NETWORK PAVEMENT EVALUATION USING FWD AND GPR

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Objectives:
1. Prepare for Full Implementation of AASHTO 2002 (Mechanistic Information)
2. Support Pavement Layers Thickness Inventory & Minimize the Need for Coring
3. Possible Integration with Pavement Management

Thickness Information
- How deep the pavement surface can be milled before resurfacing

Rehabilitation Strategies

Coring to Verify Pavement Thickness
- Needs to be Minimized

Pavement Stiffness
- Center Deflection in mils, 9000 Pounds (40 KN), 68 F (20 C)

<table>
<thead>
<tr>
<th>ESALs, Millions</th>
<th>Excellent</th>
<th>Very Good</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 30</td>
<td>&gt; 6</td>
<td>6 – 10</td>
<td>6 – 8</td>
<td>8 – 10</td>
<td>&gt; 8</td>
</tr>
<tr>
<td>10 – 30</td>
<td>&lt; 4</td>
<td>&lt; 6</td>
<td>6 – 10</td>
<td>10 – 12</td>
<td>8 – 10</td>
</tr>
<tr>
<td>&lt; 10</td>
<td></td>
<td></td>
<td>6 – 8</td>
<td>10 – 12</td>
<td>12 – 14</td>
</tr>
</tbody>
</table>

FWD
- Deflection Bowl is Dependent Upon Thickness & Material Properties

HMA
Composite

- How deep the pavement surface can be milled before resurfacing

Interstates
- Heavy Traffic
- Medium Traffic
- Light Traffic

- Pavement Stiffness
- Center Deflection in mils, 9000 Pounds (40 KN), 68 F (20 C)
GPR

- Ground Penetrating Radar (GPR) pavement related technology was developed during the SHRP program.
- Short wave pulses of electromagnetic energy are transmitted into the pavement.
- These pulses are reflected at each interface back to the radar antenna with the voltage amplitude and arrival time that is related to the thickness and material properties of pavement layers.

GPR Principles

- Reflections captured from surface and subsurface layer interfaces.
- Thickness of surface layer calculated from t1.
- Amplitudes of reflection strongly influenced by layer moisture content and density.
- Changes in surface reflection A1 used to detect segregation.
- Changes in base reflection A2 used to detect changes in base moisture content.

Dielectric Constant

<table>
<thead>
<tr>
<th>Material</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCC</td>
<td>9</td>
<td>6 – 12</td>
</tr>
<tr>
<td>Rock</td>
<td>7</td>
<td>6 – 12</td>
</tr>
<tr>
<td>HMA</td>
<td>5</td>
<td>3 – 7</td>
</tr>
<tr>
<td>Dry Aggregate</td>
<td>7</td>
<td>5 – 9</td>
</tr>
<tr>
<td>Wet Aggregate</td>
<td>15</td>
<td>10 – 20</td>
</tr>
<tr>
<td>Subgrade</td>
<td>15</td>
<td>5 – 20</td>
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<tr>
<td>Water</td>
<td>80</td>
<td></td>
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<tr>
<td>Air</td>
<td>1</td>
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</tbody>
</table>

Standard Tests

- FWD: AASHTO T – 256
- ASTM D 4694
- GPR: ASTM D 4748
**FWD Data Collection**
- Truck Lane, Both Bound Directions
- 5 Points/Mile
- 9000 Pounds Load, 68 F Temperature

**GPR Data Collection**
- Truck Lane, Both Bound Directions
- Thickness Picks, at least 5 Points/Mile

**Thickness Data**
- GPR – FWD – Cores

**FWD Response Variables**
- Normalized Deflection
- Subgrade MR & CBR
- Surface Modulus and Layer Coefficient
- Support Modulus and Layer Coefficient
- Surface Thickness & Structural Number
- Support Thickness & Structural Number
- Total Thickness and total Structural Number
- Remaining Life, Years
- Overlay Thickness Required

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**I-69 North Bound Driving Lane**

**Normalized Center Deflection, Mils**

<table>
<thead>
<tr>
<th>Reference Post, Miles</th>
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<tbody>
<tr>
<td>0</td>
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<tr>
<td>Normal Center Deflection, Mils</td>
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<td>0</td>
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**FWD Thickness, Inches**

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<tr>
<td>Mean Total</td>
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<tr>
<td>Mean Surface</td>
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**Interstate Comparisons**

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**Concrete Section**

- 330 mm (13 inches) of HMA overlay over Cracked and Sealed JRCP
- 305 mm (12 inches) of concrete overlay over JRCP
- 190 mm (7.5 inches) of fiber-modified HMA overlay over Cracked and Seated JRCP

**Rubblized + HMA Section**

- 12" Concrete Overlay
- 10" Old JRCP

**US & SR Comparisons**

- Modulus, Ksi
- Surface, Support, Subgrade

**I - 65 North Bound Driving Lane**

- SB: MM 237.8, MM 229.1, MM 223.4, MM 217.2
- NB: MM 237.8, MM 229.1, MM 223.4, MM 217.2
- 190 mm (7.5 inches) of fiber-modified HMA overlay over Cracked and Seated JRCP
- 330 mm (13 inches) of HMA overlay over rubblized JRCP
- 305 mm (12 inches) of concrete overlay over JRCP

**GPR, Pavement Thickness, Inches**

- 12" Concrete Overlay
- 10" Old JRCP

**Reference Post, Miles**

- 217 218 219 220 221 222 223 224
- 223 224 225 226 227 228 229 230
- 230 231 232 233 234
FINDINGS & CONCLUSIONS

A pavement thickness and structural capacity inventory of INDOT Interstate Highways was developed.

INDOT Interstate Highway pavements are currently in a very good structural condition.

FINDINGS & CONCLUSIONS

GPR estimates concrete thickness of concrete pavements, HMA thickness of flexible pavement and HMA thickness of composite pavements almost perfectly.

GPR thickness estimation of pavement layers underneath these layers is not as accurate and needs adjustment through very limited coring.

GPR did not provide any estimate of unbound pavement layers or total pavement thickness.

FINDINGS & CONCLUSIONS

FWD can be used to estimate combined surface thickness and total pavement thickness.

Estimate of combined surface thickness matched the GPR estimate in some situations or was slightly lower.

GPR is not expected to completely eliminate the need for coring. GPR can be used to establish the coring requirements to help interpret the GPR data fill the gaps in thickness estimation and verify thickness results.

FINDINGS & CONCLUSIONS

Network level testing employing FWD and GPR is a worthwhile, technically sound program that can be integrated in pavement management strategies.

FWD data on 2200 lane miles of the INDOT network is recommended annually for network level pavement evaluation.

Only three FWD tests per mile in the driving lane of one direction are recommended. The information collected will allow the equivalent of 100% coverage of the whole network in 5 years.

U.S. Roads and State Routes may need more emphasis in network level testing than Interstate Highways.