Kansas Department of Transportation

TECHNICAL SUMMARY

Development of Adjustment Factors and Load Ratings via Statistical Analyses of the National Bridge Inventory Database

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Introduction

A simple tool is needed to produce baseline load rating values for bridges in good or better condition. This tool should help establish expected load rating values for unrated bridges and identify erroneous load rating values that warrant further review. A method to simply account for bridge condition ratings is also needed.

The primary objective of this study was to develop and evaluate a statistical model using the National Bridge Inventory (NBI) database to establish baseline load ratings for bridges in Kansas. A linear regression model was used to identify key variables, such as age and bridge condition, that correlate with recorded inventory and operating load ratings. This method can produce an expected load rating for most concrete bridges in Kansas, establish baseline load ratings for structures without prior ratings, designate adjustment factors to adjust load ratings to account for bridge condition degradation, and validate model predictions for recorded load ratings. This approach answers the following question for a given bridge: Knowing nothing more about the structure than what is available within the NBI, what is the expected rating based on similar bridges in similar condition within Kansas?

Project Description

This study developed a new approach to establish baseline load ratings for bridges in Kansas without plans using data from the National Bridge Inventory (NBI). The approach is comprised of linear regression models to estimate load ratings for bridges with a condition rating of 8 or higher and adjustment factors to lower the estimated load rating to account for bridge condition ratings of 7 or lower. This approach beneficially establishes baseline load rating estimates for structures without prior ratings and secondary load ratings for bridges with prior load ratings to identify outliers and potential errors. The adjustment factors can be used to adjust load ratings obtained by any method to account for bridge condition if the condition was not specifically integrated into the analyses. Both the linear regression models and condition adjustment factors are designed to reflect trends among Kansas bridges within the NBI, not engineering judgment. This approach answers the following question for a given bridge: Knowing nothing more about the structure than what is available within the NBI, what is the expected rating based on similar bridges in similar condition within Kansas?

The proposed linear regression models include bridge age, modeled design load, structure kind (construction material), structure type (truss, girder, etc.) and deck width because, among variables reported in the NBI, these were most closely correlated with load rating. The adjustment factors were developed based on the median reported load rating for bridges with various condition ratings, and uncertainty was estimated using a bootstrapping simulation. The proposed models demonstrated satisfactory performance, capturing approximately half the variance observed in the data for the Inventory ($R2 = 0.50$) and Operating ($R2 = 0.49$) Ratings. Further validation and refinement, inclusion of additional predictors, and exploration of alternative methods are suggested to improve accuracy and applicability.

Project Results

The developed linear regression models considered predictor variables of bridge age, design load, structure kind, deck width, and structure type. The preliminary models exhibited satisfactory performance, effectively capturing a substantial portion of variance of the observed data for the reported inventory (R2 = 0.4) and operating (R2 = 0.35) ratings. To account for changes in load rating due to bridge condition, a sliding scale adjustment factor was applied to normalize the median reported load rating for bridges with a condition rating of 8 or 9 (i.e., very good condition). The adjustment factor was validated with a bootstrapping simulation that demonstrated a downward trend in adjustment factor uncertainty with low condition ratings. However, the sliding scale approach does not apply universally to all bridges in the datasets since some bridges with low condition ratings have higher reported load ratings than pristine bridges.

The final developed model with the applied reduction factors showed satisfactory performance, capturing half the variance in the observed data for inventory (R2 = 0.51) and operating (R2 = 0.45) ratings within the 95% prediction limits when applied to the testing datasets. The models are best used to enhance engineering judgment, help identify outliers and potential errors, and establish expected load ratings for bridges by capturing approximately half the variance in the data. These models also provide a comprehensive approach to estimating load ratings by incorporating adjustment factors to account for decreases in bridge loading rating and bridge condition degradation. The model prediction intervals account for the probabilistic uncertainty with predicted load ratings to establish a range engineers can utilize based on familiarity with the respective bridge structure. Further validation and refinement of the models are recommended to improve accuracy and applicability for various bridge types and conditions throughout Kansas.

Project Information

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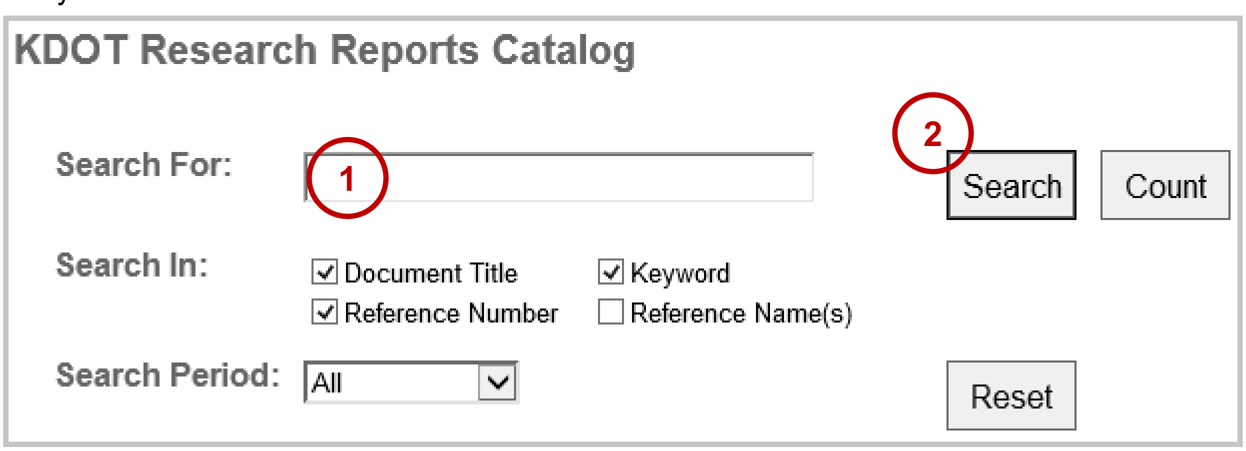

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