Strengthening Existing Non-Composite Steel Girder Bridges by the Use of Post-Installed Shear Connectors

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Summary

This paper presents the results of a study examining ways to strengthen existing non-composite steel bridge girders using post-installed shear connectors. Five full-scale beams were tested to evaluate structural performance of composite beams retrofitted with post-installed shear connectors. Results of the study indicate that the addition of a relatively small number of post-installed shear connectors can increase the load capacity of non-composite girders by a factor greater than 1.5. Based on the results of this study, a design approach based on partial composite action was developed for strengthening existing steel bridge girders by using post-installed shear connectors.

Keywords: Post-installed shear connector, retrofit, partially composite, anchor.

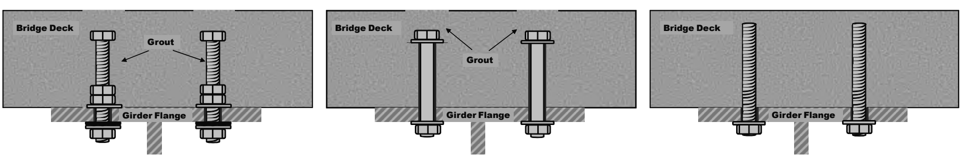
1. Introduction

A number of older bridges 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 use post-installed shear connectors to permit the development of composite action.

In this study, tests were conducted on full-scale non-composite beams that had been retrofitted using three types of post-installed shear connectors. The number of shear connectors added to the girders was based on the development of partial composite action. This paper summarizes the retrofitting strategies and the results of the test program.

2. Test Program

Three types of post-installed shear connectors were selected for full-scale beam tests. The shear connectors are shown in Fig. 1 along with their designations. Design equations to predict the ultimate static strength and fatigue strength of these shear connectors were proposed by Kayir (2006) and Kwon (2008).



a) Double Nut Bolt (DBLNB) *b) High-Tension Friction-Grip Bolt (HTFGB)* *c) Adhesive Anchor (HASAA)*

Fig 1. Post-installed shear connectors

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Fig. 2: Test setup

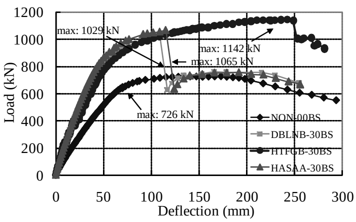

Fig. 3: Load-deflection curves for test specimens

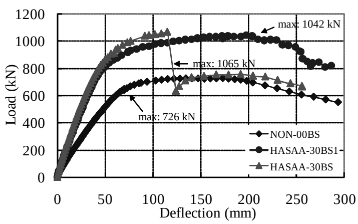

Fig. 4: Test result of Specimen HASAA-30BS1

Four full-scale partially composite beams retrofitted with the three selected post-installed shear connectors were constructed and tested under static loading. One non-composite beam was also tested as a baseline. The designation used for each specimen starts with the connection method. It is followed by the shear connection ratio in percent. “BS” stands for Beam Static test.

Non-Composite Beam (NON-00BS): The non-composite steel girder and concrete slab beam specimen, which simulates an existing bridge girder, is a simply supported beam with a span of 11.6-m. A W30x99 section was used for the steel beam; the concrete slab was 2130-mm wide and 178-mm deep (See Fig. 2).

Partially Composite Beam Specimens: The four partially composite beam specimens were each designed with a 30-percent shear connection ratio. Thirty-two shear connectors were installed in each specimen.

3. Test Results

Load vs. midspan deflection curves for Specimens NON-00BS, DBLNB-30BS, HTFGB-30BS, and HASAA-30BS are shown in Fig. 3. The partially composite beam specimens shown in Fig. 3 have uniformly distributed shear connectors along the span. The retrofitted partially composite beam specimens showed much higher stiffness and strength compared to the non-composite beam. For Specimens DBLNB-30BS and HASAA-30BS, however, a sudden strength drop was observed at around 120-mm deflection due to the nearly simultaneous failure of multiple shear connectors.

Finite element analysis by Kwon (2008) showed that moving the shear connectors near the zero moment regions can reduce slip at the steel-concrete interface at maximum moment. Specimen HASAA-30BS1 was tested to verify the FE analysis results and evaluate the system behaviour of partially composite beams with post-installed shear connectors concentrated near the zero moment regions. Specimen HASAA-30BS1 had the same number of shear connectors as Specimen HASAA-30BS, but with the connectors moved closer to the supports. Figure 4 shows test results of Specimen HASAA-30BS1. The deformation capacity of the specimen was improved significantly and is comparable to that of Specimen NON-00BS.

4. Summary

In this study, five full-scale beams were tested under static loading to evaluate the structural behavior of existing non-composite beams retrofitted with post-installed shear connectors. From the test results of this study and shear connector tests conducted in previous research, it is concluded that strengthening existing non-composite bridge girders using post-installed shear connectors can be an effective alternative to replacement of the bridges. Design recommendations for retrofitting existing steel girder bridges using post-installed shear connectors are also available in Kwon (2008).

5. Reference

Kayir, H. (2006). “Methods to Develop Composite Action in Non-Composite Bridge Floor Systems: Fatigue Behavior of Post-Installed Shear Connectors.” *MS Thesis*, Univ. of Texas at Austin.

Kwon, G. (2008). “Strengthening Existing Steel Girder Bridges by the use of Post-Installed Shear Connectors.” *PhD Dissertation*, Univ. of Texas at Austin (expected completion in August 2008).