Texas A&M Transportation Institute

# PROJECT SUMMARY

Texas Department of Transportation

# 0-6955: Development of a Strategy to Address Load-Posted Bridges through Reduction in Uncertainty in Load Ratings

## Background

Bridges posted for load can cause various issues for the traveling public that use them and the entities that manage them. Therefore, it is desirable for the Texas Department of Transportation (TxDOT) to have as few load-posted bridges in their inventory as possible. Current American Association of State Highway and Transportation Officials (AASHTO) specifications and manuals provide minimum requirements and procedures to estimate bridge behavior. However, the specifications use simplified methods intended to provide a conservative analysis that may not represent the actual demand and capacity of the bridge. This project took an in-depth look at the analysis methods for load rating bridges to identify approaches to increase posted load levels or remove postings by reducing uncertainty for typical posted bridges in Texas.

## What the Researchers Did

Researchers examined the inventory of load-posted bridges in Texas and determined that four major bridge types comprised the majority of posted bridges: simple-span steel multi-girder bridges, continuous steel multi-girder bridges, concrete multi-girder bridges, and concrete slab bridges. Researchers used a representative number of bridges selected within each group to conduct a basic load rating analysis. In this analysis, each bridge was analyzed under the current load rating procedures laid out in the AASHTO *Manual for Bridge Evaluation* (MBE). The results of this analysis were used to identify potential areas of opportunity through which load ratings could be increased, and four bridges, one from each group, were selected to be examined in depth. First, finite element method (FEM) models of these four bridges were developed. The models were examined under different loading scenarios, and refined live load distribution information was obtained from the FEM analysis. Next, an extensive load test was conducted on each bridge. The bridges were instrumented to obtain strain, displacement, and vibration data under a known dump truck loading at specific locations. The experimental results were analyzed to obtain information about live load distribution, partial composite action, end restraint, curb participation, and other characteristics relevant to load rating. All the information obtained throughout the project was compiled and conclusions pertaining to the potential areas of opportunity to improve load ratings were developed. Recommendations were provided to TxDOT to consider when performing refined load rating analysis.

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## What They Found

Researchers found the following:

- *Partial Composite Action in Steel Girder Bridges:* The simple-span steel multi-girder bridge that was load tested had girder top flanges embedded into the concrete deck with no shear studs. This bridge was found to behave as nearly fully composite under live load. The continuous steel multi-girder bridge did not have girder flange embedment, but it exhibited signs of significant partial composite action under live load. Approaches to evaluate composite action have been discussed in the recommendations to TxDOT.
- *Live Load Distribution:* The examined steel multi-girder bridges and the concrete multi-girder bridge exhibited live load distribution that was well represented by the AASHTO Standard Specifications. The AASHTO Load and Resistance Factor Design Specifications produced overly conservative live load distribution factors for almost all load cases. The concrete slab bridge included integral curbs that participated in resisting the live load. The curb participation is represented well by the equations developed in Illinois Bulletin 346 (IB346), currently used by TxDOT to load rate this bridge type. However, IB346 was found to be unconservative for estimating the moment demands in the slab region of the tested bridge.
- *End Restraint:* The three load-tested simple-span bridges were examined to determine if partial end restraint is present at the supports. All three bridges exhibited some amount of restraint at the supports, and this led to a slight reduction in the maximum applied moment at the bridge midspan.
- *Refined Analysis Models:* The FEM models of the selected bridges accurately represented the live load distribution observed in the field. Developing a refined FEM model of a load-posted bridge could provide a more accurate representation of the live load and lead to some reduction in conservatism.
- *Material Properties:* The observed concrete compressive strengths in the bridges were generally significantly higher than the strengths prescribed by the MBE. For concrete bridges, a higher concrete compressive strength can provide a slight increase in the flexural capacity. However, more accurate information confirming a higher reinforcing steel yield strength would likely lead to a greater increase. Steel girders exhibiting composite action can gain a slight increase in capacity with a higher deck concrete strength.

## What This Means

Multiple areas in which load ratings may be increased have been identified and verified. The developed recommendations provide refined methods, based on additional bridge-specific information, allowing less conservatism than the basic load rating approaches currently suggested in the AASHTO MBE. For a significant number of bridges, particularly steel multi-girder bridges, it could be possible for TxDOT to increase load ratings or even remove postings. This can ease the economic burden of these bridges on the public, and the management burden these bridges cause for TxDOT and other agencies that oversee them.

### For More Information

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