Brief

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Ground Penetrating Radar (GPR) for Pavement Thickness

Research Development and Technology Division

Missouri Department of Transportation

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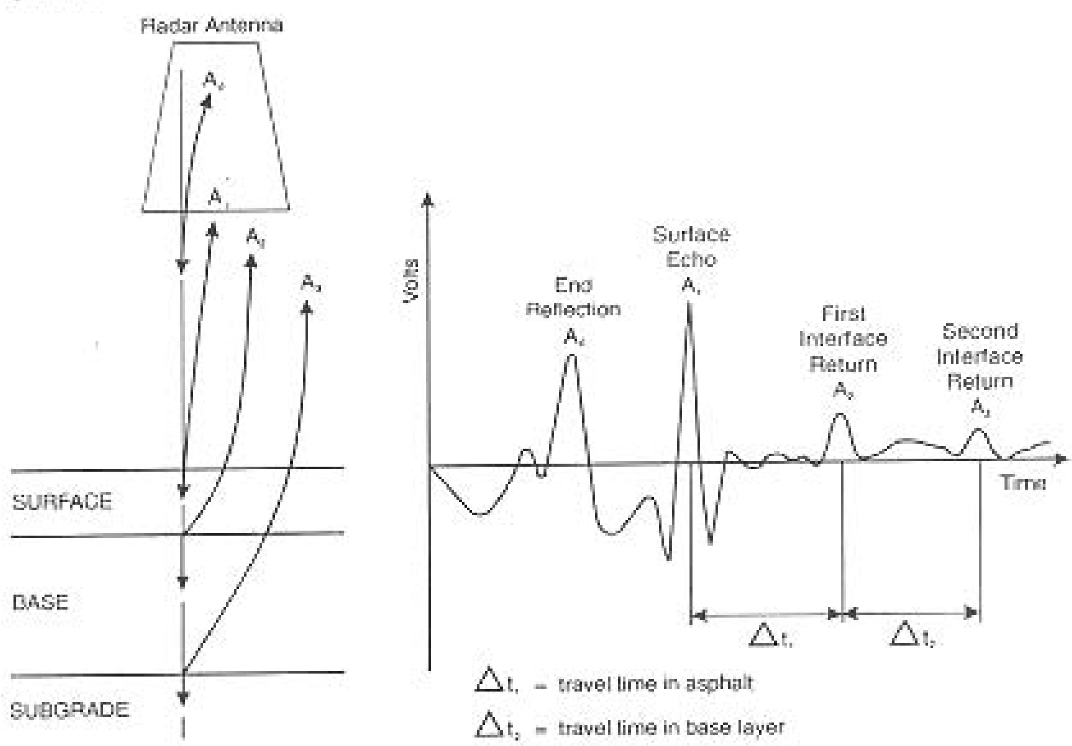
Description:
Ground Penetrating Radar (GPR) surveys were conducted for the Missouri Department of Transportation by Pavement Systems Engineering and Infrasense Inc. to compare its accuracy to current coring methods for quality control measuring of final pavement thickness. Three new pavement projects using both full depth asphaltic concrete (AC) and portland cement concrete pavement (PCCP) were measured. The projects and costs were:

Route	County	PCCP Thickness	AC Thickness	GPR Costs $/Mile	(1 pass/12' lane) $/Square Yard
10	Ray	—	12"	$ 1188	$ 0.17
63	Howell	—	17"	$ 1188	$ 0.17
71	Newton	14"	—	$ 332	$ 0.05

Ground Penetrating Radar operates by transmitting short pulses of electromagnetic energy into the pavement. These pulses, as shown in the left side of Figure 1, are reflected back to the antenna with the amplitude and arrival time that is related to the electrical properties of the pavement layers. The reflected energy is collected and displayed as a waveform, as shown on the right side of Figure 1.

Figure 1 - Principles of Ground Penetrating Radar.
The Incident Wave is reflected at each layer interface and plotted as return voltage against time of arrival in nanoseconds



Procedure:

Before paving started three foot by three foot (3' x 3') targets of aluminum foil were set on top of the base rock with the intent that more accurate thickness could be obtained with a reflective layer at the interface of the pavement bottom and top of base rock. After paving cores were taken at the normal intervals of 1000 ft. A van equipped with a 1.0 GHz air launched pulsed radar antenna and processing equipment was then used to run ground penetrating radar (GPR) profiles down the center of the pavement in order to measure pavement thickness at locations over the aluminum foil targets and near the coring locations. Missouri specifications currently require the pavement to be no more than 0.2 inches thin of the plan depth or deductions in contract price are made.

Advantage:

GPR thickness measurement is much faster than conventional coring and virtually non-destructive. The GPR van can move at 15 mph or more and takes a continuous scan of the pavement thickness (1 trace per foot at 30 mph) compared to a core taken every 1,000 feet. Since GPR is also non-destructive, full depth coring in the brand new pavement can be almost eliminated.

Results:

The GPR data collected on the two AC projects was judged to be of good quality. The interface between the AC and the Granular Base was clearly located. On the 12" AC the average error between the 30 measured core thicknesses and those computed blind (not calibrated to cores) with GPR was 0.46 inches or 3.5%. Given two core thicknesses to calibrate against accuracy improved to 0.17 inches or 1.4% when . On the 17" AC the average error between the 49 measured core thicknesses and those computed with GPR was 0.2 inches or 1.1%. GPR profiles determined the average AC thickness in both lanes was greater than 17.5 inches. According to GPR less than 1% of the total project was computed to be less than 16.4 inches thick, these being highly localized short problem areas. GPR has another potential benefit, it can be used to check for other defects such as poorly compacted lower layers and for the presence of anomalies with in the AC.

Several challenges arose when trying to measure the 14" PCCP using GPR. Because the dielectric properties of concrete change as the concrete cures, the pavement could not be surveyed until it was over 30 days old. The objective of the aluminum foil sheets placed on top of the base was to provide a reflective target to enhance the detection of the GPR signal at bottom of the concrete. Coring later showed no signs of the foil, suggesting that the foil had disintegrated through reaction between the aluminum and concrete. Even so, the average error between the 70 measured core thicknesses and those computed by GPR was 0.39 inches or 2.8%. Infrasense Inc. believed a better target than the aluminum foil, which did not work, could have improved the GPR's accuracy. They suggested using a 1 1/2" diameter steel pipe, 3' long, set transverse to the roadway and laying flush with the top surface of the base layer. GPR did prove, however, promising enough to consider using it on another upcoming PCCP project for comparison with present coring procedures. If GPR procedures can be improved enough, the need for coring can be reduced or possibly even eliminated. Cores would need to be taken only to calibrate the GPR and to verify areas of deficient pavement thickness or anomalies which may be due to inferior quality concrete.

Conclusions:

GPR may never totally replace coring but it has the potential of identifying where cores should be taken and to radically reduce the number of cores required on any project. It is currently being used by many highway agencies to measure the thickness of existing pavements and using the data in pavement management systems. The use is two fold because while gathering thickness data, GPR is also gathering data that can show other anomalies in AC or PCC pavements, areas of poor quality in new pavements or deterioration in old ones. MoDOT is currently carrying out research using GPR in several different applications: for bridge deck evaluation; locating sink holes, caves, tunnels and underground storage tanks; archeological investigations; and for detecting scour around bridge piers.

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Want the Whole Story?

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