Kansas Department of Transportation

TECHNICAL SUMMARY

Long-Term Implications of Redecking Bridges With Prestressed Concrete Girders

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Introduction

Precast/prestressed concrete girders with cast-in-place decks are commonly used for bridge construction throughout the United States. However, girder lifespans exceed the lifespans of concrete decks, resulting in the need for deck replacement. This study surveyed United States Department of Transportation (DOT) engineers to determine common deck removal practices. Survey results showed that, although most states have a need to replace bridge decks, few states have comprehensive plans for assessing the long-term effects of deck replacement on girder behavior. This study developed a Python model to estimate girder behavior over its lifespan that accounts for the effects of deck replacement, changes in loading conditions, changes in restraint conditions, and concrete deformations. Time-step analysis was used to calculate incremental changes in girder behavior throughout time, considering several lifespan stages delineated by changes in loading or boundary conditions. The B4 model was used to estimate the creep and shrinkage strain in the concrete. The model was validated against examples in the literature and applied to an example bridge to illustrate function. Modelling results suggest that deck replacement had minimal effect on long-term girder behavior for the bridge considered. A parametric study was also conducted to evaluate the influence of input parameter variations on long-term prestress loss, deflections, and stresses and strains for the example bridge. Parametric study results showed that girder behavior varies widely based on input parameters, suggesting that more research is needed to determine whether other bridge configurations would also be insensitive to deck replacement.

Project Description

The objective of this study was to build a model to assess the effects of removing and replacing a damaged concrete deck over prestressed concrete girders. The main research tasks included the following:

- Review the literature on the deck removal process, prestressed concrete girders, prestress losses, and long-term deformations in concrete.
- Survey engineers at state DOTs to document deck replacement practices in the United States.
- Develop and validate a model to evaluate the long-term performance of a prestressed concrete girder, including the calculation of stresses/strains and camber/deflection throughout the service life.
- Apply the model to a prestressed concrete girder bridge to illustrate the effects of deck replacement on bridge behavior.

This study developed a detailed analytical model to simulate bridge superstructure behavior to analyze prestressed concrete I-girder bridges with bonded tendons. The product of this study is an analytical tool to estimate the camber, deflection, rebound, effective prestressing, stresses, and strains at any time throughout the service life of a bridge. A parametric study was also conducted to show the influence of design variables, loadings, and environmental parameters on an example bridge. The study was limited to linear and elastic material behavior in response to load; it does not consider temperature variations or gradients, damage caused during deck replacement, live load effects, concrete deterioration, or reinforcement corrosion. Several assumptions were also made for model development, as described in Chapter 3, and the model is applicable only to cases where the enumerated underlying assumptions are reasonable. The results of this study will help the Kansas Department of Transportation (KDOT) determine the suitability of deck replacements for existing bridges.

Project Results

The Preliminary conclusions and observations were made based on application of the model described in this report to the bridge example described in Chapter 4. It should be noted that future modifications to the model and evaluation of other structures, as proposed in Section 5.2, may result in different conclusions. Conclusions of the current study include: (1) Deck replacement in the example bridge only minimally affected long-term bridge behavior. Although several input parameters had an important effect on the long-term behavior of the girder, the effects of deck replacement were small and insensitive to most model inputs. (2) Creep and shrinkage significantly affected the long-term performance of the girder. Concrete creep in the example bridge caused approximately 60% of the prestress loss, and shrinkage caused 15% of the loss. Girder deflection was also affected by concrete creep, particularly during the initial days when creep rate was highest. (3) Removing the deck caused the girder to rebound and camber upward, but the camber after deck removal was less than the camber before the deck was initially applied for the cases considered due to concrete deformation during deck placement and deck removal. Girder rebound remained within acceptable limits for the cases considered. (4) Deck replacement after 10 years of construction had minimal impact on the remaining service life of the girder for the bridge considered. The time elapsed between deck removal and placement of the new deck also was shown to have minimal effect on girder behavior. (5) Continuity diaphragms restrain girder-end rotations and alter stress distribution. Nevertheless, the restraint moments, which are limited by the moment strength at the girder end, had minimal effect on the long-term behavior of prestressed concrete girders.

Project Information

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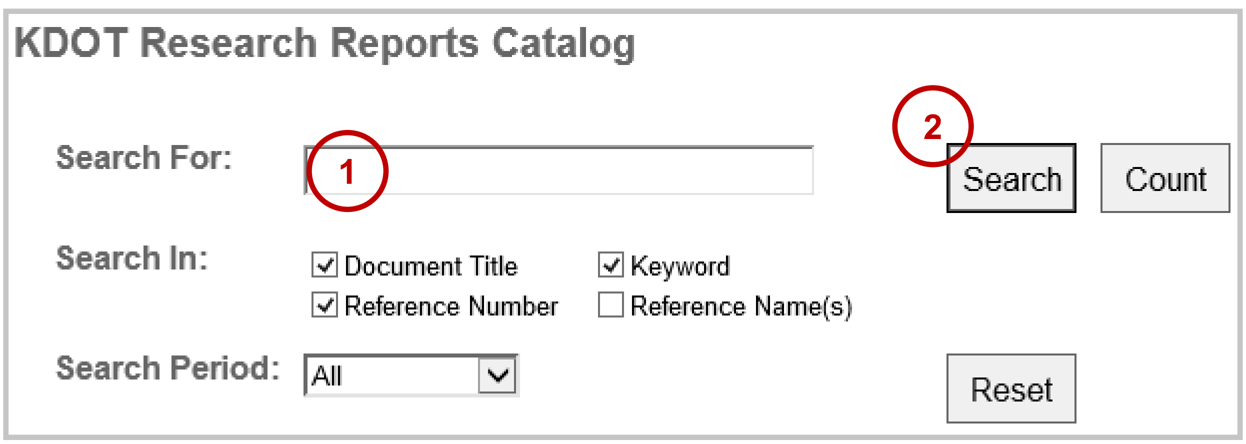

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