Kansas Department of Transportation

TECHNICAL SUMMARY

Performance and Capacity Assessment of Reinforced Concrete Bridge Piers Considering the Current Load and Resistance Factor Design Provisions and Plastic Hinge Length in Kansas

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Introduction

Kansas Department of Transportation (KDOT) has implemented the new AASHTO LRFD provisions in the state specific LRFD design procedure (KDOT-LRFD). There have been some significant updates in new version of AASHTO-LRFD (2010), compared to previous versions of the code. Most of the existing bridges constructed before the new provisions, have been designed and constructed based on the old provisions. In the study reported here, these changes have been assessed against the latest pertinent research. Also, adequacy of the bridges designed and constructed based on the old code has been studied by analyzing several representative bridge columns from two main different categories. The main changes in the AASHTO-LRFD (2010) and KDOT-LRFD (2011) compared to previous versions, here called old code, studied in this report are as follows:

- The return period of the design earthquake has been changed from 500-years to 1000-years (AASHTO-LRFD 2010)
- The vehicular collision impact force has been changed to the 400 kips applied at a height of 4 ft above the ground surface
- A length of plastic hinge region has been specified and required when designing reinforced concrete bridge columns to enhance the strength and ductility of the bridge structure. Accordingly, a minimum amount of lateral reinforcement is required within the plastic hinge region, as specified by the revised code.
- Subsequently, in AASHTO-LRFD (2012), the vehicular collision force was updated to 600 kips applied in a direction of 0 to 15 degrees with the edge of the pavement in a horizontal plane at a distance of 5.0 ft above the ground level (this change is not reflected in the KDOT-LRFD as of the time of this study).

Project Objective

Since the existing bridges (as of the time of this study) are designed based on the old codes, they need to be evaluated to know if they meet the new requirements. This assessment is necessary to decide if a column needs to be retrofitted or not.

Methods

Assessment of the strength and ductility of bridge columns can be done by using the code procedure in which the real strength of the column may be underestimated, or by analyzing the column performance using the most realistic material models and analytical tools in which the real strength and ductility can be evaluated.

In this study, both procedures were used, and the models and analytical methods were scaled to the latest models and methods backed by the latest research findings. A windows-based computer program was used for assessment of the real performance of bridge columns. The program KSU-RC uses the latest analytical models and methods and can be used to analyze the performance of reinforced concrete bridge columns with various geometry, confining material, and load pattern.

In general, the two representative bridges provided by KDOT for this study, represented state bridges designed and constructed based on two different versions of the code that can safely address the demanded loads considering their actual strength and bridge structural-redundancy and load redistribution process.

Project Results

There is no immediate concern in terms of serviceability or collapse of these bridges under demanded loads, including the extreme vehicular impact load. However, the calculated shear strength of most of the columns designed and constructed based on the old codes may not be enough considering the new vehicular impact load required by the new code revisions as shown in this study.

While no immediate action seems to be necessary in terms of serviceability and safety of these bridges, engineering judgment and a realistic case-based performance assessment is needed to decide if enhancement of the shear strength and the amount of lateral reinforcement within the plastic hinge length is necessary. Proper method to retrofit these types of columns as detailed in Chapter 2 can be used, once a decision is made for a case to implement the aforesaid enhancement. Choosing the appropriate method for retrofitting is case specific and can be done for each case considering the column geometry, service load, reinforcement details and material properties.

Project Information

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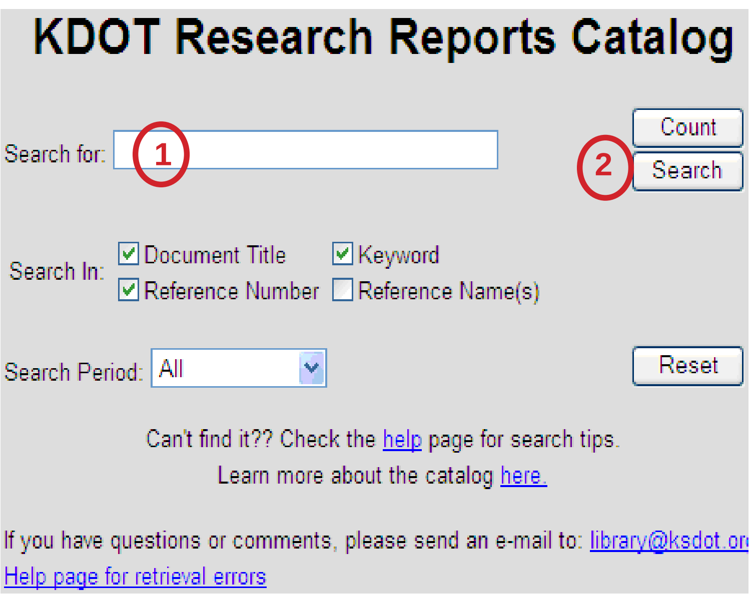

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