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Pavement Management Performance Modeling: Evaluating the Existing PCI Equations,

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Abstract

The work described in this report documents the activities performed for the evaluation, development, and enhancement of the Iowa Department of Transportation (DOT) pavement condition information as part of their pavement management system operation. The study covers all of the Iowa DOT's interstate and primary National Highway System (NHS) and non-NHS system. A new pavement condition rating system that provides a consistent, unified approach in rating pavements in Iowa is being proposed. The proposed 100-scale system is based on five individual indices derived from specific distress data and pavement properties, and an overall pavement condition index, PCI-2, that combines individual indices using weighting factors. The different indices cover cracking, ride, rutting, faulting, and friction. The Cracking Index is formed by combining cracking data (transverse, longitudinal, wheel-path, and alligator cracking indices). Ride, rutting, and faulting indices utilize the International Roughness Index (IRI), rut depth, and fault height, respectively.

Keywords

Condition surveys, Evaluation and assessment, Geographic information systems, Pavement management systems, Pavement performance

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Roadway Infrastructure Management and Operations Systems (RIMOS) is a program at CTRE dedicated to developing practical tools for viewing, understanding, and making decisions for asset quality and performance over time. The tools and systems RIMOS develops are helping transportation agencies make cost-effective decisions about their roadways and related assets.

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Pavement Management Performance Modeling: Evaluating the Existing PCI Equations

tech transfer summary

A new pavement condition rating system that provides a consistent, unified approach in rating pavements in Iowa has been proposed through this analysis.

Background

Pavement condition indices are used for strategic decision making, such as setting statewide goals for infrastructure conditions, and comparing the performance of highway systems among the states.

A pavement condition index (PCI) provides a numerical rating for the condition of road segments within the road network. Researchers and highway agencies around the country have developed a host of pavement indices to measure or evaluate pavement condition.

A surface distress index, for example, may aggregate several distress types (e.g., cracking, rutting, bleeding for asphalt pavement; and cracking, faulting, spalling for concrete pavement). The selected distress types included in the index depend on agency needs. Alternatively, each distress type may be expressed as an individual index.

Similarly, other pavement characteristics that are perceived to be important to road users, such as roughness or ride quality, are often utilized as an index. These different pavement measures can be combined in an overall index.

Problem Statement

Pavement condition is often a function of exhibited distress types, the severity of these distress types, and the extent of these distress types (extent of occurrence in surveyed pavement area). The primary challenge is how to combine these characteristics into a single distress index if needed.

The development of an overall condition index is even more challenging because other pavement characteristics such as surface roughness are also considered, adding an extra dimension to the index. An overall condition index should combine the pavement condition indicators considering local experience.

Goal and Objectives

The goal of this project was to establish a new system to assess and rate the condition of Iowa pavements. The primary objective was to develop new performance indicators (or PCIs) for Iowa pavements without changing the current Iowa Department of Transportation (DOT) data collection practices.

Research Description

The Iowa DOT Pavement Management Information System (PMIS) database contains every aspect of pavement data: identification information, construction history, design information, maintenance, distress, etc. The pavement network is divided into segments (pavement management sections). The Iowa DOT maintains the PMIS section data based on historical records.

Each segment has the same pavement type, maintenance, and traffic levels. The segments are identified by route, county, direction of travel, and begin and end mileposts. By 2012, the total lengths of the pavement sections in the database were 2,571 miles (44.7% Portland cement concrete/PCC surfaces and 55.3% asphalt concrete/AC surfaces) for interstate and 15,699 miles (29.2% PCC and 70.8% AC) for Iowa and US (or primary) routes.

This study included data for all of the Iowa DOT interstate and primary National Highway System (NHS) and non-NHS system. A data set of 11,795 data points that included data for pavement sections from 1998 through 2012 was created. (The final report provides additional details about the data and screening of the data for this study.)

With input from Iowa DOT experts, major condition indicators were determined. Five individual indices, each on a scale of 100, were established, based on the distress type, with a Cracking Index, Riding Index, Rutting Index, Faulting Index, and Friction Index. The Cracking Index was formed combining the Transverse, Longitudinal, Wheel-path, and Alligator Cracking sub-indices, based on the pavement type.

The Cracking Index is composed of 60% transverse cracking and 40% longitudinal cracking for PCC pavements and, similarly, 20% transverse cracking, 10% longitudinal cracking, 30% wheel-path cracking, and 40% alligator cracking for AC surfaces. The Riding, Rutting, and Faulting indices utilize the International Roughness Index (IRI), rut depth, and fault height, respectively. The proposed pavement condition index, PCI-2, combines individual indices to reflect the overall score.

Key Findings

The proposed system is based on the five individual indices derived from specific distress data and pavement properties, and an overall PCI, PCI-2, that combines individual indices using weighting factors.

The overall pavement condition index, PCI-2, is calculated as follows for PCC and AC surface:

$$\text{PCI-2}_{PCC} = 0.40 \times (\text{Cracking Index}) + 0.40 \times (\text{Riding Index}) + 0.20 \times (\text{Faulting Index})$$

$$\text{PCI-2}_{AC} = 0.40 \times (\text{Cracking Index}) + 0.40 \times (\text{Riding Index}) + 0.20 \times (\text{Rutting Index})$$

Implementation Readiness and Benefits

The proposed PCIs that make up PCI-2 provide a consistent unified approach in terms of inputs used to calculate the condition measures.

The researchers compared proposed PCI-2 results to existing PCI results and found that, in general, PCI-2 offers fairly good correlation to PCI condition results, particularly, for the pavement types where PCI utilizes distress and roughness data. The poorly related ones are due to the fact that some of the current PCI is heavily characterized by pavement age with various other data, such as material property and traffic, and is characterized less than PCI-2 by the pavement distress and roughness data.

PCI-2 offers a dynamic model that can be further tweaked based on response from the field (such as modifying the weight factors for combination indices). Furthermore, PCI-2 is currently based on distress (cracking, rutting, faulting) and roughness; additional input, such as patching and structural soundness, could be added.