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RESEARCH
SERVICES SECTION

TECHNICAL SUMMARY

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PROJECT COST:
$219,823

Researchers load-tested this bridge and found that the old methods for determining its carrying capacity underestimated the stresses actually measured.

Load Rating of Composite Steel Curved I-Girder Bridges Through Load Testing with Heavy Trucks

What Was the Need?

Effectively evaluating a bridge requires accurately calculating its load rating: How much can the bridge carry, and how will it behave as its load limit is approached? The methodology for calculating a load limit depends upon the particular materials and design of the bridge. For the past 40 years, the method for calculating the load rating of a composite steel curved I-girder bridge has used a model that was developed for bridges with straight I-girders, with some parameters modified to account for the differences presented by the curved girders. With improved technology and changing traffic patterns, this method was due for an update.

What Was Our Goal?

The objective of this study was to help ensure the full and safe utilization of composite steel curved I-girder bridges by developing and testing a new methodology for determining load ratings that is better tuned to the specific characteristics of this type of bridge.

What Did We Do?

Researchers first conducted a literature search and held meetings to devise a methodology for load testing an existing bridge with heavy trucks to improve the accuracy of calculated load ratings.

Researchers then instrumented an off-ramp connecting Trunk Highway 35 southbound with TH 535 southbound near Duluth with 12 displacement devices and 128 strain gages. They used eight quad-axle dump trucks (with an average gross vehicle weight of 72,000 pounds) to perform 43 static tests with varied configurations of trucks, and 13 dynamic tests in which the trucks moved at a constant speed, a constant speed over a wooden two-by-four, and a constant speed followed by braking. During these tests, sensors captured girder, diaphragm and lateral bracing strains and stresses; vertical and rotational girder displacements; and actual girder and diaphragm stiffness.

Using both custom and commercially available analysis software, researchers compared the results of these field tests with the load-rating predictions generated by a model called the grillage method, which expresses the structural elements of the bridge as a network of skeletal members rigidly connected to one another at nodes.

They then identified parameters that could be used to properly tune the modeled stresses in the bridge to match the measured ones, using data from two additional bridges to extend the applicability of the study. Parameters studied included the effects of lateral wind bracing, properties of the girder cross section, and the relative contribution of concrete and rebar to the stiffness and stress calculations.

What Did We Learn?

Load testing showed that the load distribution on curved I-girder bridges is significantly different for the differently curved spans. Analysis of the static tests indicated that the load distribution between the girders depends strongly on the location of the load. The girder on the interior of the curve supports 45 percent of a centered load, 66 percent of a load offset toward the interior and 23 percent of a load offset toward the exterior girder. These load distribution values also change along the length of the bridge.

continued

"This was an interesting project that provided valuable information on a complex analysis that can be used for future overweight permitting."

–Edward Lutgen,
Bridge Rating Engineer, Mn/DOT Office of Bridges and Structures

"This test is important because we put some of the highest stresses ever on a curved I-girder bridge. It is exceptional that Mn/DOT supported it. They showed a lot of leadership."

–Jerome Hajjar,
Professor, University of Illinois at Urbana-Champaign Department of Civil and Environmental Engineering (formerly University of Minnesota)

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Lateral wind bracing, provided by the crossed steel ties shown above, was an important component to include in the model of the bridge in order to properly reproduce the measured stresses.

Researchers found that composite action of the bridge components should be included in the stiffness and stress calculation, that the inclusion of lateral wind bracing is critical for accurate results, and that the dynamic impact factors obtained from the load testing were similar to those specified by AASHTO design guidelines.

They found that the measured bending stresses compared well with the models, while the measured restraint stresses were well-correlated in magnitude, but were in less overall agreement. They recommended appropriate values for parameters in the grillage model such as effective width and modular ratio whose values differ from the original design values, but more accurately account for the measured stiffness of the bridge.

The calibrated grillage analysis yielded a load factor rating of 0.73, a more conservative result than the 0.81 rating computed using the older methodology. One of the primary reasons for this difference is that the older method does not accurately model the load distribution between the girders: Stresses measured in this test were larger than expected.

What's Next?

This study produced recommended procedures for future load rating of I-girder bridges, both procedures incorporating load testing with heavy trucks and those not involving load testing. More analysis is needed to further refine and generalize these new analysis methods. A national project is under way on construction engineering of curved I-girder bridges that promises to further inform Mn/DOT's specifications in this area.

This Technical Summary pertains to Report 2006-40, "Load Rating of Composite Steel Curved I-Girder Bridges Through Load Testing with Heavy Trucks," published October 2006. The full report can be accessed at http://www.lrrb.org/PDF/200640.pdf*. For more information on the national study mentioned, please contact investigator Don White at* don.white@ce.gatech.edu.