Ground Penetrating Radar (GPR) for Pavement Thickness

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:

<table>
<thead>
<tr>
<th>Route</th>
<th>County</th>
<th>PCCP Thickness</th>
<th>AC Thickness</th>
<th>GPR Costs $/Mile</th>
<th>GPR Costs $/Square Yard</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Ray</td>
<td>—</td>
<td>12&quot;</td>
<td>$1188</td>
<td>$0.17</td>
</tr>
<tr>
<td>63</td>
<td>Howell</td>
<td>—</td>
<td>17&quot;</td>
<td>$1188</td>
<td>$0.17</td>
</tr>
<tr>
<td>71</td>
<td>Newton</td>
<td>14&quot;</td>
<td>—</td>
<td>$332</td>
<td>$0.05</td>
</tr>
</tbody>
</table>

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.

\[ \Delta t_1 = \text{travel time in asphalt} \]
\[ \Delta t_2 = \text{travel time in base layer} \]
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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