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OFFICE OF TRANSPORTATION SYSTEM MANAGEMENT

TECHNICAL SUMMARY

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PROJECT COST:

\$78,000



GPR can be used on vans traveling at highway speeds.

Putting Research into Practice: Improving Calculation Tools for Testing Pavement Strength

What Was the Need?

To conduct field evaluations of pavement stiffness, engineers sometimes use the falling weight deflectometer. This involves dropping a large weight onto the pavement surface and transmitting the load through a circular plate; sensors placed on the pavement record the deformation in response to the load. MnDOT periodically conducts FWD testing at various locations on the state road network and at the request of Minnesota local transportation agencies. The data from these tests can help determine the maximum allowable weights for vehicles on the road and is useful for other pavement research and design purposes.

Calculating stiffness from FWD readings requires either estimating or measuring the thickness of the pavement layers. One device for measuring the pavement layer thickness is ground penetrating radar, in which radio waves are used to detect variations in the electrical properties of layer materials.

Despite the effectiveness of FWD and GPR for evaluating pavements, their use is limited by the complexity of interpreting the data they produce, and traditional methods for data analysis can require assumptions that reduce their precision. However, recent research has made newer methods available that address these problems. Research was needed to update MnDOT's existing software for FWD analysis, called GopherCalc, and to integrate GPR analysis into it, improve the software's ease of use and increase its accuracy by incorporating new GPR analysis methods.

What Was Our Goal?

The objective of this project was to update GopherCalc FWD analysis software with a user-friendly graphical user interface and the latest analysis methods. This would allow engineers to more easily evaluate pavements using FWD and GPR data.

What Did We Implement?

This project leverages [GPR](#) and [FWD](#) research to update MnDOT's GopherCalc program for calculating Young's modulus, a measure of a material's stiffness, from FWD deflection data. GopherCalc was built using MATLAB, a software tool for analyzing and visualizing data, as part of a 2007 project, [Resilient Modulus Development of Aggregate Base and Subbase Containing Recycled Bituminous and Concrete for 2002 Design Guide and Mn/Pave Pavement Design](#).

What Did We Do?

Investigators made improvements to the FWD analysis software GopherCalc to include GPR analysis and improve its accuracy. The updated software incorporates an improved method for calculating modulus from FWD data. It also incorporates an improved method for interpreting GPR data using an artificial neural network, a computer program that models learning and pattern recognition. GPR analysis involves using information about the travel times of electromagnetic waves, for which traditional methods

The GopherCalc software updated in this project will allow county and state engineers to more easily evaluate the structural capacity of pavements using falling weight deflectometer and ground penetrating radar data.

“The updated version of GopherCalc uses more comprehensive data in its calculations and consequently has the potential to improve MnDOT’s structural evaluation of pavements.”

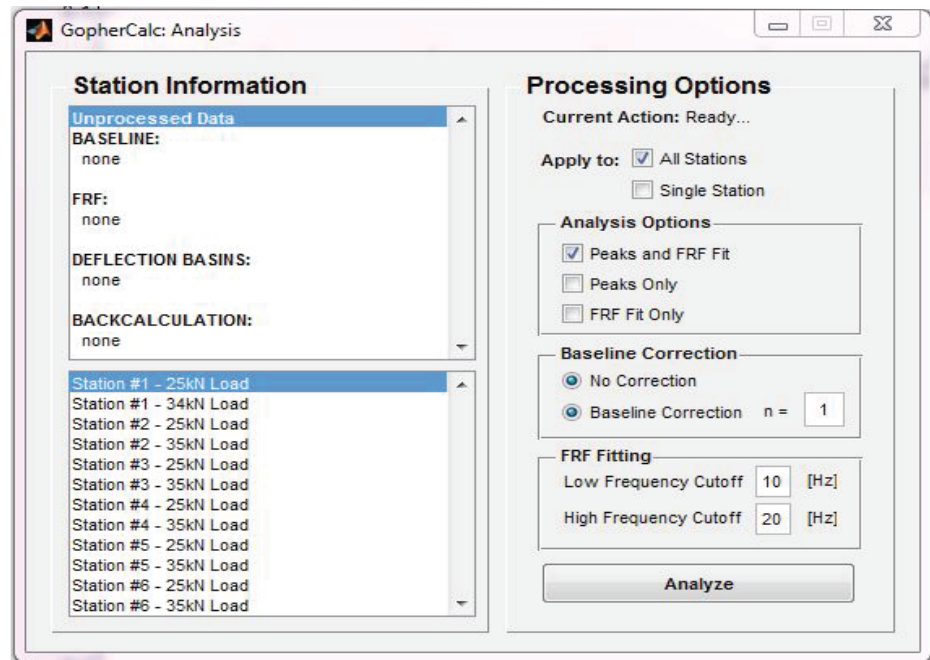
—Shongtao Dai,
Research Operations
Engineer, MnDOT Office
of Materials and Road
Research

“This software allows GPR estimates of pavement thickness to inform FWD analyses, increasing the accuracy of the results.”

—Joseph Labuz,
MSES/Miles Kersten
Professor, University of
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GopherCalc’s graphical user interface provides a user-friendly way to conduct analyses of GPR and FWD data.

have limitations. The new method uses the results of recent research in GPR to increase the accuracy of estimates of layer thickness.

Investigators also developed a graphical user interface for this software that provides a common interface for interpreting FWD and GPR data, and follows a step-by-step process that users can easily follow. Then they tested the software on pavement test cells at MnROAD, Minnesota’s pavement research facility.

What Was the Impact?

The new GopherCalc software has two separate graphical user interfaces for interpreting GPR and FWD data. Users can easily switch between these interfaces to perform step-by-step analyses. The FWD analysis makes use of the thickness calculated using the GPR analysis when this is available. Otherwise, it prompts the user to input the needed thickness data. The interface allows users to calculate modulus from FWD data.

The software improves on existing calculation methods by allowing GPR data to complement FWD data. The software facilitates visualizing GPR data in a way that allows examining data validity and preprocessing data to subtract ambient noise. Users should be aware that using GPR data to estimate layer thickness can be CPU-intensive.

The updated software makes FWD and GPR analysis more accessible to field engineers through a menu-driven package. The final report includes a user manual with step-by-step instructions for using the software to import data and conduct these analyses.

What’s Next?

Investigators recommend further field testing of the software as well as hands-on demonstrations for county engineers. Ultimately, the software developed in this project can be used by state and local agencies to more accurately evaluate pavement capacities.

This Technical Summary pertains to Report 2013-29, “Implementation of Pavement Evaluation Tools,” published November 2013. The full report can be accessed at <http://www.lrrb.org/PDF/201329.pdf>. The 2007 report mentioned that developed MATLAB is available at <http://www.lrrb.org/PDF/200725.pdf>.