



## RESEARCH SERVICES SECTION

# TECHNICAL SUMMARY

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### PROJECT COST:

\$96,000



Researchers used a percometer to measure dielectric constants in order to find correlations with pavement and soil material properties.

# Pavement Evaluation Using Ground Penetrating Radar

### What Was the Need?

Pavement engineers use ground penetrating radar to determine physical properties and characteristics of the pavement or subgrade. GPR helps engineers to determine the thickness of a pavement structure without resorting to excavation, and it has the potential to find utilities and other subsurface objects.

GPR can be mounted on a moving vehicle. Instead of shutting down a section of roadway, cutting out (coring) a number of samples, putting workers at risk and inconveniencing motorists, engineers can perform subsurface surveys with a GPR van operating at 50 mph. Another advantage of GPR is that it produces continuous data for pavement survey. Coring, in contrast, only provides data on a 6-inch diameter pavement sample; many cores may be required for a 1-mile pavement survey.

GPR identifies the types of materials detected using a material property called the dielectric constant, which describes a material's ability to propagate electromagnetic waves. When the dielectric constant of two materials is similar, as is the case for aggregate and concrete cement, radar waves reflecting off those materials can be difficult to distinguish. GPR readings are not, therefore, always reliable and must be carefully compared to records of pavement design and construction activity.

### What Was Our Goal?

The goal of this project was to develop new, more accurate algorithms for backanalyzing GPR field measurements performed on paved roads. These algorithms would need to efficiently translate GPR images into reliable information about the thickness of the asphalt concrete and aggregate base layers, and the mass density of the asphalt concrete layer. The algorithms should also present engineers with a clear picture of pavement distress, such as instances of delamination.

These findings should enable development of more accurate uses of GPR in assessing pavement thickness and the presence of subsurface anomalies even in cases where pavement records may not be available and coring is limited or absent.

### What Did We Do?

Researchers analyzed past methods of interpreting GPR data and developed a new approach using sophisticated electromagnetic waveform analysis methods and an appropriate backcalculation model. This involved developing pattern-recognition technology that can be used on a pavement system without prior dielectric layer information, as well as a computer model that generates synthetic GPR time histories. These histories were tested in an algorithm that derives pavement layer thicknesses, dielectric constants and specific forms of damage from such data.

Researchers identified correlations in data and adjusted backcalculation methods for more accurate interpretation of GPR data.

### What Did We Learn?

The computer model developed for this study generates synthetic GPR time histories for a wide range of pavement profiles, as characterized by layer thicknesses, dielectric constants and specific forms of damage. The resultant database of synthetic histories has been used in pattern-recognition software that can analyze measured pavement time histories to instantly identify the pavement as fitting a particular profile. This procedure

*"This technology is great. If you want to redesign a distressed pavement, you have to know the pavement's thickness. This gives us a continuous profile of the pavement rather than information from specific cores at a limited number of points."*

**—Shontao Dai,  
Mn/DOT Research  
Operations Engineer**

*"Unlike the traditional GPR method, this emerging technology can be deployed with no prior information about the pavement system's dielectric layer properties. It carries significant potential to evaluate pavement distress."*

**—Joseph F. Labuz,  
Professor, University of  
Minnesota Department  
of Civil Engineering**



GPR is mounted on a van and gathers pavement structural data, such as thickness, at 50 mph so workers don't need to close traffic lanes to cut out multiple pavement samples.

does not require any prior information or assumptions about the pavement system, such as dielectric layer properties, nor does it require subjective image adjustments.

This study enabled researchers to refine the backcalculation method and deliver a calibration system based on the height of the GPR unit during the survey. This method provides a way to measure pavement thickness at far less cost, inconvenience and risk to workers than coring. It measures conditions in the field without the need for pavement design or construction records.

### **What's Next?**

With further refinement and corrections, the tools developed for this study will be applicable to Mn/DOT's GPR data analysis: Mn/DOT already advises regional engineers to use GPR for pavement profiling—particularly in determining asphalt layer thickness—and for locating utilities.

Using the GPR time history database to classify pavements offers significant potential for evaluating pavement distress, including delamination. Accuracy in this area is particularly important in situations where fluctuations in moisture levels within the pavement system can lead to a serious misdiagnosis and unnecessary rehabilitation.

Other diagnostic uses for GPR—and other non-GPR methods for determining dielectric constants—could be developed to further refine GPR use.

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