Kansas Department of Transportation

TECHNICAL SUMMARY

LRFD Software for Design and Actual Ultimate Capacity of Confined Rectangular Columns

Report Number: K-TRAN: KSU-11-3 ▪ Publication Date: April 2013

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Introduction

Columns are considered the most critical elements in structures. The unconfined analysis for columns is well established in the literature. Structural design codes dictate reduction factors for safety. It wasn't until very recently that design specifications and codes of practice, like AASHTO LRFD, started realizing the importance of introducing extreme event load cases that necessitates accounting for advanced behavioral aspects like confinement. Confinement adds another dimension to columns analysis as it increases the column's capacity and ductility. Accordingly, confinement needs special non linear analysis to yield accurate predictions. Nevertheless the literature is still lacking specialized analysis tools that take into account confinement despite the availability of all kinds of confinement models. In addition the literature has focused on axially loaded members with less attention to eccentric loading. Although the latter is more likely to occur, at least with misalignment tolerances, the eccentricity effect is not considered in any confinement model available in the literature.

It is widely known that code Specifications involve very detailed design procedures that need to be checked for a number of limit states making the task of the designer very tedious. Accordingly, it is important to develop software that guide through the design process and facilitate the preparation of reliable analysis/design documents.

Project Objectives

This study is intended to determine the actual capacity of confined reinforced concrete columns subjected to eccentric loading and to generate the failure envelope at three different levels. First, the well-known ultimate capacity analysis of unconfined concrete is developed as a benchmarking step. Secondly, the unconfined ultimate interaction diagram is scaled down based on the reduction factors of the AASHTO LRFD to the design interaction diagram. Finally, the actual confined concrete ultimate analysis is developed based on a new eccentricity model accounting for partial confinement effect under eccentric loading. The analyses are conducted for rectangular columns confined with conventional transverse steel. It is important to note that the present analysis procedure will be benchmarked against a wide range of experimental and analytical studies to establish its accuracy and reliability.

It is also the objective of this study to furnish interactive software with a user-friendly interface having analysis and design features that will facilitate the preliminary design of circular columns based on the actual demand. The overall objectives behind this research are summarized in the following points:

- Introduce the eccentricity effect in the stress-strain modeling.
- Implement non-linear analysis for considering the confinement effects on column's actual capacity.

- Test the analysis for rectangular columns confined with conventional transverse steel.
- Generate computer software that helps in designing and analyzing confined concrete columns through creating three levels of Moment-Force envelopes; unconfined curve, design curve based on AASHTO-LRFD and confined curve.

Project Results

This study accomplished several objectives at the analysis, material modeling, design implications and software development levels. It may be concluded that:

- Based on the extensive review of the confined model available in the literature, Mander Model is found to be the most suitable concentric loading model expressing the stress-strain behavior of circular and rectangular columns confined with convenient lateral steel and steel tubes as well.
- The eccentric based stress-strain model developed in this study provides more accuracy compared to the available concentric confined models in the literature as it is shown through comparison with experimental data
- For rectangular columns, the ratio of the area of compression zone to the sectional gross area is more representative than the normalized alone eccentricity in correlating eccentric behavior.
- The non-linear numerical procedure introduced, using the eccentric model and the finite layer approach, successfully predicted the ultimate capacity of rectangular reinforced concrete columns confined with steel.
- A computer program named "KDOT Column Expert" is developed based on the non-linear approach implemented for analysing and designing rectangular columns confined with lateral steel hoops.
- The unconfined concrete analysis carried out by KDOT Column Expert is benchmarked successfully against well-established commercial software for a range of design parameters
- The confined concrete analysis implemented by KDOT Column Expert is well correlated to experimental data.

Project Information

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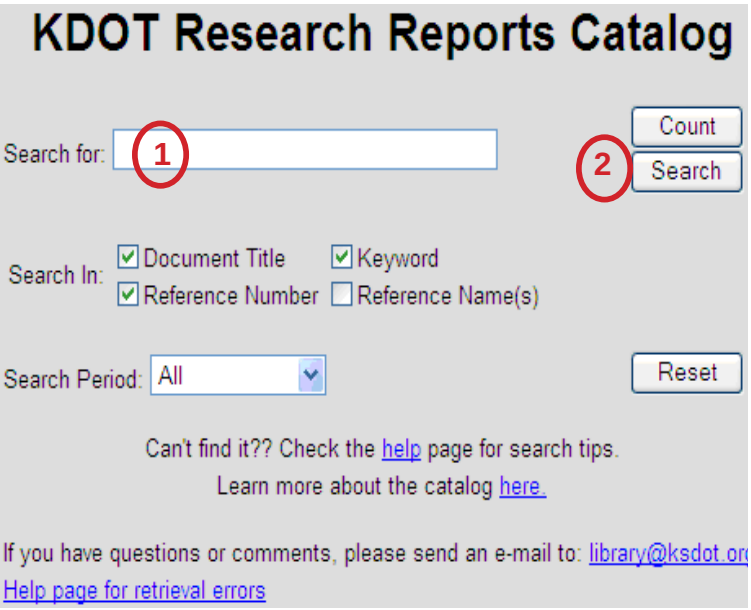

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