Project Summary
Texas Department of Transportation

0-4124: Methods to Develop Composite Action in Non-Composite Bridge Floor Systems

Background

A number of older bridges in Texas are constructed with floor systems consisting of a non-composite concrete slab over steel girders. 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 to work together in a far more efficient manner than possible in the original non-composite condition.

To achieve the benefits of composite action, the existing steel girder must be connected to the existing concrete slab so as to permit the transfer of shear forces at the steel-concrete interface. For new bridges, composite action is achieved by welding shear studs to the top of the steel girder prior to casting the concrete slab. In the case of an existing bridge, this approach is not possible, since the slab is already in place. Consequently, to take advantage of composite action in existing bridges, economical and practical methods for post-installing shear connectors are needed. The objective of this study was to identify structurally efficient and practical ways to post-install shear connectors in existing bridges, and to develop data and methods for design of a girder strengthening system using post-installed shear connectors.

What the Researchers Did

A variety of concepts for post-installing shear connectors in bridges were developed in this project. An extensive series of tests on individual shear connectors were conducted under static, high-cycle fatigue, and low-cycle fatigue loads to identify connectors with the most advantageous structural performance characteristics. Based on the results of the single-connector tests, full-scale beam tests were performed to evaluate system performance of beams retrofitted for composite action with post-installed shear connectors. Information from the tests was used to develop a design approach for post-installed shear connectors.

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What They Found

The results of this study clearly demonstrate that the strength and stiffness of existing non-composite steel bridge girders can be increased significantly by post-installing shear connectors. The addition of post-installed shear connectors can increase the load capacity of existing steel girders on the order of 40 to 50 percent.

Of the various types of post-installed shear connectors investigated in this study, the most promising, from a structural performance and constructability point of view, are the: (1) double-nut bolt; (2) adhesive anchor; and (3) high-tension friction grip bolt. These connectors consist of high-strength bolts or threaded rods placed in holes that are drilled in the concrete slab and top flange of the steel girder. The holes are filled with high-strength grout (double-nut bolt and high-tension friction grip bolt) or structural adhesive (adhesive anchor). Installation of the double-nut bolt and high-tension friction grip bolt require construction operations on both the top and bottom sides of the concrete slab. The adhesive anchor, on the other hand, can be completely installed from underneath the slab, thereby minimizing traffic disruptions on the bridge. Tests on these post-installed shear connectors show they have static strength values similar to or greater than conventional welded shear studs, and significantly better fatigue performance. The outstanding fatigue performance of the post-installed shear connectors is attributed, in large part, to the fact that no welding is involved in their installation.

The approach developed in this project for determining the number of post-installed shear connectors needed to strengthen an existing bridge girder relies on the concept of *partial* composite design. Partial composite design is not normally used for new composite bridge girders, because fatigue typically controls the required number of shear connectors. However, because of the outstanding fatigue characteristics of the post-installed shear connectors, fatigue is not likely to control the required number of shear connectors, thereby enabling partial composite design. With partial composite design, 50 to 70 percent of the shear connectors normally needed for full composite design can be eliminated, while still achieving a 40 to 50 percent increase in load-carrying capacity in positive moment regions of a girder.

What This Means

The techniques, data, and design approach developed in this project can be used to increase the load capacity of existing non-composite steel girders by post-installing shear connectors. In positive moment regions, strength increases of 40 to 50 percent can be achieved with a relatively small number of shear connectors. Results of the research provide information needed to implement this strengthening technique, including recommendations for design, materials selection, and installation techniques.

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