conference preview

INCREASING SPANS AND POSSIBILITIES

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Two bridge projects show what's possible with a long-span I-girder scheme.

THE USE OF STEEL I-girder bridges for spans exceeding 450 ft can be a cost-effective solution in today's market. Two bridge projects, one over the Missouri River and the other over a canal adjacent to the Mississippi River, demonstrate this.

U.S. Highway 34

Efforts to upgrade U.S. Highway 34 as it crosses the Missouri River between Iowa and Nebraska called for a new bridge just south of Omaha. The 3,276-ft-long structure, currently under construction and scheduled to be completed late this year, includes a 1,297-ft-long, three-span main river unit (391 ft, 515 ft and 391 ft) that uses a haunched steel girder with a substringer system. The cross section of the main river unit consists of five haunched steel plate girders spaced at 20 ft, 6 in. with substringers located in the middle of each bay.

With any steel girder bridge design, the engineer is faced with deciding the appropriate level of analysis for final girder design and which analysis will produce acceptable preliminary design sizes. Girder design forces are dependent on a complex behavior of load transfer and geometry in three dimensions. For this project, a 3D finite element model (FEM) was developed for analysis and final design. These results were compared to a preliminary line girder analysis.

The range of applicability of the AASHTO LRFD approximate live load distribution factors is constrained by the original research and development of the approximate equations. The girder and substringer superstructure configuration, which is typically used for long-span structures, would inherently exceed the specification limits for the span length, beam spacing and stiffness criteria.

Until further research is established to substantiate the applicability of the LRFD approximate equations beyond the current limits, a more sophisticated analysis is required. However, the use of the equations for preliminary design and initial girder sizing is of real interest to design engineers. Based on this analysis, the LRFD approximate factors resulted in reasonable correlation to the 3D results for this structural system. While further research would need to be performed to allow use of the LRFD approximate equations in final design of this structure type, the LRFD specifications can be reliably used for preliminary sizing.

The size of the field sections required ready barge access for transport to the project site. With haunched girder web depths up to 24 ft and field sections ranging up to 135 ft long, some sections weighed up to 150 tons. Handling the girders efficiently became the biggest shipping challenge on this project. Laser

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➤ A drop-in segment for U.S. Highway 34.

scanning equipment was used during girder laydown to fabricate customized field splice plates and helped to eliminate fit-up problems during girder erection. In addition, general contractor Jensen Construction built a scale model of the main river unit in its office to help plan their erection sequence.

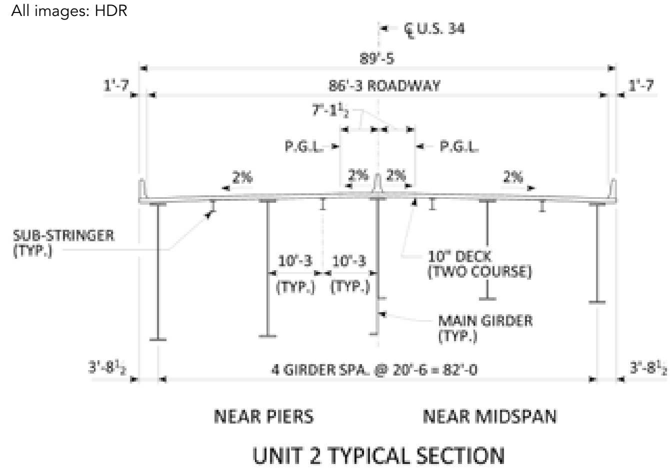
The company used two 300-ton cranes mounted on barges to perform the main span girder erection. The crane limitations were a concern with the size of the field sections. The boom distances combined with load shifting due to listing of the barges pushed the cranes near the load chart limits. However girder erection progressed smoothly and the total duration for steel girder erection of the main river unit was approximately three months.

Owners
Iowa Department of Transportation (Lead)
Nebraska Department of Roads

Structural Engineer
HDR, Omaha

General Contractor
Jensen Construction Co., Des Moines

All images: HDR

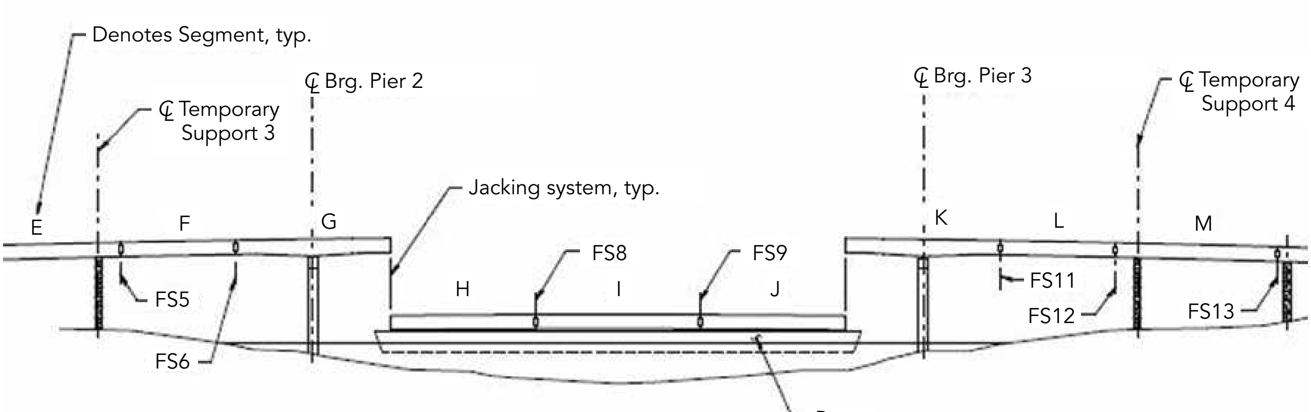


I-270 Bridge

I-270 is a four-lane interstate expressway that serves as a north bypass to St. Louis and carries an average of 54,700 vehicles per day between Illinois and Missouri. This project included the replacement of a pair of truss bridges over the Chain of Rocks Canal adjacent to the Mississippi River, with a single steel I-girder bridge on a new alignment just north of the existing bridges. The Chain of Rocks Canal provides a bypass for all Mississippi River barge traffic in the region and is necessary due to the rock outcrop in the portion of the river in the vicinity of I-270. On average, more than 70 million tons of cargo per year passes through the canal, making it the busiest navigation area on the Mississippi River.

The United States Coast Guard (USCG) required that the bridge provide a 350-ft horizontal navigational clearance and that the 50-ft vertical clearance match what was provided by the existing I-270 bridges. A reduction in the 350 ft horizontal clearance, to 200 ft, was permitted by USCG during construction. These temporary horizontal clearance requirements were considered when determining the main span length of the new bridge. A continuous steel plate-girder bridge was evaluated as the most economical and best in terms of structural redundancy, seismic performance and maintenance and inspection categories.

The new 1,970-ft-long bridge consists of five continuous spans: 250 ft, 440 ft, 490 ft, 440 ft and 350 ft; the span arrangement was dictated by the need to span the canal and adjacent



▲ The center span strand jack lift for I-270.

➤ Storing girders for I-270.

east flood protection levee. The bridge is 94 ft, 2 in. wide and can accommodate a future lane arrangement of six total lanes. It consists of 10 variable depth steel plate I-girders, and given the amount of steel required, the design strived to achieve economy with regard to material, fabrication and construction.

Flange plate thicknesses are repeated throughout the structure as much as possible, in an effort to reduce the number of plate thickness sizes required to be procured by the fabricator. Flange plate transitions were limited to field splices only, except for a flange plate transition on each side of each interior pier. A thicker web is used at the support locations in order limit the number of stiffeners required. Grade 50W and HPS70W steel is used in the structure.

Variable-depth girders are employed to reduce the amount of web material and also to provide appropriate girder depth for the required demands. The web depth transitions at Pier 1 and the girders are haunched at the main canal piers. Straight-line depth transitions are used to simplify the girder fabrication and reduce fabrication costs.

Intermediate and pier cross-frames are an X-type shape, due to girder spacing and girder depth that provide a mostly square shape for the cross frame; WT sections are used for all cross frame members. Based on the 3D finite element method (FEM) analysis, the cross frames are subjected to dead, wind, thermal and live load and seismic

▲ The steel superstructure of I-270 before the last lift.

▼ Girder web depth transition at Pier 1 of the I-270 bridge.

Top flange lateral bracing for the bridge.

demands, as well as forces due to a future part-width deck replacement.

Top flange lateral bracing, consisting of WT sections, is used in the exterior girder bays along the entire length of the bridge and is required while the bridge is being constructed. The top flange lateral bracing prevents excessive lateral movement due to wind at intermediate stages of steel erection and also prior to and during placement of the concrete deck. Additionally, in each span, the steel erection begins with a twin girder system. The top flange lateral bracing adds torsional stiffness and increases global buckling resistance of the initial twin girder systems during steel erection.

Construction began in October 2011. Steel girders started being delivered in July 2012 and were placed at a local storage yard near the project site. Steel erection began on the west side of the bridge, before the completion of Piers 3 and 4 on the east side of the canal; the first girders were set in November 2012. Three separate center span strand jack lifts occurred between mid-October 2013 and early November 2013. Girder lines and cross frames were constructed on a nearby floating barge and then moved into place below the steel superstructure, then strand jacks were used to lift the assembly into place. This method of construction reduced the closure window of the canal to under 24 hours. The new I-270 bridge is expected to open to traffic this summer. ■

Owner

Illinois Department of Transportation

Structural Engineer

HDR, Chicago

Steel Team

Fabricator and Detailer

Stupp Bridge Co. (a division of Stupp Brothers, Inc.) St. Louis (AISC Member/NSBA Member)

Erector/General Contractor

Walsh Construction Co., Chicago (AISC Member/AISC Advanced Certified Steel Erector)

This article serves as a preview of Session B6, "Design of Long-Span Plate Girder Bridges" at the World Steel Bridge Symposium, taking place in tandem with NASCC March 26-28 in Toronto. Learn more about the conference at ***www.aisc.org/nascc****.*