# PLACEMENT OF PRECAST PRESTRESSED CONCRETE GIRDER BRIDGE SPANS WITH SELF PROPELLED MODULAR TRANSPORTERS – PIONEER CROSSING DESIGN/BUILD PROJECT, AMERICAN FORK, UT

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**ABSTRACT**

This paper outlines the design differences between a conventional superstructure and one moved into place using Self Propelled Modular Transporters (SPMT's) and the impact of the method on construction. Details of the SPMT support configuration and the challenges of maintaining proper support of the girders during the process are reviewed. An active monitoring system that was developed to measure the spans' deformations while being moved, for comparison to allowable deflections, is presented and the necessity of such a system is addressed.

## INTRODUCTION

The $180 million Pioneer Crossing Project in American Fork Utah has been under way since October of 2008. It is composed of 6 miles of a new arterial connection between two major development centers in Utah County and 1 mile of reconstruction of Interstate 15 (I-15), just south of Salt Lake City. The new roadway will serve 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, which when completed, will be the second diverging diamond interchange (DDI) in the United States (see Figure 1).

**Figure 1 – Diverging Diamond Interchange Rendering**

The interchange with I-15 was originally conceived by UDOT as a Single Point Urban Interchange (SPUI) provided by the "Pioneer Crossing, Lehi / I-15 American Fork Interchange Request for Proposals" (RFP) (1). Included within the RFP specifications was an Alternate Technical Concept (ATC) process which allowed for individual Design-Build teams to develop, gain UDOT approval, and include innovative concepts into their proposals for the project. The Kiewit/Clyde team (a Joint Venture between Kiewit Western Company and W.W. Clyde), with Parsons as design manager and lead designer, submitted the DDI concept, providing necessary traffic modeling analysis that supported the concept. This ATC also provided a significant cost savings to the project. UDOT's management team took a bold step in granting approval of Kiewit/Clyde's concept to place the structures using accelerated bridge construction techniques which would minimize lane closures and disruption of traffic flow on both the interstate and the arterial roadway crossing over the interstate. The Kiewit/Clyde 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 2-span prestressed concrete girder structures replacing an existing 4-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 the SPMT's. Once in place, closure pours were placed to achieve continuity of the 2-span structure.

**LAYOUT AND DESIGN OF BRIDGES**

Once the preliminary alignments of the DDI were established, design on the bridge structures began. Design of the bridges was based on AASHTO LRFD Bridge Design Specifications, 4th Edition, 2007 and 2008 Interims (2) and the UDOT Structures Design Manual (3). The final in-place design called for nine precast, prestressed concrete bulb-tee beams, each with a 94 ½ in. depth and a maximum length of 190 ft-9 ½ in. (see Figure 2). Each beam has a top flange of 4 ft-6 in. and contains fifty-six 0.6 in diameter straight strands and eighteen 0.6 in diameter draped 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 compressive strength of 10,000 psi at 28 days and 7,000 psi at prestress transfer.

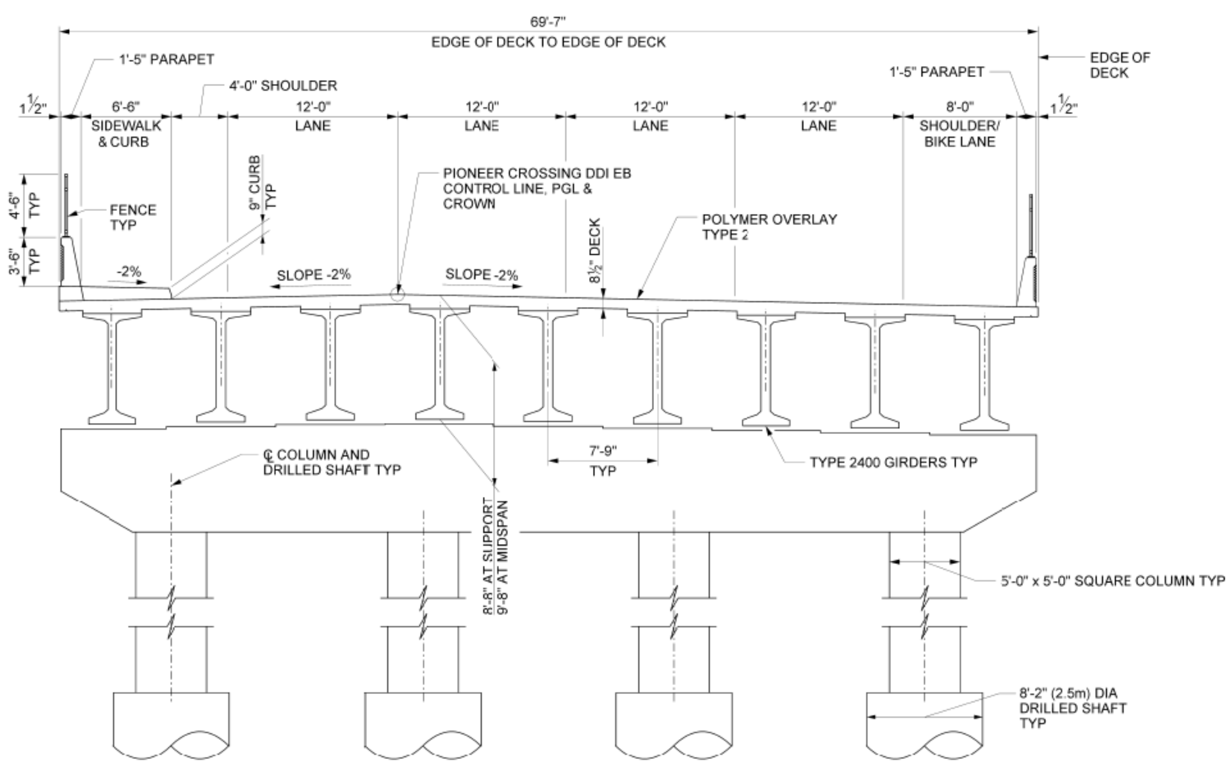


**Figure 2 – Typical Section Eastbound Bridge (Westbound Bridge Similar)**

While the design of the spans was progressing, Mammoet, was engaged to finalize the location of the SPMTs. The permanent abutments were supported on pipe pile foundations that were enclosed with two-stage MSE walls. Due to this arrangement at the abutments it was necessary to locate the SPMT's at approximately the 20th point of the spans. This location avoided any conflict between the SPMT's and the abutment walls.

Once the SPMT support locations were defined, the superstructure was analyzed for the temporary support conditions during the transport of the bridge spans from the Bridge Staging Area (BSA) to the permanent location. The geometric shape of the prestressed concrete girders was constrained by the available forms from the fabricator and the number of prestressing strands was near the upper capacity of the fabricators bed. The concrete girders were essentially fixed by the conventional design, and if the temporary loading condition exceeded the stress limitation of the superstructure, few options other than revising the SPMT locations were available to influence the stresses. This was different from a typical steel girder superstructure where plates can be thickened or stiffeners added to handle the temporary loading condition during transport.

Composite behavior of the superstructure allowed the girders to theoretically remain in compression during transport of the spans. The deck was in tension along the length of the span with the highest tensile stresses experienced over the SPMT support locations. Additional reinforcing was added to the deck to handle these tensile forces and the stress limits in the reinforcing were limited to 30.0 psi per the UDOT Manual for the Moving of Utah Bridges Using Self Propelled Modular Transporters (SPMTs) (4). To help limit the tensile stresses in the deck the concrete end diaphragms were not placed until the spans were in their final locations. Additionally, the deck was held back from the ends of the girders to reduce the tensile stresses and to facilitate the center-bent closure pour to establish live load continuity.

Many items were considered during the design phase to potentially limit the stresses within the superstructure and the overall weight of the superstructure. Added external temporary post-tension was discussed to counteract a portion of the tensile stresses within the deck during the move. Due to the complexity of the system required to achieve the post-tensioning, the option was dismissed. Light weight concrete for the deck was considered to limit the overall weight of the superstructure and the dead loads applied to the girders. Both the proximity of the aggregate source and the additional cost of the aggregate eliminated any potential gains due to the light weight concrete.

**CONSTRUCTION OF THE SPANS**

The westbound superstructure spans were constructed in a BSA located southwest of the permanent location and the eastbound superstructure spans are currently being constructed in a BSA located northwest of the permanent location (see Figure 3). The individual spans are being constructed on temporary false work which is supported on large concrete spread footings. Due to existing site conditions, the BSA's required extensive geotechnical investigations to determine any potential settlement and determine the required mitigations.

Once the temporary abutments were in place at the BSA, the construction of the individual superstructure spans progressed similar to that of a conventional superstructure.

The most critical item during the construction steps was monitoring of the bearing seat elevations of each individual girder. Potential differential settlement of the bearing seats would result in uneven bearing supports in the final bridge location and would induce additional stresses within the superstructure. Bearing seat elevation adjustments were made at the final bridge location to compensate for any differential as-built elevations.


**Figure 3 – Westbound Bridge Aerial**

## 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 into place using SPMT's in the United States. Each span was supported on each end with dual SPMT's lines with 20 axle lines each, which ultimately resulted in each span being supported by 240 wheels each (see Figure 4). The SPMT's supported a series of cribbing and lateral bracing that supported the spans at the required vertical elevation.

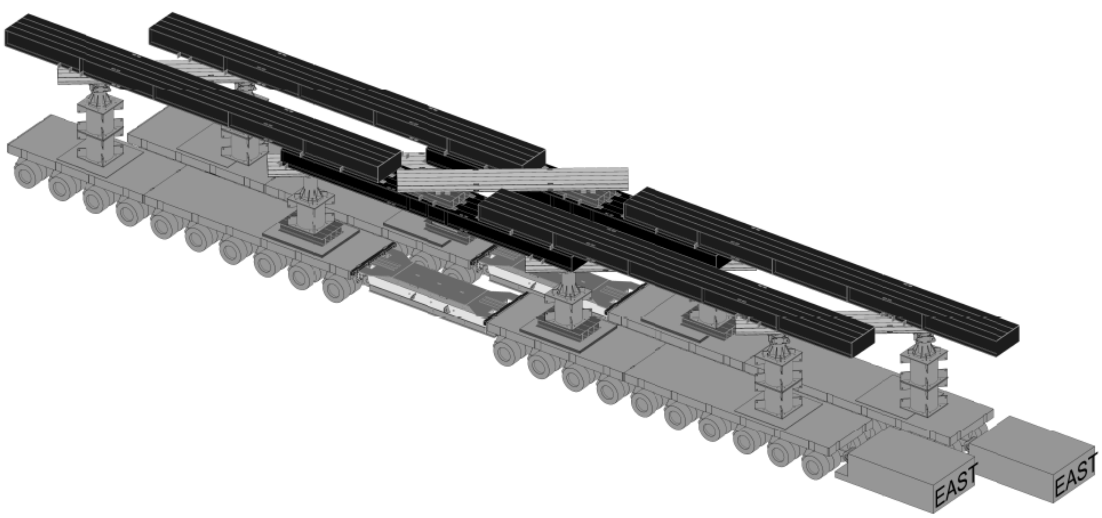


**Figure 4 – Single SPMT Support Layout**

Tapered plywood shims were employed in the final support between the SPMT cribbing and the girders to make up for the longitudinal slope of the girders. The shims were centered under the centerline of the girders to concentrate the load on the portion of the bottom flange supported by the girder web.

The hydraulic support systems of the SPMT's were set up to provide a four-point support system for the transport of each span. The four-point support system required strict twist monitoring of the superstructure during the transport. A simplified string line monitoring system was adapted from the UDOT SPMT Manual to monitor the twist during the transport of the spans (see Figure 5).

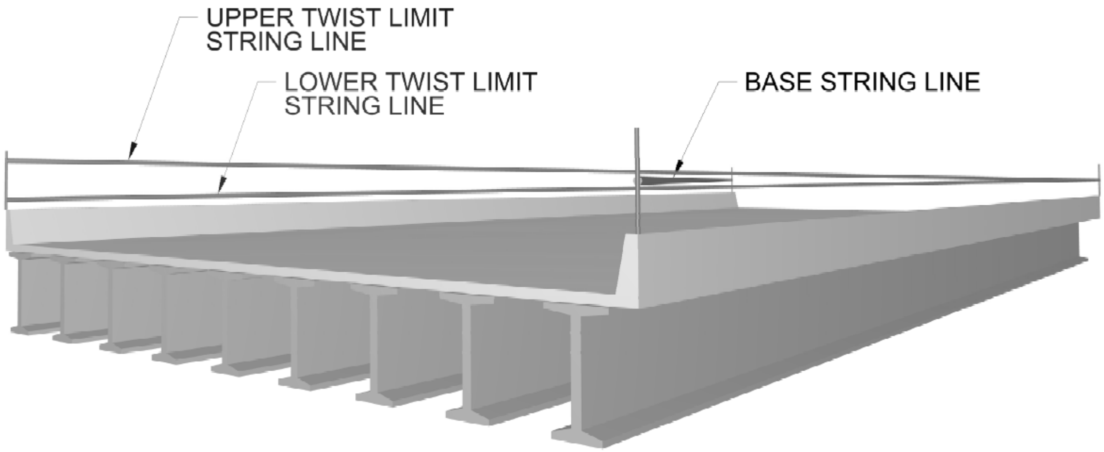


**Figure 5 – String Line Layout**

A base string line was set along one diagonal of the bridge at a constant offset from the top of deck. On the opposite diagonal a duel string was set. At one end of the duel diagonal both strings were set at the constant offset from the top of the deck. On the opposite end one string was set at the constant offset plus the twist allowance and the other was set at the constant offset minus the twist allowance. This resulted in a definition of the twist limit in the center where the strings crossed.

During lifting and transport, as any support moved relative to the other 3 supports, a displacement result where the diagonal string lines intersect in the middle of the spans was obtained. The string lines were monitored during the transport by personnel placed on the span and active adjustments were made to the supports as the move progressed. This resulted in a very efficient and simple method of monitoring the twist.

The twist limits of the superstructure were developed using procedures established within the UDOT SPMT manual. A 3-dimensional analysis was performed to calculate the allowable superstructure twist with the reinforcing tensile stress being the limiting factor.

Final setting of the spans relied heavily on the precise elevation control provided during the construction of the spans in the BSA. As the spans are lowered onto the permanent bearing locations, eighteen points of support must be at the exact design elevations. As mentioned above, any difference in elevation induces unanticipated transverse stresses within the superstructure.

## CONCLUSIONS

The spans of the westbound bridge were placed on the weekend of October 16$^{th}$, 2009. Upon final setting, preparations began immediately for the necessary closure pours to tie the spans together at the center pier and abutments. The westbound bridge was opened to traffic on November 30$^{th}$, 2009. Ultimately many lessons were learned during the placement of the westbound spans that will be investigated further during the placement of the eastbound bridge and future structures.

- Utilization of a continuous support beam at the girder ends in the BSA to minimize any potentially differential deflections between the individual girders.
- Automation of the monitoring system if a 4 point support condition is used with the SPMT's. As mentioned in the UDOT SPMT Manual, the string line system could be automated to eliminate the need for personnel to be on the spans while it is being moved.
- Development of a support system between the SPMT cribbing and the bottom of the girders that provides a more consistent support than the tapered plywood.
- Review of the torsional capacity of the span to determine if a 3-point support system could be employed. A 3-point support system would minimize stresses during transport due to the twist allowed by a 4-point system; however it remains to be determined whether or not the open girder sections possesses the rigidity for such a system to succeed.

## REFERENCES


(1) UDOT 2008: *Pioneer Crossing, Lehi / I-15 American Fork Interchange Request for Proposals*, Utah Department of Transportation, 2008.

(2) AASHTO 2008: *AASHTO Load Resistance Factor Design Bridge Design Specifications*, 4$^{th}$ Edition, 2007 with 2008 Interims, American Association of State Highway and Transportation Officials, 2008.

(3) UDOT 2006: *Structures Design Manual*, Utah Department of Transportation, 2006.

(4) UDOT 2008, *Manual for the Moving of Utah Bridges Using Self Propelled Modular Transporters (SPMTs)*, Utah Department of Transportation, 2008.