CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-6862: Improved Tub Girder Details

Background

Steel trapezoidal box girders, generally referred to as tub girders, have been widely used on a number of bridges throughout the State of Texas. The smooth profile of the girder systems provides an aesthetically appealing bridge that also possesses several structural advantages compared to other girder types. Due to the significant torsional stiffness of the closed box section, the girders are a popular choice in straight and horizontally curved systems where the bridge geometry leads to large torsional moments.

While tub girders have primarily been used on bridges with longer spans where concrete girders are not viable, an application of relatively shallow steel tub girders was recently used in the TxDOT Waco District on a bridge with span lengths normally reserved for concrete girder systems. The resulting bridge provided an aesthetically appealing structure that satisfied a demanding vertical clearance requirement and was cost-comparable with precast concrete girders. This shallow tub girder application demonstrates that steel trapezoidal box girders offer a viable alternative that should be considered for a wider variety of bridge applications.

However, to augment the viability of tub girders, improved details can further enhance their economic and structural advantages. The objective of this research is to develop improved details for tub girders as well as design methodologies for the girders and bracing components.

What the Researchers Did

The research study focused on changes in the details for the tub girder cross section as well as the bracing configurations and included laboratory experiments and parametric finite element analyses to develop design guidelines. The work was conducted at the Ferguson Structural Engineering Laboratory at the University of Texas at Austin. The following major tasks were completed on this project:

1. Three tub girder specimens were designed and fabricated for carrying out full-scale testing in the laboratory. The specimens consisted of the following: 1) Baseline girder using common details, 2) Tub girder with offset flanges to facilitate improved connections, 3) Tub girder with flatter slope on webs to increase tributary area of girder. Variable bracing was utilized in all girders to study the behavior.
2. 40 experiments were carried out on each of the three girders within the elastic range of behavior. Although the girders were straight, the applied loading included combined bending and torsion to simulate the behavior of horizontally curved girders.
3. A composite concrete slab was cast on the each of the three girders. Two support conditions were used with each girder: 1) 2-span continuous girder, and 2) simply-supported

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girder. The girders were loaded to failure in both the negative and positive moment regions.

4. Laboratory results provided validation data for three-dimensional FEA models.
5. Parametric FEA studies were used considering the range of variables typically found in practice.
6. Guidelines were developed for the design of the girders and bracing systems for general conditions.

What They Found

1. The laboratory experiments and parametric FEA showed that the changes in the geometrical layout doesn't have an adverse effect on the behavior during construction or in the finished bridge and can result in significant improvements in the economy.
2. For straight or mildly-curved tub girders, partial top flange lateral truss bracing often provides a more efficient and economical system with little impact on the girder torsional stiffness. Offsetting the top flanges inward, provides much more room to make connections with the top lateral truss. The designer does need to consider the slenderness of the offset flange to avoid issues with local flange buckling.
3. Although internal K-frames are often provided at every panel point for the top lateral truss, the research team recommends a spacing of at least every 2 panel points. Test results and the parametric FEA studies demonstrated that the spacing between the internal K-frames can be increased with no significant impact on the girder behavior.
4. When partial top flange lateral bracing is utilized, the bracing forces do increase, but these forces can be accounted for during the design.
5. Provided that a partial or full top flange lateral truss is utilized, the use of flatter sloped webs did result in a significant change in the behavior of the girders. The use of a flatter web slope can lead to tub girders with a larger cover width and may result in the elimination of a girder line.
6. Changes in the tub girder geometry or bracing layout did not have any discernable impact on the ultimate strength of the composite girders.

What This Means

Improved economy and efficiency can be achieved in steel tub girder systems with changes in the detailing methods for both the girders and the bracing. The primary stage when the bracing is needed is during shipping, erection, and construction. Minimizing the bracing provided can result in significant savings in the cost of steel tub girder bridges. Improving the economy and efficiency of steel tub girders may make the girders a viable alternative for shorter span or shallow girder applications that are often dominated by other bridge types.

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