CENTER FOR TRANSPORTATION RESEARCH
THE UNIVERSITY OF TEXAS AT AUSTIN

Center for Transportation Research
The University of Texas at Austin

Project Summary Report 0-4322-S
Project 0-4322: Develop a New Methodology for Characterizing Pavement Structural Condition for Network-Level Applications
Authors: Zhanmin Zhang, Lance Manuel, Ivan Damnjanovic, and Zheng Li
October 2002

PROJECT SUMMARY REPORT

Summary of Research Findings on the Development of a New Methodology for Characterizing Pavement Structural Condition for Network-Level Applications

Introduction

Over the years many state highway agencies, including the Texas Department of Transportation (TxDOT), in order to preserve the large highway network, have applied extensive seal coats, thin overlays, and other types of surface treatments to improve the surface condition and to seal the existing cracks. In Texas, even though such measures were applied consistently, the overall condition of the pavements kept deteriorating due to the structural inadequacy associated with some of the pavements. Therefore, there was an urgent need for an effective pavement structural index that could discriminate between pavements requiring additional strength through overlays, rehabilitation, or reconstruction, and those where the application of surface treatments would be sufficient.

To make proper decisions about the type of treatment needed, one should consider characterizing the pavement structural condition. The structural condition of a pavement can be assessed through several different approaches, but the most comprehensive approach involves the use of the Falling Weight Deflectometer (FWD) data. The FWD, a type of Non-Destructive Testing (NDT) for structural evaluation of pavements, is widely used by the Texas Department of Transportation (TxDOT). The Pavement Management Information System (PMIS) currently used by the TxDOT contains FWD data. The FWD measures deflections when known impulse loads have been induced on the pavement to be examined. The FWD data is commonly used to back-calculate the layer moduli of the pavement.

According to the statistics from the TxDOT PMIS, the ride score (RS) of the highway network in Texas is decreasing at an average of three score points per year. The decrease in the ride score is due to an increase in pavement roughness caused by the permanent deformation of the pavement structure. The deformations are the results of inadequate pavement strength for the existing traffic load.

The main objective of this research was to develop a Structural Condition Index (SCI) based on the FWD deflection readings of a pavement and the total thickness of the pavement layers. The SCI should be sensitive enough to discriminate between pavements requiring additional structural reinforcement and those where

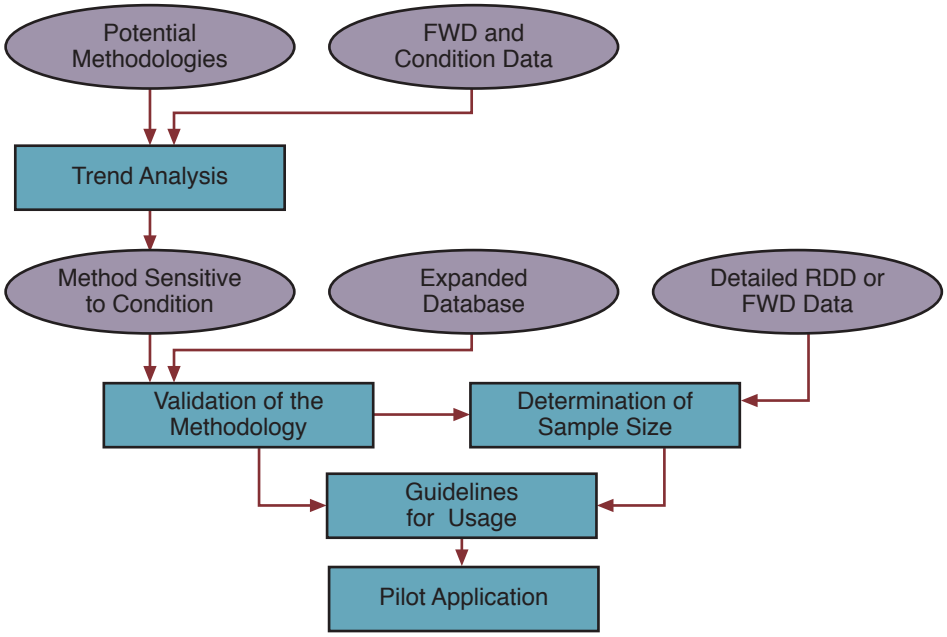

Figure 1: The Framework Used for the Analysis

surface treatments would be sufficient.

What We Did...

A literature review of the potential methods for estimating structural condition of pavements was undertaken in which different methods were examined. The key criterion for selecting a potential method was whether the data required by a potential method is available in the PMIS. The researchers have focused their attention on five different methods that have complied with such a criterion. Those methods can be used to estimate either the Structural Number (SN) of a pavement or the moduli of the pavement layers.

The trend analysis was conducted in order to qualitatively characterize the proposed methods for describing the structural condition. The Unit ESAL Deterioration (UED) of the PMIS condition scores was introduced as a variable for the trend analysis. Such a variable has proved to be the best deterioration descriptor among all of the deterioration descriptors considered. The Structural Condition Index (SCI) has been introduced as a screening tool to discriminate between pavements that need structural reinforcement and those that do not. Furthermore, the guidelines for using such an index were developed. A contingent sampling procedure was developed to determine the minimal number of FWD tests required for each management section of the pavements. Finally, a pilot project analysis was undertaken to verify the validity of the methodology.

The research methodology was based on a sequential analysis process as illustrated in Figure 1. First, the assessment of the potential methods for use in the structural evaluation of the pavements was conducted by examining the input data that was available from the TxDOT PMIS. Second, the trend analyses were conducted and subsequently conclusions regarding the sensitivity of the methods to the deterioration variables were made. Third, the validation of the trends established in the previous step, followed by the overall methodology

validation, was conducted using an expanded database of pavement sections extracted from the PMIS. In addition, the statistical analysis process for determining the sample size (sampling frequency) was developed. Finally, guidelines and recommendations for using the Structural Condition Index (SCI) were developed and validated with a pilot project application.

What We Found...

The methods considered for estimating the structural condition of a pavement showed different trends with respect to the UED. The best trends were established by examining all the methods. The Structural Condition Index (SCI) was defined as the ratio of the existing SN and the required SN of a pavement:

$$SCI = \frac{SN_{eff}}{SN_{req}}$$

where SCI = the Structural Condition Index,
SN_{eff} = the existing (estimated) Structural Number, and
SN_{req} = the required Structural Number.

Some half-mile sections stored in the PMIS contained the FWD deflection measurements with spacings of one-tenth of a mile. These sections allowed the researchers to conduct an in-depth assessment of the true variability associated with the pavements in terms of the SN derived from the FWD deflection measurements. The information about the variability of the SN allowed the researchers to develop a recommendation for the sample size of the FWD data collection.

The Researchers Recommend...

The SCI is sensitive to the deterioration variables; therefore, it is recommended that the SCI be used for each management section of the network. However, using an average SCI value of the tested sections that constitute a Maintenance and Rehabilitation (M&R) project as the only criterion is not sufficient for determining if an M&R strategy of adding structural capacity should be used for the project, considering the general variability of the pavements in terms of the SN. The researchers recommend the use of two criteria. The first criterion is that at least 50 percent of the sections of the project have an SCI value smaller than 1.0, and the second criterion is to use a threshold percentage (calibrated by the TxDOT) of tested sections whose SCI values fall below a defined minimum SCI level. For example, if 20 percent or more of tested sections of a project give an SCI value below the threshold SCI value of 0.70, then an M&R strategy of adding structural capacity should be used for the project.

In addition, it is recommended that an M&R project be defragmented into sections that demonstrate similar structural conditions if feasible. It is also recommended that TxDOT increase the frequency of FWD tests to at least 2 tests per half-mile section.

For More Details...

Research Supervisor: Zhanmin Zhang, Ph.D., (512) 471-4534
email: z.zhang@mail.utexas.edu
TxDOT Project Director: German Claros, Ph.D., P.E., (512) 467-3881
email: gclaros@dot.state.tx.us

The research is documented in the following reports:

4322-1 *Development of a New Methodology for Characterizing Pavement Structural Condition for Network-Level Applications,* August 2003

To obtain copies of a report: CTR Library, Center for Transportation Research,
(512) 232-3138, email: ctrlib@uts.cc.utexas.edu

TxDOT Implementation Status December 2003

The pilot implementation of the findings of project 0-4322 will be done by the PMIS branch of TxDOT. They are planning to code the SCI algorithm into the mapping application called Map Zapper. This application will allow districts to calculate and map SCI values for road sections that have deflection data. Two or three districts will be selected for the pilot implementation of the SCI.

Contact: Dr. German Claros, P.E., Research and Technology Implementation Office, (512) 465-7403, gclaros@dot.state.tx.us.

Your Involvement Is Welcome!

Disclaimer

This research was performed in cooperation with the Texas Department of Transportation and the U. S. Department of Transportation, Federal Highway Administration. The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. Trade names were used solely for information and not for product endorsement. The engineer in charge was Zhanmin Zhang, Ph.D.

Center for Transportation Research
The University of Texas at Austin

The University of Texas at Austin
Center for Transportation Research Library
3208 Red River #115
Austin, TX 78705-2650