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Retrofit Methods for Distortion Cracking Problems in Plate Girder Bridges

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8. ABSTRACT

This report is formatted to independently present four individual investigations related to similar web gap fatigue problems. Multiple steel girder bridges commonly exhibit fatigue cracking due to out-of-plane displacement of the web near the diaphragm connections. This fatigue-prone web gap area is typically located in negative moment regions of the girders where the diaphragm stiffener is not attached to the top flange. In the past, the Iowa Department of Transportation has attempted to stop fatigue crack propagation in these steel girder bridges by drilling holes at the crack tips. Other nondestructive retrofits have been tried; in a particular case on a two-girder bridge with floor beams, angles were bolted between the stiffener and top flange. The bolted angle retrofit has failed in the past and may not be a viable solution for diaphragm bridges. The drilled hole retrofit is often only a temporary solution, so a more permanent and effective retrofit is required. A new field retrofit has been developed that involves loosening the bolts in the connection between the diaphragm and the girders. Research on the retrofit has been initiated; however, no long-term studies of the effects of bolt loosening have been performed.

The intent of this research is to study the short-term effects of the bolt loosening retrofit on I-beam and channel diaphragm bridges. The research also addressed the development of a continuous remote monitoring system to investigate the bolt loosening retrofit on an X-type diaphragm bridge over a number of months, ensuring that the measured strain and displacement reductions are not affected by time and continuous traffic loading on the bridge.

The testing for the first three investigations is based on instrumentation of web gaps in a negative moment region on Iowa Department of Transportation bridges with I-beam, channel, and X-type diaphragms. One bridge of each type was instrumented with strain gages and deflection transducers. Field tests, using loaded trucks of known weight and configuration, were conducted on the bridges with the bolts in the tight condition and after implementing the bolt loosening retrofit to measure the effects of loosening the diaphragm bolts. Long-term data were also collected on the X-diaphragm bridge by a data acquisition system that collected the data continuously under ambient truck loading. The collected data were retrievable by an off-site modem connection to the remote data acquisition system. The data collection features and ruggedness of this system for remote bridge monitoring make it viable as a pilot system for future monitoring projects in Iowa.

Results indicate that loosening the diaphragm bolts reduces strain and out-of-plane displacement in the web gap, and that the reduction is not affected over time by traffic or environmental loading on the bridge. Reducing the strain in the web gap allows the bridge to support more cycles of loading before experiencing fatigue, thus increase the service life of the bridge.

Two-girder floor beam bridges may also exhibit fatigue cracking in girder webs. The fourth investigation describes a bridge that was retrofitted with bolted angles at the connection between the top flange and the web stiffener. The retrofit failed and was repaired. A short-term load test was completed to determine the behavior and effectiveness of the repaired retrofit. Testing indicated large displacements, and data suggest the retrofit was ineffective. The study concluded that the bridge should be inspected frequently for signs of failure in the retrofit and cracking in the web.

9. KEY WORDS
Diaphragm bolt, Distortion cracking,
Retrofit method, Steel girder bridge, Web gap fatigue

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