Rapid, *Economical* **Bridge** Replacement

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Shallow trapezoidal steel box girders provide a highly constructible, light and efficient structure.

WITH THE NORTH AMERICAN FREE TRADE AGREEMENT (NAFTA) spurring commerce, the Texas Department of Transportation (TxDOT) is intent on upgrading transportation routes. Part of this effort is a multi-year corridor improvement plan to expand the four-lane I-35 to six lanes. I-35 stretches 1,565 miles from Laredo, Texas to Duluth, Minn., including 500 miles within the state of Texas. The massive project includes upgrades of many of the overpasses along the route, offering bridge engineers both challenges and opportunities.

One of these projects is the FM 3267 bridge. Located 75 miles north of Austin on one of the busiest segments of the nation's interstate highway system, the project offered the challenge of how to span the widened highway without raising the approaches and still maintaining the required vertical clearance.

One project goal was to create a signature design aesthetic while providing a rapidly constructible and cost-efficient structure. The interior bent caps were eliminated in order to accelerate the construction. The shallow superstructure, in conjunction with the inclined exterior pier faces and lack of interior bent caps, provides an attractive structure from all views. The structural efficiency provided by trapezoidal steel girders allowed them to be proportioned to meet the required depth and strength requirements.

One of the design challenges for this bridge was minimizing girder depth as much as possible. Several superstructure options were considered, including prestressed concrete U-beams, I-beams and steel plate girders. The system chosen features single columns under each shallow trapezoidal steel box girder and simple spans of 45, 100, 100 and 65 ft. The structural efficiency provided by trapezoidal steel girders allowed them to be proportioned to meet the required depth and strength requirements.

The bridge has an overall width of 78 ft, carries a roadway width of 76 ft., and uses six lines of 36-in.-deep steel box girders at 13.2-ft centers with 6-ft overhangs. A cast-in-place deck was constructed in two phases with a longitudinal joint in the deck on top of one of the girder flanges.

The girder sections were standardized and common details saved design, fabrication and erection costs. Figure 1 illustrates a typical transverse girder section that has a span capability of 100 ft. The 45-ft and 65-ft spans have a typical steel girder section con-

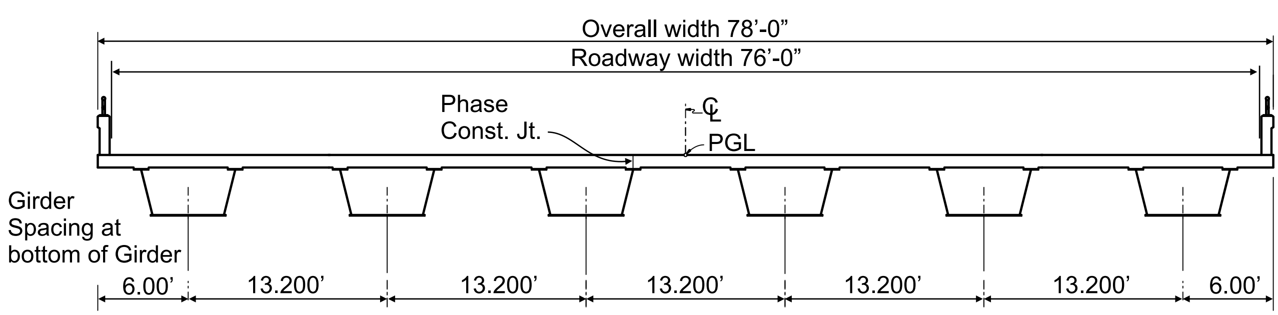
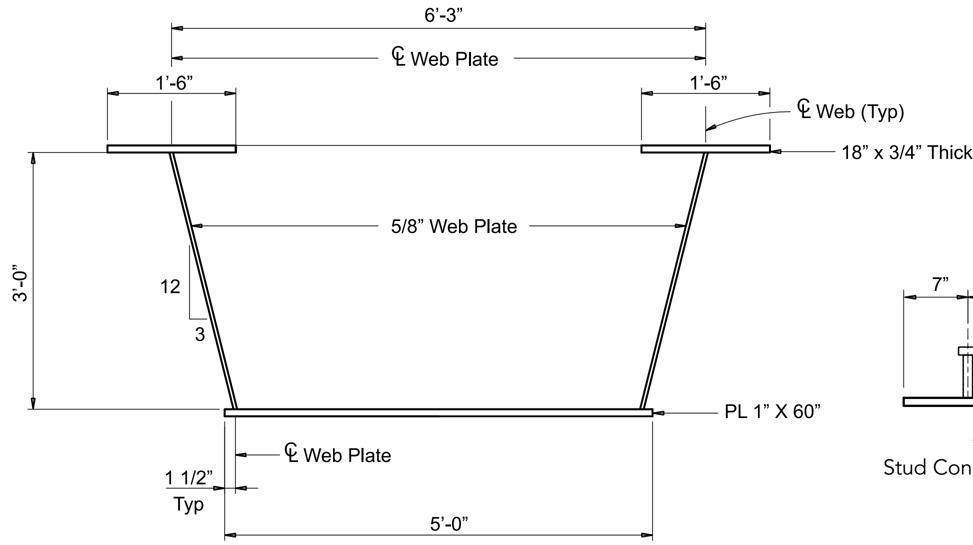


Fig. 1: Typical transverse girder section for 100-ft span.



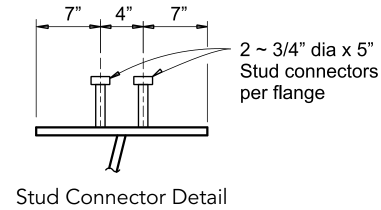


Fig. 2: Typical steel girder section for 100-ft span.

sisting of 36-in. web plates, two 18-in. × ¾-in. top flanges and a 60-in. × ¾-in. bottom flange. The 100-ft span has 36-in. web plates, 18-in. × ¾-in. top flange and 60-in. × 1-in. bottom flange. Figure 2 shows the typical steel girder section for 100-ft span. The girder is designed according to the 2004 AASHTO *LRFD Bridge Design Specifications*. The girder is designed as a compact composite section and is checked for ultimate strength, service stress and deflection. The strength controls the design of the 100-ft span steel girder section.

The maximum span/total depth ratio is approximately 25. The top and bottom flanges of tub girders are designed primarily to carry the girder bending stresses. Top flanges also are subjected to significant lateral bending stresses that were generated by sloping webs and temporary supporting brackets for slab overhangs. In addition, top flanges also are subjected to erection loads, as most contractors lift steel girder sections by clamping to the top flanges.

The design includes three interior cross frames (Diaphragm-Type B) per span. There is an internal K-frame located at 9-ft spacing throughout the span. Figure 3 shows the framing plan with cross frames and diaphragms.

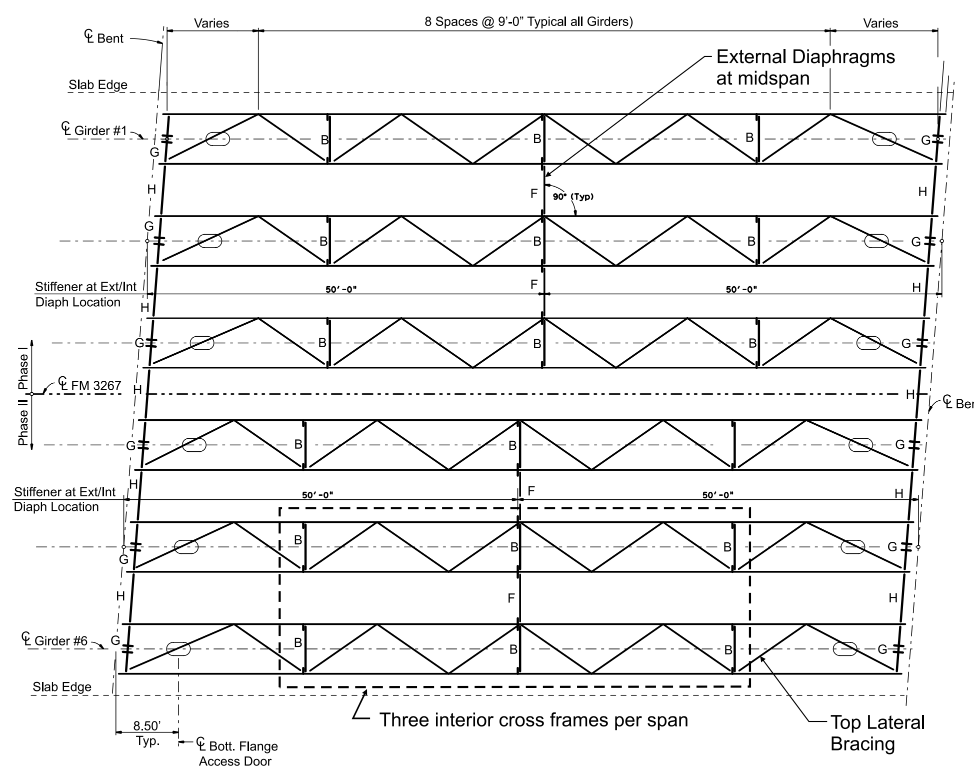


Fig. 3: Framing plan with cross frames and diaphragms.

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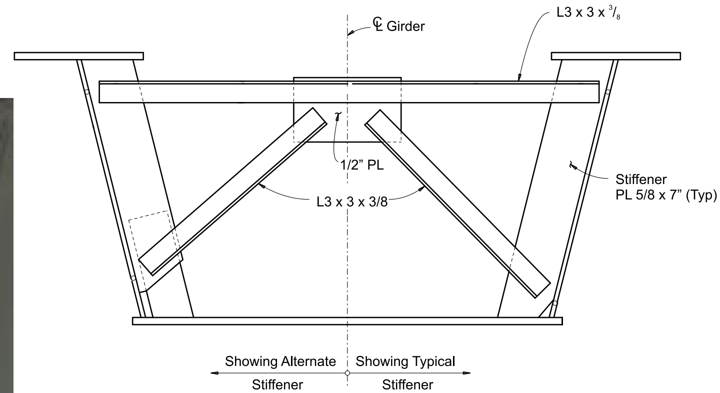


Fig. 4: Interior K-frame details.

Figure 4 shows the interior K-frame details. An external diaphragm with W21×44 at the middle of each span was left for future redecking.

Two types of external bracing are typically used for steel box girders, K-type cross frames and solid diaphragms. Typically solid diaphragms only have been used at support areas, on skewed bridges. The external end diaphragms at the supports have access manholes for future inspection. Figure 5 shows the end diaphragm (Type H). The internal diaphragms at the supports are full-depth plate girder sections. The diaphragms are supported by two bearing stiffeners. The bearing supports provide better torsional resistance and induce less bending stress in the internal diaphragms. Top flange lateral bracing is designed to form the top side of the box girder until the slab is in place. Providing a lateral bracing system increases the torsional stiffness of the tub girders. Figure 6 shows the internal diaphragm (Type G).

The design makes use of ASTM A709 Grade 50W weathering steel, specified for its durable performance with low maintenance costs. The drip tabs and other details are provided to reduce the potential for substructure staining from the weathering steel.

Girder erection and deck placement were accomplished during several nighttime road closures. The steel box girders were erected individually and connected with end diaphragms and cross frames between pairs of stiffeners. The elimination of field splices reduced erection time and minimized traffic disruption. The deck is continuous over the interior piers, providing a jointless, low-maintenance 310-ft-long bridge.

Simple laminated elastomeric bearings are used at the supports. The columns were cast-in place with a formliner to give the appearance of large limestone blocks. Outer columns were designed with tapered width for added aesthetic value. The foun-

Fig. 5: End diaphragm.

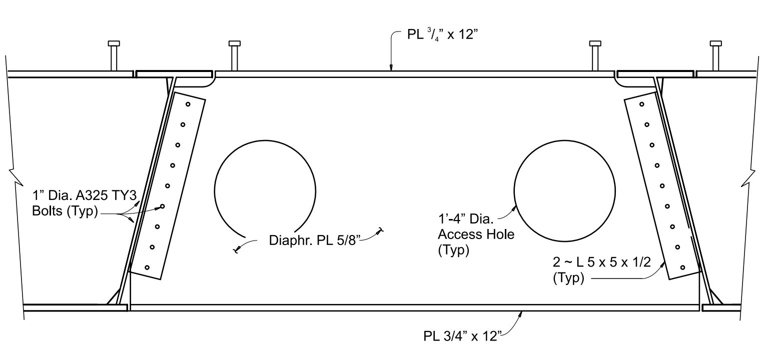
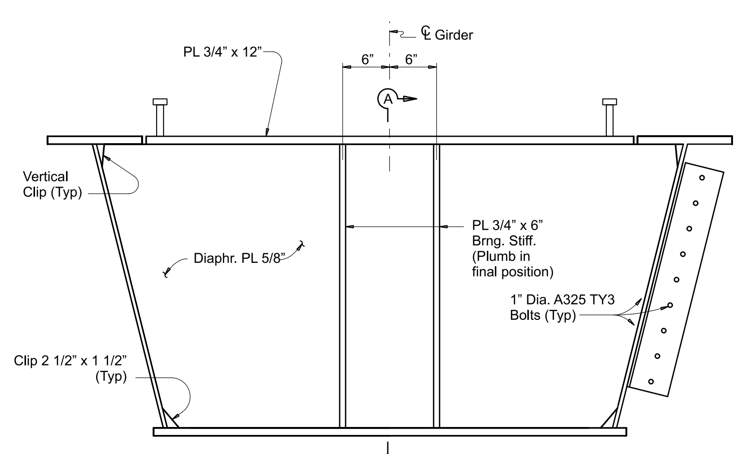


Fig. 6: Internal diaphragm.



Because of the steel box girders' light weight and wide spacing, each could be supported on individual columns, which eliminated the need for a bent cap.

Side elevation of the completed bridge.

dations consist of one 30-in.-diameter drilled shaft at each interior pier and two 30-in.-diameter drilled shafts at the end piers. Due to the wide spacing of girders and the light weight of the steel box girder, each girder was able to be directly supported on individual columns, eliminating the need for a bent cap, which also reduced the construction time.

Choosing weathering steel also reduces future maintenance. Careful detailing of drip rails and stainless steel pans under the bearings prevents staining of the pier elements. The girders were abrasive-blasted to remove mill scale and to provide a uniform weathered appearance. The interior of the girders was shop-coated white to enhance visibility during routine inspections.

The clean lines of the bridge and the contrast between the dark, weathered steel and the white concrete rail and pier elements provide an attractive solution. The rapid construction of the interior bents, without caps, and the shallow steel box girders, without field splices, minimized the construction time and work zone duration. This also provided the necessary span length and satisfied the available superstructure depth limitations.

The FM 3267 bridge was let in June 2006, along with the Old SH 81 bridge in a contract that also contained a steel plate girder bridge along with roadway, drainage and numerous other items typically contained in a large highway project. Construction was essentially complete as of August 2010. MSC

Owner

Texas Department of Transportation

General Contractor

W.W. Webber Inc, Houston

Steel Fabricator

Hirschfeld Industries, San Angelo, Texas (AISC and NSBA Member)