation control obtained during the construction of the spans in the staging areas. As the spans were lowered onto their permanent bearings, 18 points of support had to be at exact elevations to control stresses.

The spans of the westbound bridge were placed on the weekend of October 16, 2009, and the spans of the eastbound bridge were placed on the weekend of June 4, 2010. Each individual span was placed in a single 8-hour traffic closure. This greatly minimized impacts to the traveling public and supported UDOT's Accelerated Bridge Construction goals. Pioneer Crossing was opened to traffic on August 23, 2010, and the DDI became just the third such interchange opened to traffic in the United States.

Steve Haines is project engineer with the Parsons Corporation located in Denver, Colo.

For more information on this or other projects, visit www.aspirebridge.org.

A finished single bridge span in the bridge staging area prior to transport to the final location with SPMTs.