Available online at www.sciencedirect.com

ScienceDirect

International Journal of Pavement Research and Technology 9 (2016) 14–19

www.elsevier.com/locate/IJPRT

Enhancing pavement performance prediction models for the Illinois Tollway System

Laxmikanth Premkumar *, William R. Vavrik [1]

Applied Research Associates, Inc., 100 Trade Centre Drive, Suite 200, Champaign, IL 61820, USA

Available online 5 January 2016

Abstract

Accurate pavement performance prediction represents an important role in prioritizing future maintenance and rehabilitation needs, and predicting future pavement condition in a pavement management system. The Illinois State Toll Highway Authority (Tollway) with over 2000 lane miles of pavement utilizes the condition rating survey (CRS) methodology to rate pavement performance. Pavement performance models developed in the past for the Illinois Department of Transportation (IDOT) are used by the Tollway to predict the future condition of its network. The model projects future CRS ratings based on pavement type, thickness, traffic, pavement age and current CRS rating. However, with time and inclusion of newer pavement types there was a need to calibrate the existing pavement performance models, as well as, develop models for newer pavement types.

This study presents the results of calibrating the existing models, and developing new models for the various pavement types in the Illinois Tollway network. The predicted future condition of the pavements is used in estimating its remaining service life to failure, which is of immediate use in recommending future maintenance and rehabilitation requirements for the network.

Keywords: Pavement performance models; Remaining life; Pavement management

1. Background

The Illinois State Toll Highway Authority's (Tollway) network provides heavily used key interstate highway routes in the Chicago area, the State of Illinois, and the Midwest. Commuters, freight haulers, and the overall traveling public rely on the Tollway each day to provide safe, reliable, and cost-effective highway transportation and have done so since the 1950s. In fulfilling this mission, the Tollway has been faced with an aging highway network that requires substantial maintenance and rehabilitation to provide continued satisfactory service. By the beginning of the 21st century, components of many of the existing pavements were over 40 years in age and in need of major rehabilitation. In addition, at that time funding uncertainties precluded efforts to rehabilitate (or reconstruct) major portions of the network.

To address its pavement concerns, the Tollway implemented a comprehensive pavement management system and continues to update the system on a yearly basis. The Tollway's pavement management system warehouses a comprehensive database of pavement-related information, and it allows the Tollway to quickly identify current pavement conditions, project future pavement performance, identify future pavement maintenance and rehabilitation needs, and generate multi-year pavement repair plans.

The Tollway uses the condition rating survey (CRS), a subjective pavement rating system developed by the Illinois Department of Transportation (IDOT) in the early 1980s [1], to rate the condition of its roads. The CRS provides

* Corresponding author. Tel.: +1 (217) 356 4500; fax: +1 (217) 356 3088.
E-mail addresses: lpremkumar@ara.com (L. Premkumar), wvavrik@ara.com (W.R. Vavrik).
[1] Tel.: +1 (217) 356 4500; fax: +1 (217) 356 3088.
Peer review under responsibility of Chinese Society of Pavement Engineering.

http://dx.doi.org/10.1016/j.ijprt.2015.12.002
1996-6814/© 2016 Chinese Society of Pavement Engineering. Production and hosting by Elsevier B.V.

an overall pavement condition rating on a 1-to-9 scale, with 9 representing a newly constructed or resurfaced pavement and 1 representing a completely failed pavement. CRS ratings are based on the type, amount, and severity of the evident pavement distresses, as well as the overall roughness of the pavement surface, level of wheel path rutting, and magnitude of transverse joint faulting. Summaries of the CRS ratings and corresponding pavement conditions for the Tollway are provided in Table 1. CRS surveys are performed in each direction of traffic, and the resulting CRS ratings represent the entire roadway width for a given traffic direction [2].

Annual updates of the Tollway pavement management system begin with updating current construction history, traffic, cost, and pavement condition data to optimize the effectiveness of its pavements. Future pavement condition is projected based on current year CRS values and the performance models.

Traditional CRS prediction models involve identifying individual pavement sections and modeling the expected future CRS value. The rate of change or slope of CRS over time is calculated for each pavement section by dividing the change in CRS by change in age. The average slope for each individual pavement type is used for the prediction model. The model uses a two-slope method for predicting CRS with age, with different slopes above and below a CRS break point value of 6.5 [1]. However, these models only predict future CRS based on age and do not consider other variables that affect pavement performance like traffic and structure. The model form is shown below in Eqs. (1) and (2):

If current CRS $\geqslant$ BP,

$$\text{Future CRS} = \text{Current CRS} - \text{slope}_{9.0-\text{BP}} * \text{years of prediction} \quad (1)$$

If current CRS < BP,

$$\text{Future CRS} = \text{Current CRS} - \text{slope}_{\text{BP}-1.0} * \text{years of prediction} \quad (2)$$

where

current CRS = CRS value from the most recent survey,
BP = break point,
$\text{slope}_{9.0-\text{BP}}$ = model slope value from a CRS of 9.0 to the break point,
$\text{slope}_{\text{BP}-1.0}$ = model slope value from a break point to CRS of 1.0,
years of prediction = number of years into the future the prediction is desired.

Table 1
Summary of CRS pavement condition ratings.

CRS rating	General pavement condition
7.5–9.0	Excellent
6.5–7.4	Acceptable
6.0–6.4	Transitional
4.5–5.9	Fair
1.0–4.4	Poor

The Tollway pavement performance prediction models developed in early 2000 project future CRS ratings based on pavement type, thickness, pavement age, traffic and current CRS, unlike the traditional model. The models were developed originally for the IDOT Interstate highway network, and customized for the Illinois Tollway using the Tollway CRS data collected from 1997 to 2002 [2]. The pavement performance models were developed to predict future pavement conditions, trigger various rehabilitation activities, and evaluate the impact that various rehabilitation programs has on pavement conditions.

In 2013, due to addition of new pavement types in the network, there was a need to develop new performance models and re-calibrate the existing performance models using updated Tollway CRS data. As part of the calibration effort, performance models for the following seven pavement types were considered, with new models developed for SMA-JPCP and JPCP with 15-ft joint spacing. It is to be noted that the calibration and development of models for the new pavements types involved obtaining revised/new regression coefficients based on the existing pavement performance prediction model.

- Continuously reinforced concrete pavement (CRCP).
- Jointed plain concrete pavement, with 20-ft joint spacing (JPCP-20).
- Jointed plain concrete pavement, with 15-ft joint spacing (JPCP-15).
- Asphalt-overlaid JPCP with 20-ft joint spacing (HMA-JPCP-20).
- Full Depth Asphalt Pavement (HMAC).
- SMA-overlaid JPCP with 20-ft joint spacing (SMA-JPCP).
- Asphalt-overlaid JPCP with no dowel, and variable joint spacing between 12-ft and 20-ft (D-Crack).

These seven pavement types generally represent the pavement structure located within the Tollway network. The models presented in this study are specific to pavement types in the Tollway network and input data obtained from the Tollway pavement management database.

2. CRS calibration methodology

The steps involved in calibration of the CRS performance models are shown in Fig. 1. Detailed description of the individual steps is shown in subsequent sections.

2.1. Data mining and assembly

The first step in CRS model calibration was data mining and assembling data in the required format. The following information was required to calibrate the performance models: