CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-6719: Strengthening Continuous Steel Girders with Post-Installed Shear Connectors

Background

A number of older bridges in Texas were constructed with floor systems consisting of a non-composite concrete slab over steel girders. Many of these bridges were designed in the 1950s and 1960s based on smaller loads than the standard design loads currently used for new bridges. The inadequate strength of these bridges can result in the need to limit truck loads on the bridge through load posting or may require replacement of the bridge. Alternatively, strengthening measures can be undertaken to increase the load rating of the bridge.

A potentially economical means of strengthening these floor systems is to connect the existing concrete slab and steel girders to permit the development of composite action. Composite action permits the existing steel girder and concrete slab to act together more efficiently than in the original non-composite condition. The concept of strengthening existing non-composite bridges by the use of post-installed shear connectors was demonstrated in Texas Department of Transportation Research Project 0-4124 (completed in 2007) and in Implementation Project 5-4124 (completed in 2009) for simple span bridges.

The overall objective of Project 0-6719 was to extend the concepts developed in Project 0-4124 to permit the use of post-installed shear connectors to strengthen continuous multi-span non-composite bridges with inadequate capacity in both negative and positive moment regions.

What the Researchers Did

The main goal of this research project was to develop procedures to strengthen continuous non-composite steel girder bridges using post-installed shear connectors and inelastic moment redistribution. To accomplish this objective, both experimental and analytic work was conducted at the Ferguson Structural Engineering Laboratory at The University of Texas at Austin. The following major tasks were completed in this project:

1. A survey was completed of continuous non-composite steel girder bridges in Texas to determine typical characteristics of bridges that may be candidates for strengthening in the proposed manner.
2. Strengthening design concept studies were completed for typical Texas bridges.
3. Additional fatigue testing was conducted on adhesive anchor post-installed shear connectors as recommended by Project 0-4124 to develop improved fatigue life predictions.

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4. Large-scale laboratory tests were conducted on two-span continuous girders strengthened with post-installed shear connectors to study the structural performance of the system. This included fatigue testing, shakedown testing, and ultimate strength testing.
5. Parametric studies were conducted to evaluate various post-installed shear connector configurations.
6. Design recommendations were developed for strengthening continuous non-composite bridges with post-installed shear connectors.

What They Found

Significant strength gains can be achieved by post-installing shear connectors and allowing for moment redistribution in continuous bridges. Increases of more than 60 percent in the load rating of bridges from the survey of Texas bridges were attained by strengthening to a composite ratio of only 30 percent. Most of the bridges in the survey require a composite ratio of 30 percent and minimal to no moment redistribution to reach a load-carrying capacity exceeding that required by current design standards.

Adhesive anchor shear connectors have improved fatigue performance over conventional welded studs. This allows for partially composite design to be used in the strengthening process because the fatigue limit state is not likely to control the number of connectors required. Strengthened bridge girders exhibited excellent and resilient structural performance under service, fatigue, and strength limit states.

Interface slip should be considered when determining the force demand on shear connectors in a partially composite girder. The slip reduces the loads required to be transferred by the shear connection, oftentimes to a very large extent. This can be done analytically using the spreadsheet-based calculation method described in the project report or computationally using simple three-dimensional models.

Concentrating the post-installed shear connectors in groups near points of low moment demand increases the ductility and performance of the partially composite girder at strength limit states.

What This Means

Many existing non-composite steel girder bridges in Texas have a significantly lower load-carrying capacity than is required by current design standards. Strengthening continuous non-composite steel girder bridges with post-installed shear connectors and moment redistribution is a feasible and efficient method of extending the useful service life of a bridge. For typical Texas bridges, the load rating can be increased by 60 percent or more by post-installing a relatively small number of shear connectors. The recommended procedure for design of a strengthening system using post-installed shear connectors is straightforward, and a design example is included in the project report.

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