Performance Prediction of Concrete Elements in Bridge Substructures using Integrated Deterioration Method

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Summary

The typical probabilistic deterioration model cannot guarantee a reliable long-term prediction for various situations of available condition data. To minimise this limitation, this paper presents an advanced integrated method using state-/time-based model to build a reliable transition probability for prediction long-term performance of bridge elements. A selection process is developed in this method to automatically select a suitable prediction approach for a given situations of condition data. Furthermore, a Backward Prediction Model (BPM) is employed to effectively prediction the bridge performance when the inspection data are insufficient. In this study, a benchmark example-concrete element in bridge substructures is selected to demonstrate that the BPM in conjunction with time-based model can improve the reliability of long-term prediction.

Keywords: probabilistic deterioration model; integrated method; transition probability; long-term performance; Backward Prediction Model (BPM); time-based model; state-based model.

1. Introduction

Reliable decision making of a bridge Maintenance, Repair and Rehabilitation (MR&R) activities is highly dependent on the reliable current year's inspection data and well-estimated future structure conditions. To achieve cost-effectiveness of MR&R during bridge service life, developing a reliable deterioration model is essential. A large number of historical bridge condition ratings are usually required for a reliable deterioration model in a bridge management system (BMS) to attain best possible outcomes. However, some bridge agencies may not have sufficient historical bridge inspection records to achieve the basic requirement of running a deterioration model in the current BMSs. Thus, development of an advanced bridge deterioration model to predict reliable long-term bridge performance is an issue of utmost urgency.

The difficulty in developing a reliable deterioration model is that bridge condition is mostly inspected using a quantitative method on a discrete scale, which implies inherent uncertainty in bridge deterioration conditions. Generally, the bridge deterioration process is affected by the explanatory variables, such as traffic volume, climatic condition, and material properties [1]. However, the most explanatory variables are unable to be captured by filed bridge inspection. Therefore, deterioration is often characterised by using probabilistic models to predict uncertain deterioration in condition state variation at a given discrete time and explanatory variables. The probabilistic models can be grouped into two categories: state-based and time-based model. The state-based models predict long-term bridge performance using transition probability obtained from the difference between the two condition states at a given discrete time interval. The most common example is Markov chain models. Time-based models, on the other hand, employ probability density function of time, referring to the state duration time required for a bridge element to deteriorate from an initial condition state to its next specified state. Parametric, semi-parametric and non-parametric models have been proposed to generate the probability distribution function of transition time [2].

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