CENTER FOR TRANSPORTATION RESEARCH

PROJECT SUMMARY

Texas Department of Transportation

0-7042: Use of Larger-Diameter Shear Studs for Composite Steel Bridges

Background

Composite steel bridge girders are typically constructed using 7/8″ diameter shear studs. A large number of shear studs is typically needed to satisfy AASHTO fatigue and ultimate strength requirements. Using a larger-diameter shear stud can significantly reduce the required number of shear studs which in turn can improve construction worker safety, expedite the girder fabrication process, and facilitate the use of partial depth precast concrete deck panels (PCPs). The overall objective of this research project was to evaluate the feasibility of shear stud diameters greater than 7/8″ for composite steel bridge construction. Shear stud diameters of 1-1/8″ and 1-1/4″ were considered in this study.

What the Researchers Did

The research included preliminary design studies to quantify the reduction in the number of shear studs that can be achieved with larger-diameter shear studs. This was followed by an extensive investigation of stud welding, followed by push-out tests to evaluate the static and fatigue performance of larger-diameter shear studs. Parametric finite element studies were conducted to extend information developed in the static push-out test program. Two large-scale composite beams were constructed in the laboratory and tested to failure to evaluate the performance of bridge girders constructed using larger-diameter shear studs. Finally, based on all previous tasks, the research team developed design recommendations.

What They Found

Preliminary Design Studies

The reduction in the number of shear studs was found to be significant when larger-diameter shear studs are used. Compared to 7/8″ shear studs, the reduction in the number of studs was found to be on the order of 40%, and 50% for 1-1/8″ and 1-1/4″ diameter shear studs.

Stud Welding Investigations

It was found that larger-diameter shear studs can be welded with consistent good quality using commercially available stud welding equipment. However, the welding of 1-1/4″ studs was quite sensitive to the selected welding parameters and base metal conditions, and conducting a bend test on 1-1/4″ studs was much more difficult than for 1-1/8″ studs. Based on the results of the stud welding investigations, the decision was made to proceed with the use of 1-1/8″ studs for the remainder of this research project.

Static Push-Out Tests

The results of the push-out tests showed excellent performance of 1-1/8″ shear studs. The ultimate strength of 1-1/8″ shear studs in all tests exceeded

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the stud ultimate strength requirements of both the 9th Ed. AASHTO LRFD Bridge Design Specifications and the proposed 10th Ed. AASHTO LRFD Bridge Design Specifications. For decks with PCPs, the ultimate strength of both 7/8″ and 1-1/8″ shear studs was less than the corresponding specimens constructed with full-depth CIP decks.

Fatigue Pish-Out Tests

All specimens exhibited fatigue lives that exceeded the requirements of both the 9th Ed. AASHTO and the proposed 10th Ed. AASHTO S-N curves.

Finite Element Studies

A focus of these studies was the behavior of 7/8″ and 1-1/8″ studs in bridge decks constructed using PCPs. Based on these studies, recommendations were developed for minimum penetration distance of the stud into the bridge deck and minimum clear distance between the stud and the PCP needed to achieve stud strength that satisfies the 9th Ed. AASHTO and the proposed 10th Ed. AASHTO.

Large-Scale Beam Tests

The large-scale beam tests showed satisfactory strength and ductility of 1-1/8″ shear studs.

Design Recommendations

Recommendations were developed for welding of 1-1/8″ studs, and for the design of 1-1/8″ studs for static and fatigue loading.

What This Means

The results of this research project have shown that 1-1/8″ shear studs can be safely used in composite steel bridges in Texas. The use of 1-1/8″ studs, compared to conventional 7/8″ studs, can significantly reduce the number of shear studs on a steel girder, thereby enhancing safety during construction and facilitating the use of partial depth precast concrete panels in the decks of steel girder bridges.

For More Information

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