LOUISIANA TRANSPORTATION RESEARCH CENTER

TECHSUMMARY September 2017

State Project No. 30000144 / LTRC Project No. 14-2P

Assessment of Continuous Deflection Measurement Devices in Louisiana – Rolling Wheel Deflectometer

INTRODUCTION

The Louisiana Department of Transportation and Development (DOTD) uses a comprehensive pavement management system (PMS) through which the pavement network is surveyed once every two years. However, no structural condition data are collected to assist in the process of selecting a suitable treatment strategy. This may lead to two types of errors and loss of state funds because of the lack of consideration of structural conditions: adding structure to a pavement that does not require it (Type I error – False Positive) and not adding structure to a pavement that requires it (Type II – False Negative). In 2009, DOTD conducted a comprehensive testing program of the Rolling Wheel Deflectometer (RWD). Based on the results of the experimental program, three structural capacity indicators were developed: the RWD index (RI), the RWD Structural Number (SN_{RWD}), and the Zone RWD Index (ZRI).

OBJECTIVE

The objective of this study was to evaluate the aforementioned structural capacity indicators in predicting pavement structural capacity based on RWD measurements and to estimate the subgrade resilient modulus (M_r) based on the RWD data. In addition, a methodology was developed to integrate the most promising indicator into the Louisiana PMS decision matrix and into Louisiana's overlay design procedure. This project assessed the cost-efficiency of RWD testing in identifying and repairing structurally deficient sections prior to reaching very poor conditions.

SCOPE

Measurements from the RWD testing program were analyzed. Furthermore, the research team analyzed PMS data to determine the rate of structural and functional deteriorations for pavements that are structurally deficient and those that are structurally sound. Current practices for selecting pavement maintenance and rehabilitation strategies were evaluated and modified such that both structural and functional pavement conditions were considered in treatment selections and to improve the accuracy of the state overlay design procedure.

METHODOLOGY

A comprehensive review of Louisiana PMS and recent studies dealing with continuous deflection testing was conducted. In addition, a critical evaluation of the structural capacity indicators developed for RWD was performed. Based on this evaluation, modifications were introduced for the most promising structural capacity indicator in order to improve identification of structurally deficient sections. A methodology was also developed to incorporate the most accurate structural capacity indicator into Louisiana PMS and overlay design. Furthermore, the cost-efficiency and benefits of RWD testing in identifying and repairing structurally deficient sections were evaluated.

Results

The SN_{RWD} model was found to be the most promising model. Modifications were introduced to the SN_{RWD} model to improve its capability in identifying structurally deficient pavements and to allow for predicting the SN at a 0.1-mile interval, referred to as $SN_{RWD0.1}$. The modified model showed an acceptable coefficient of determination (R^2) of 0.7677 and a Root-Mean square Error (RMSE) of 0.8. Core samples showed that sections that were predicted to be structurally deficient suffered from asphalt stripping and material deterioration problems.

LTRC Report 581

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A Structural Condition Index (SCI) was developed based on $SN_{RWD0.1}$ to categorize pavement sections according to structural conditions. Sections with very low SCI values were observed to deteriorate significantly faster than those with high SCI values. An approach was developed to implement RWD measurements into the State overlay design procedure. The proposed procedure implements the $SN_{RWD0.1}$ in the AASHTO 1993 design method instead of assuming a 50% loss in structural capacity. The new overlay design procedure would allow for optimum funding allocation and would assist the designer to avoid both Type I error and Type II error.

The SCI was converted into a scaled indicator from zero to 100, known as SSCI, and its incorporation into the PMS decision matrices was developed. Two enhanced decision trees for collectors and arterials were developed for demonstrating the incorporation of RWD measurements and the SSCI into the PMS decision-making process. An Artificial Neural Network- (ANN-) based pattern recognition system was trained and validated to arrive at the most optimum decisions with an overall decision prediction accuracy of 96.9%.

An ANN-based model was developed to estimate the subgrade resilient modulus based on RWD measurements. The model was developed based on data obtained from District 05 and was validated based on data obtained from the MnROAD facility in Minnesota. The limits of agreement methodology showed that 95% of the differences between the M_r values calculated based on FWD and RWD measurements will not exceed the range of ± 3 ksi, which is acceptable especially at the network level.

CONCLUSIONS & RECOMMENDATIONS

Two approaches were developed to implement RWD measurements into the DOTD current practices. In the first approach, the SSCI was added to the state PMS treatment selection matrix. In the second approach, the calculated $SN_{RWD0.1}$ was added to the state overlay design procedure. In the first approach, only Type II error would be addressed (i.e., applying a functional treatment to a structurally deficient pavement). Since the functional indices were not changed, Type I error was not addressed by adding the proposed structural condition index. To address both Type I and II errors, the second approach is recommended.

Based on the results of this study, it is recommended that structural capacity indicators be incorporated into the Louisiana PMS for treatments' selection as well as the state overlay design procedure. The effective pavement structural number should be implemented in the overlay design procedure instead of the current practice of assuming 50% loss in the original structural capacity. Results of the study found that RWD could result in significant savings to the Department if implemented in testing medium to high traffic volume roads (e.g., interstates and major arterials) with an Annual Average Daily Traffic (AADT) of 5,000 or more. The proposed modification to the overlay design procedure is implementation-ready and should be utilized by the Department to maximize savings from using RWD.

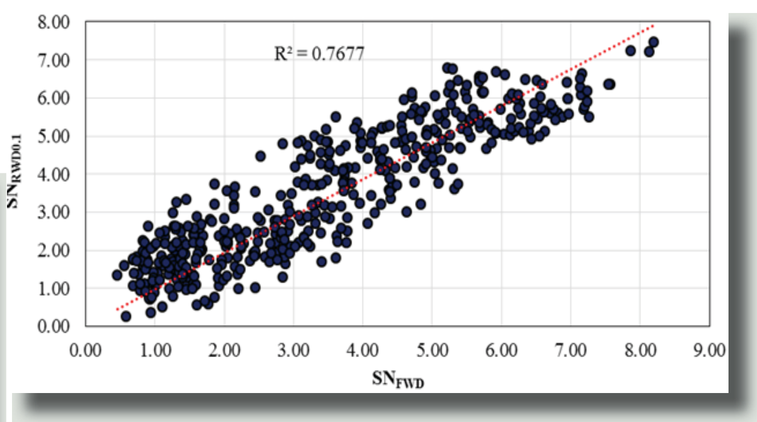

Figure 2
Comparison of structural number calculated from RWD and FWD based on the Proposed Modified Model

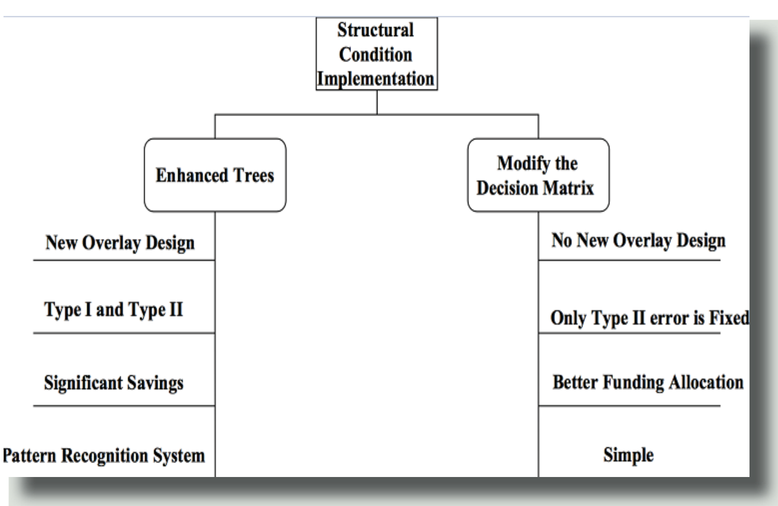

Figure 1
General layout of proposed implementation approaches