CENTER FOR TRANSPORTATION INFRASTRUCTURE SYSTEMS
THE UNIVERSITY OF TEXAS AT EL PASO

Project Summary Report 1711-S
Project 0-1711: Development of a Rational Method for
Determination of Remaining Life of Existing Flexible Pavements

Author(s): Carlos Ferregut, Soheil Nazarian, Imad Abdallah, and Octavio Melchor-Lucero

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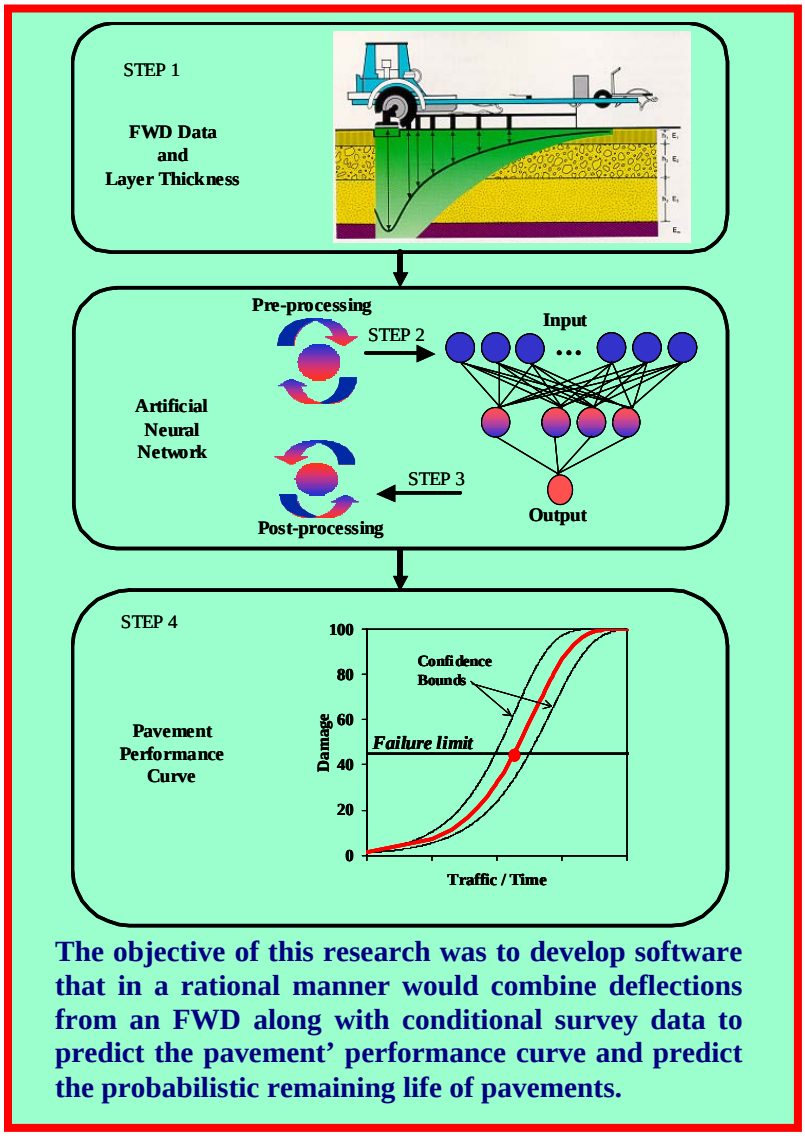
PROJECT SUMMARY REPORT

Rational Estimation of Pavement Performance Software - REPP 2000-

The deflection basin obtained with the Falling Weight Deflectometer (FWD) is used to backcalculate the pavement layers' moduli and to estimate the pavement's remaining life. The success of this process seems to depend on the pavement structure, the skills of the person conducting the backcalculation, and the accuracy with which the pavement layer thickness is known. This research provides an alternative approach to the computation of the remaining life of a given section. In this approach, the functional condition of a pavement (i.e., percent cracking and depth of rut) at the time of FWD testing is combined with simple remaining life models to predict the pavement performance curve. The remaining lives are directly estimated from the pavement structure and FWD deflection.

The significance of the software is that TxDOT personnel can potentially make a more informed decision in retrofitting the flexible pavements in their districts.



The objective of this research was to develop software that in a rational manner would combine deflections from an FWD along with conditional survey data to predict the pavement' performance curve and predict the probabilistic remaining life of pavements.

What We Did …

We created a software tool that estimates the pavement performance curve of a three- or a four-layer pavement and the uncertainty associated with them in real-time without using backcalculation.

A new branch of artificial intelligence named the Artificial Neural Networks (ANN) was utilized for this purpose. The artificial neural network technique is based on the understanding of how the information is processed in the brain and aims to develop the mathematical relationships that would reproduce a similar process. To develop an ANN, it is necessary to have a set of examples that show specific values of the independent variables and the corresponding values of the dependent variable(s).

The independent variables include the:

- FWD Deflections
- Layer Thickness

The dependent variables are one or all of the following parameters:

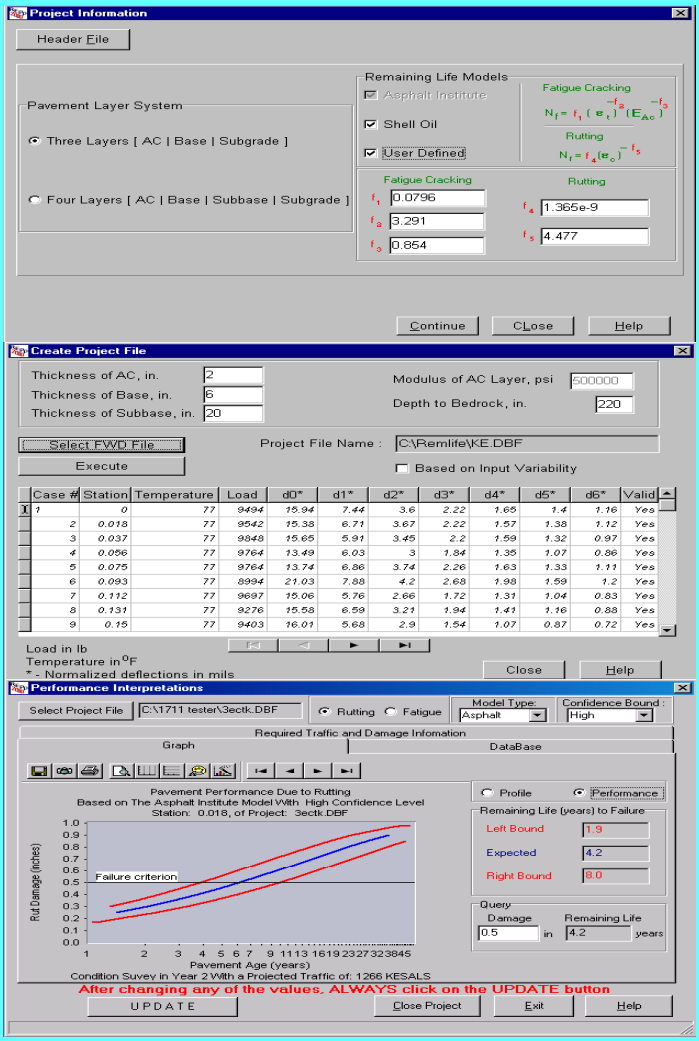
- The rutting and fatigue remaining lives using a number of well-established models
- The critical tensile and compressive strains at the interfaces of different layers to be used in any other remaining life model, and
- Depth to a rigid layer (if applicable).

The impact of uncertainty in the layer thickness and in the deflection basin on the predicted remaining life of a pavement should be considered in any rational design methodology. The Monte Carlo simulation is the only reliable and accurate means of defining confidence bounds for the predicted remaining life. The use of Monte Carlo simulation is not practical in conventional methods because of the computation time involved. Since the process of predicting any of the parameters above is instantaneous, the uncertainty associated with each one of them can be readily determined using the Monte Carlo simulation.

What We Developed…

Rational Estimation of Pavement Performance (REPP 2000) is a state-of-the-art software that combines artificial neural network (ANN) technology with uncertainty analysis to determine the performance

A user-friendly computer program named REPP2000 has been encoded to provide a pavement performance curve (PPC) along with the uncertainty bound along the project.



of a flexible pavement using measurements from the Falling Weight Deflectometer.

The software integrates a series of artificial neural network models developed for a wide range of three and four-layer flexible pavement sections with variable depth to rigid layer.

The software provides the following capabilities:

- Input data automatically from a FWD file
- Process all ANN models mentioned above
- Account for uncertainty in the predicted remaining life using the Asphalt Institute, the Shell, or any user-defined model in rutting and fatigue cracking
- Incorporate information from traffic reports and condition surveys to develop and graphically display a pavement performance curve (PPC)
- Provide an automatic and real-time report
- Provide graphical presentation of the variation in remaining life along the pavement section with relevant statistics
- Establish upper and lower bounds for the PPC and the profile of the test section.

What We Found ...

So far, the proposed methodology has been validated with data obtained from the Texas Mobile Load Simulator (TxMLS) test sites. Results of the measured and predicted degradation of the section match closely when the structural and functional conditions of the pavement are combined.

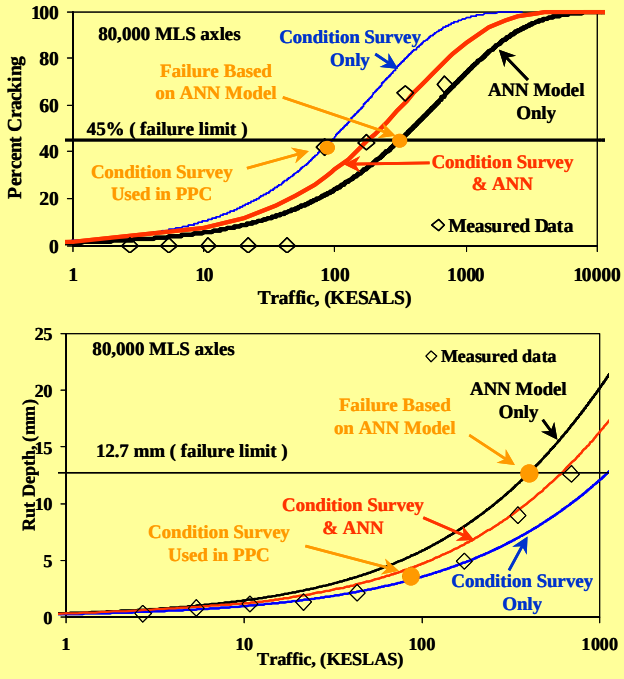
The following specific conclusions can also be drawn from our validation activities:

- The most reasonable predicted remaining lives were obtained when the condition survey at the time of the FWD testing was combined with the deflection measurement.
- Typically, the proposed model underestimated the remaining life based on rutting and over-predicted due to fatigue cracking. The differences can be mainly attributed to approximations involved in the proposed models and to the way localized damage is defined.
- When the geometrical and material-related variability of the site was considered, the remaining lives seem to fall between a 95% confidence interval for both rutting and fatigue.

The Researchers Recommend…

Based on the validation studies, Repp2000 is recommended for immediate implementation particularly by those districts that conduct routine network level FWD and condition survey of their pavements.

The proposed methodology has been validated with data obtained from the Texas Mobile Load Simulator (TxMLS) test sites. Examples of pavement performance curves due to rutting and cracking are demonstrated below. The measured and predicted degradations of the section match closely when the structural and functional conditions of the pavement are combined.



For More Details…

The research is documented in Reports

- 1711-1, *Artificial Neural Network-Based Methodologies for Rational Assessment of Remaining Life of Existing Pavements (April 1999)*
- 1711-2, *Artificial Neural Network Models for Assessing Remaining Life of Flexible Pavements (December 1999)*
- 1711-3F, *Stiffness Properties of Composite Pavements Using Artificial Neural Network-Based Methodologies (January 2001)*

Research Supervisor: Carlos Ferregut, Ph.D.
ferregut@utep.edu, (915) 747-6925
TxDOT Project Director: Ken Fults, P.E., Retired

To obtain copies of the report, contact Laura Cocke, Center for Transportation Infrastructure Systems, (915) 747-6925, or email http://ctis@utep.edu. See our catalog on-line at http://cits.utep.edu

TxDOT Implementation Status
November 2003

The primary application of REPP 2000 software is the calculation of pavement remaining life. The models included in the software will require further calibration before wide implementation can be done. TxDOT will not implement the finding of this project in the routine evaluation of pavements until this calibration can be accomplished.

However, the REPP 2000 software will be included in a web-based site in the future so people can have access to the software.

Contact: Dr. German Claros, P.E., Research and Technology Implementation Office (512) 467-3881, gclaros@dot.state.tx.us for further information.

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