Nondestructive Evaluation of Bituminous Compaction Uniformity: GPR

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What is GPR?

- GPR is a non-invasive, non-destructive testing tool for mapping subsurface conditions.
- E-M waves detect objects and determine distance from the object.
Why Use GPR for Air Voids?

• Washington DOT 1989 study found pavement density has great effects on performance
  – Each 1% increase in air voids beyond 7% leads to ~10% loss in pavement life
• Lack of density is local, can be missed by coring
  – Core is local evaluation
  – Need full coverage evaluation of the surface
• GPR is a potential tool: Continuous profile
  – Locate relative high- or low-density areas based on dielectric map
Rolling Density Meter

• RDM operates in passes in regions of interest (e.g., near longitudinal joint)
  – Pass width depends on number of antenna arrays, size of region

• Can be operated without extensive training
  – Data acquisition relatively quick
  – Data processing/analysis handled by software
SHRP2 R06C

- PI: Tom Scullion, Texas A&M
- Completed: December 2013

Using Infrared and High-Speed Ground-Penetrating Radar for Uniformity Measurements on New HMA Layers

SHRP2 RENEWAL RESEARCH
Rolling Density Meter

Saarenketo and Scullion, 2000
1. Survey Setup
   a. Survey wheel calibration
   b. Project and data file input format
   c. General survey considerations
   d. Survey types
   e. Survey Distance
2. Survey Data Collection
   a. RDM data collection
   b. Core data collection
3. Data Processing
   a. Exporting data
   b. Airvoid VS Dielectric Calibration
4. Data Analysis and Applications
Survey Distance

• 500 ft survey recommended
• Generally larger than construction/design changes
• Makes data entry easier
• Limits user input and processing errors
• Any data loss is limited to 500ft
• Limits walking distance when returning for cores
• Small section allows RDM survey to stay close to paving crew during moving operations
General Survey Considerations

- Surveys should be conducted as soon after paving as possible.
- Survey parameters must consider paving speed/closure time.
- Battery charge typically limits RDM surveys to 6 hrs.
- Conducting a joint survey requires a minimum of 9 in. of pavement on the other side of the joint. Coordinate traffic barrel placement and removal accordingly.
- **Survey closest to traffic should be conducted against the direction of traffic**, allowing users to see any troublesome vehicles before they arrive.
**Survey Methods: Survey Types**

**Lane pass survey:** The center sensor is offset 6ft from longitudinal joint.

**Joint pass survey:** The center sensor is offset 2.5ft from the longitudinal joint.

**Swerve survey:** The center sensor is offset 6ft from longitudinal joint and the cart is swerved.
• Operator can view dielectrics in real time to provide feedback to paving crews
Infield Data Analysis

Though dielectric does not give direct, immediate measurements of compaction, it can provide valuable infield insights:
• Effect of different roller variables (pattern, vibration, etc)
• Relatively high and low joint compaction achievement
• Regions of anomalous low dielectric (low compaction) can be compared with construction practices at that location
• Overall variability
Example of Infield Data Analysis: Joint anomaly worthy of investigation
Core Data Collection

- Cores are necessary for creation of the dielectric - % air void calibration curve.
- Unique dielectric -% airvoid curves need for unique sections.
- Consult with contractors to determine “unique sections”
- A minimum of 10 recommended
- Location of high and values can be found in “File Playback” -> ‘Core Locations’.

<table>
<thead>
<tr>
<th>Relative Dielectric</th>
<th>Sensor Position</th>
<th>Distance (ft)</th>
<th>Dielectric (%)</th>
<th>1 ft Average</th>
<th>2 ft Average</th>
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</thead>
<tbody>
<tr>
<td>High</td>
<td>Center</td>
<td>1155+99.02</td>
<td>5.68</td>
<td>0.08</td>
<td>0.11</td>
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<td>0.09</td>
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<td>0.06</td>
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<td>5.66</td>
<td>0.10</td>
<td>0.13</td>
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<td>5.65</td>
<td>0.10</td>
<td>0.14</td>
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<tr>
<td>Low</td>
<td>Left</td>
<td>1155+23.95</td>
<td>4.79</td>
<td>0.08</td>
<td>0.12</td>
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<tr>
<td>Low</td>
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<td>0.07</td>
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<td>4.80</td>
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</tbody>
</table>

- Current stationing – core location = distance to core
- 1160+00 – 1155+99.02 = 400.98 ft
Core Data Collection (cont.)

- $L_{\text{unique}} < 2500\text{ft}$: Collect two high, two low, and one medium core in both the first and last 500ft sections of the unique section. This results in 10 cores.
- $2500\text{ft} < L_{\text{unique}} < 10000\text{ft}$: Collect one high AND one low in each 500ft section. This results in 10 – 40 cores.
- $L_{\text{unique}} > 10000\text{ft}$: Collect one core, alternating high and low, in every other 500ft section. This produces a minimum of 10 cores.

- Cores should be distributed spatially and cover full range of dielectrics
- If joint cores are unavailable, shoulder can be cored for low dielectric values
%Airvoids vs Dielectric Calibration

- Filter cores with QA/QC
- If “Core Survey” was collected, average data within +/- 0.25ft of core
- Fit exponential curve to %airvoids vs dielectric in Excel or RDM software (recommended)
- Go into main menu ->Collect-Existing Project->Core Calibration -> Calc from Cores and enter airvoid and dielectric data
- Select ‘save’
- Dielectrics can now be viewed as air void
Air Void Maps

- Once calibration coefficients are entered air void map can be plotted
Case Study: HW52

- Core vs RDM data can be used to convert dielectric values to air void content with unique confidence interval (1 std) information specific to each project/unique section.

- More specific core data produces better fit
Case Study (cont.)

- Relating compaction to construction practices
• Construction records suggest reduced binder content or transition to new paving day may have resulted in decreased compaction
Surface view of dielectric map with associated air void changes due to construction.
Key Lessons Learned

• RDM survey allows real time feedback which can influence paving decisions

• RDM survey must be adapted to project characteristics

• Data file organization is crucial

• Air void calibration with associated confidence intervals can be used to evaluate the compaction efforts at a greater coverage than is achievable using cores alone

• Identification of low and high air void content areas can be compared with construction practices to determine the most critical factors in achieving improved density
Opportunities to Enhance QC on Asphalt Pavements

- Use RDM for continuous profiling of critical locations such as longitudinal joint evaluation
- Evaluate density based on GPR mapping, not just on limited core samples
- Provide feedback during paving operation to optimize performance
- Evaluate new innovative construction methods
  - e.g., Use map or profile to show actual benefit of the method to determine if/when it should be applied