Bridge Deterioration Models to Support Indiana’s Bridge Management System

Introduction

An effective bridge management system that is equipped with reliable deterioration models enables agency engineers to carry out monitoring and long-term programming of bridge repair actions, and therefore has uses at both project and network levels. At the project level, deterioration models help the agency to track the physical condition of bridge elements and to specify when bridge maintenance, rehabilitation, and replacement should be implemented. Also, with reliable deterioration models, the agency can customize bridge repair or replacement schedules that incorporate element condition, functional obsolescence, and prespecified performance thresholds. At the network level, component-specific deterioration models are useful for system-wide needs assessment over a specified future time horizon, and for quantifying the system-wide consequences of funding shortfalls or funding increases in terms of specified performance measures that include the average bridge condition and remaining service life.

The bridge deterioration models that are currently in use in the Indiana Bridge Management System were developed over two decades ago. Since then, significant changes have taken place in inspection methods, technologies used, and statistical tools for data analysis. Also, because of the lack of reliable data, such items as truck traffic and climate conditions were not included in the past. In recent years, these obstacles do not exist, and therefore there is an opportunity to update the deterioration models for the various bridge components.

This study was commissioned by the Indiana Department of Transportation (INDOT) to address this research need. The study developed families of curves representing deterioration models for bridge deck, superstructure, and substructure. The National Bridge Inventory database was used, and the models have the NBI condition ratings as their response variables. The model families were categorized by administrative region, functional class, and superstructure material type. The explanatory variables include traffic volume and truck traffic, climatic condition, and design type and features.

Findings

This study used the NBI database to develop families of deterioration curves for the bridge deck, superstructure, and substructure components. The study confirmed that environmental variables play a significant role in bridge deterioration. For several of the deterioration models, the climate variables of freeze index, number of freeze-thaw cycles, and average precipitation were found to be significant predictors of bridge component deterioration.

Compared to the superstructure and substructure, deck deterioration was found to be more affected by traffic loading. It was also observed that bridge components that had undergone some repair since their construction exhibited patterns of deterioration that were different when compared to those that had not received any such
repairs, which can be explained by the salubrious effect of the repair actions. Also, for the same bridge material type and traffic loading, there were generally some differences in deterioration across the Indiana regions, but this was not always the case.

**Implementation**

The research product was designed to facilitate implementation of the study product (that is, the bridge deterioration models) in the bridge management system. This was done to demonstrate that they are appropriate and useful for the purpose for which they are intended. With the study product, INDOT is expected to be in a better position to monitor the condition of its bridges for purposes of bridge management, and also to generate the necessary input data for its bridge management system software packages. A reliable set of deterioration models can improve the processes and procedures for bridge rehabilitation scheduling, and thus help to avoid the relatively lower levels of service associated with mistimed (hastened or deferred) rehabilitation or reconstruction. Improved deterioration models will provide greater confidence in the decisions made by INDOT regarding bridge investments.

It is expected that the primary user and implementer of the study product will be the bridge management office of the Indiana Department of Transportation.

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