Kansas Department of Transportation

TECHNICAL SUMMARY

Computationally Informed Methodologies for Capturing the Effect of Intervening Structures During Truck Impact Events: Phase II

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Introduction

Reinforced concrete (RC) barriers are often used as railings to protect bridge piers against vehicular collision force (VCF). RC barriers absorb collision energy and/or redirect vehicles. According to bridge design specifications of the American Association of State Highway and Transportation Officials (AASHTO), barriers used to protect bridge piers should have a minimum height of 42 in. and survive MASH Test Level 5 (TL-5). Although many barriers in current use do not meet this requirement, these sub-standard barriers can reduce the severity of vehicle-pier collisions and decrease the AASHTO-specified VCF for pier resistance in upgraded bridges.

The primary objective of this research was to assess the performance of sub-standard RC barriers as protection for bridge piers against VCF and quantify their reduction of the equivalent static force (ESF) that piers must resist according to AASHTO specifications. This report describes current procedures to determine the transverse static capacity of RC barriers and proposes alternative, accurate methodologies. A matrix of crash scenarios is simulated in dynamic explicit analysis using the finite element software LS-DYNA to comprehensively encapsulate the behavior of sub-standard RC barriers. The investigated parameters include energy dissipation, velocity reduction, contact force absorption, and lateral displacement. This research also utilized a simulation matrix on a bridge pier that failed to withstand the ESF under the required AASHTO's extreme load event behind a sub-standard barrier. A series of dynamic impact force time histories was used to extract the ESF and compare the resulting ESF to the AASHTO-required force, leading to a proposed reduction in the ESF due to the presence of sub-standard RC barriers.

Project Description

The aim of this research was to assess the performance of sub-standard RC barriers as protective structures for bridge piers against VCF and to quantify their reduction of required ESF resistance per current AASHTO specifications. This study established the following objectives:

1. Develop rigorous analysis and innovative methodology to evaluate the transverse structural capacity of RC barriers.
2. Assess the performance of sub-standard RC barriers as protective structures for bridge piers against VCF.
3. Estimate the VCF on bridge piers with sub-standard intervening RC barriers.

Project Results

The aim of this research was to assess the performance of sub-standard RC barriers as protection for bridge piers against VCF and quantify their reduction of the ESF that piers must resist. Several objectives were established for this research. The first objective was to explore current methodologies to obtain the lateral capacity of RC barriers and propose accurate methods to predict the actual transverse capacity of RC barriers. Subsequent investigation showed that the current AASHTO procedure of YLA significantly underestimates the transverse capacity of RC barriers. This study also developed a detailed YLA procedure and a truss technique as alternative methodologies for estimating the transverse capacity of RC barriers. A case study of a sub-standard barrier was analyzed using these methods and verified against FEA using Abaqus. Results showed agreement between the FEA and the proposed methods, and the AASHTO YLA was shown to underestimate the capacity of the sub-standard barrier by approximately 50%.

The second objective of this study was to assess the performance of sub-standard barriers as bridge pier protection to comprehensively understand barrier behavior during high TL crash events (TL-4 and TL-5). An extensive and detailed simulation matrix was conducted for various QoI, including kinetic energy, velocity of the impacting vehicle, lateral displacement, and contact force demand on the sub-standard barrier. Results confirmed that the sub-standard barrier was disqualified because the vehicle rolled over. However, in both TLs, the sub-standard barrier redirected the impacting vehicle without penetration. The results also showed that the base boundary condition of the barrier significantly influences important performance parameters such as the contact force and the lateral displacement. For example, compared to the free-base boundary condition, the fixed-base boundary condition more efficiently reduces lateral displacement and increases the contact force demand on the barrier, but it is less economically efficient.

The third objective of this research was to assess the effect of sub-standard barriers for reducing VCF on bridge piers. A bridge pier that inadequately addressed VCF under the required AASHTO ESF was applied to a simulation matrix to obtain a range of DIF time histories. After obtaining the ESF from these time histories, the proposed reduction in VCF was at least 25%.

Project Information

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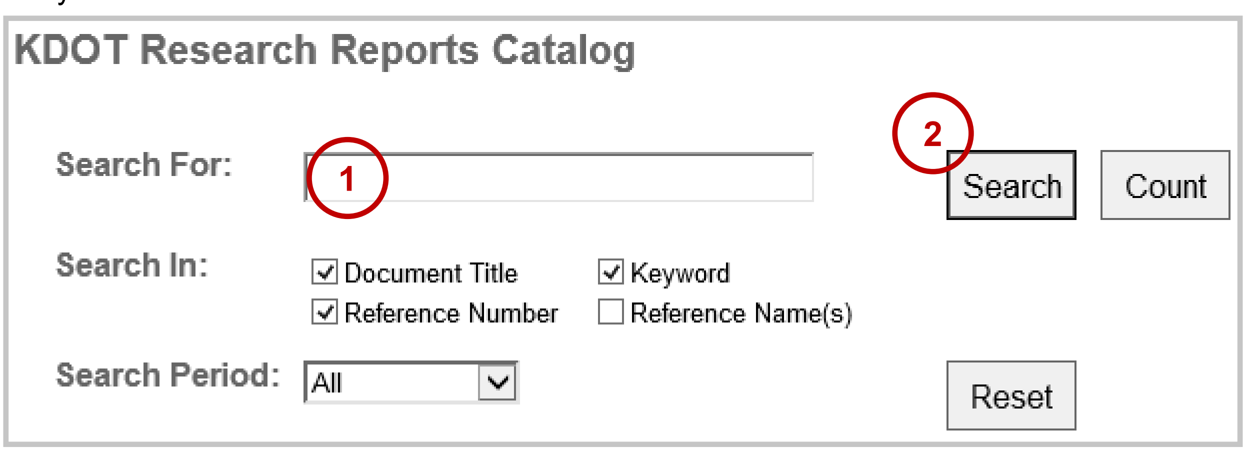

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