Kansas Department of Transportation

TECHNICAL SUMMARY

Improving Infrastructure Sustainability 1: Extending Useable Lives of Steel Bridges by Halting Distortion-Induced Fatigue Crack Propagation Using Pretensioned Bolts and Plate Washers

Report Number: K-TRAN: KU-11-3 ▪ Publication Date: January 2016

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Introduction

Drilling crack-arrest holes to halt fatigue crack propagation is a simple technique that is commonly used by bridge owners controlling and/or repairing fatigue cracking in steel bridges. Well-established relationships exist for sizing the diameter of the crack-arrest holes for in-plane fatigue loading; however, the effectiveness of crack-arrest holes under out-of-plane (distortion-induced) fatigue is not well understood.

Distortion-induced fatigue cracking is much more common in steel bridge infrastructure than in-plane fatigue cracking, and bridge owners often utilize drilled crack-arrest holes in these cases as a "first response" against fatigue cracks discovered during inspections. The purpose of the crack-arrest hole is to smooth out the sharp crack tip, reducing the stress concentration and halting/delaying crack propagation. Common knowledge has been that large diameter crack-arrest holes are more effective at halting crack propagation under distortion-induced fatigue than small diameter crack-arrest holes. However, drilling large diameter crack-arrest holes can have strength implications for a structure, and may not be desirable. Additionally, there is little evidence in the literature that large diameter crack-arrest holes perform better than small diameter crack-arrest holes under distortion-induced fatigue.

Project Description

A study examining the effectiveness of crack-arrest holes of varying diameters under distortion-induced fatigue loading was performed. The investigation was comprised of both experimental and analytical components. The experimental study was performed on segments of plate girder loaded under distortion-induced fatigue. Crack-arrest holes of various diameters were drilled at the tips of the cracks of different lengths, and their effectiveness was evaluated. A suite of three-dimensional, solid-element finite element analyses was also used to parametrically vary crack-arrest hole diameter, placement, and crack length. The study also included an analytical examination of using pretensioned bolts and plate washers in a crack-arrest hole. Limited effectiveness was noted for this technique, so the majority of the research focused on appropriate crack-arrest hole sizing and placement.

Project Results

The findings from the experimental and analytical components of this study were compared against common industry practices. The results show that crack-arrest hole placement, rather than hole diameter, has a much greater effect on the effectiveness of the crack-arrest hole in bridge girders susceptible to distortion-induced fatigue.

Project Information

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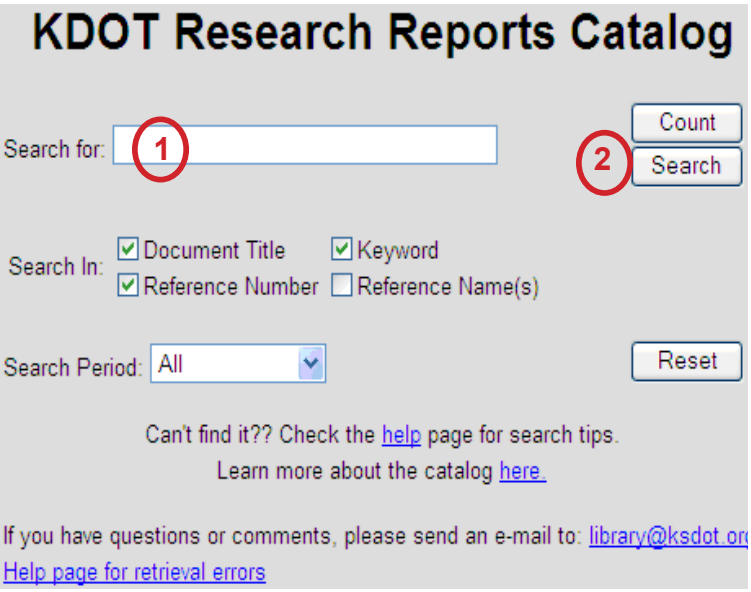

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