Detection of Stripping in HMA

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Outline

- Objective
- Project Hypotheses and Testing Methods
- Pilot Project Findings
- Conclusions
- Recommended Survey Strategy
Project Objectives

- To develop an asphalt pavement survey protocol using nondestructive techniques to detect stripping in HMA

Goal:
The protocol developed to quantify the affected area, depth, and severity of stripping in pavements that are mill and overlay candidates
Project Hypotheses

- The modulus, tensile strength and tensile strain of an HMA mixture are significantly affected by the level of moisture damage.
- GPR technology can be used to identify areas with non-uniform properties associated with moisture damage.
- Seismic test results can provide a measure of the modulus of the HMA.
- Seismic testing provides comparable results to laboratory measured modulus values.
Equipment/Methods Employed
Two Pilot Projects

- Phase I project involved full suite of candidate technologies
- Phase II project involved a reduced set of the most effective technologies
Pavement Structures

Phase I
- 1964
  - SG: 12"
  - GAB: 8"
  - HMA Base: 10"
  - HMA: 3"
  - O/L: 1-½"
  - FC: 2 inches AC ‘B MOD’
  - ¾ inches OGFC ‘E’

Phase II
- 1974
  - 12 or more inches AC Base
- 1977
  - 6 inches GAB
- 1983
  - 2 inches AC ‘B MOD’
- 1993
  - 1½ inches AC ‘B MOD’
- 1994
  - 1 inch AC ‘B MOD’

ARA
Baseline HMA Modulus

Temperature, °F

Total Resilient Modulus, ksi

Expected Low Values
Expected High Values
Baseline for I-75
Phase I Seismic Chart

Control Chart: Adjusted Seismic Modulus; 77°F

Station

Adjusted Seismic Modulus, ksi

800+00 850+00 900+00 950+00 1000+00 1050+00 1100+00

Baseline

Upper Limit

Lower Limit
GPR Uniformity Index

- Changes in electromagnetic properties are associated with changes in physical properties characteristic of moisture damage.
- Because moisture damage varies spatially, localized variability in electromagnetic properties can be an indicator of moisture damage.
- Uniformity index measures local variability. A uniform condition results in UI = 1.0.

\[
UI(x) = \frac{\overline{A}(x)}{\overline{A}\left(x \pm \frac{L}{2}\right)}
\]
Phase I Uniformity Index

Milepost

Stripping Index

Seismic Modulus (ksi)

Uniformity Index

GPR Uniformity Index

Seismic Modulus

Milepost
Phase I IDT Results

- **Core Number**
- **IDT Dynamic Modulus, ksi**

- **Expected High Value**
- **Expected Low Value**

- **Binder Layer - Stripping**
- **Binder Layer - No Stripping**
- **Base Mix - No Stripping**
Phase I Findings

- Thermal anomalies were not good indicators of deterioration from stripping in full-depth asphalt pavements.
- Forward-calculated HMA moduli from FWD basins were not sensitive to moisture damage.
- Seismic tests indicate that the uppermost layer (3 to 4 inches) is in good condition with lower quality material between 4 and 6 inches below the surface.
Phase I Findings (concluded)

- GPR is an effective screening tool to identify areas with changes in electromagnetic properties possibly caused by moisture damage.
- The GPR Uniformity Index provides a method to pinpoint localized non-uniformity within the pavement section.
- The upper 8 inches of HMA should be removed during rehabilitation to preclude significant distortions from construction traffic.
Recommendations for Phase II

1. Eliminate FWD and IR thermography from survey protocol.
2. Use GPR and seismic in combination to identify layers with moisture damage or other anomalies.
3. Obtain cores from pavement section and conduct IDT testing on selected cores.
4. Compare the GPR UI, seismic modulus, and core condition to confirm the initial criteria used. Make any adjustments for the specific HMA mixture.
5. Designate the areas with various levels of moisture damage for use in rehabilitation design.
Phase II Seismic Control Chart

Adjusted Seismic Modulus, ksi

Milepost

Baseline
Upper Limit
Lower Limit
Phase II GPR UI and Seismic Modulus

![Graph showing GPR Uniformity Index and Seismic Modulus vs. Milepost. The graph includes a trendline for Seismic Modulus.]
GPR Uniformity Index

Distance from MP270 (ft.)

Lane 1
Lane 2
Lane 3

Uniformity Index: 7” to 16” Depth

Uniformity Index: 3” to 7” Depth

MP270

Distance from MP270 (ft.)

Lane 1
Lane 2
Lane 3

Uniformity Index: 7” to 16” Depth

Uniformity Index: 3” to 7” Depth

MP271 (est.)
Phase II IDT Results

 факторы

- 3 to 5 in.
- 7 to 10 in.
- 14 to 16 in.

Expected High Value

Expected Low Value

IDT Dynamic Modulus, ksi

Core Number

ARA

EXPANDING THE REALM OF POSSIBILITY
Phase I and II Fatigue Properties

Dynamic Modulus, ksi

Tensile Strain at Failure, mils/in.

ADEQUATE FATIGUE PROPERTIES

INFERIOR FATIGUE PROPERTIES

- Standard Mix - AASHTO
- Ph I Base
- PH 1 Binder
- PH II Base
- Ph II Binder
- Ph II Surface
General Conclusions

- Visual observations of cores are inconclusive. Laboratory tests on the cores are required to characterize the degree of the moisture damage.
- Seismic and GPR technologies should be used in combination to improve on the reliability of identifying layers with moisture damage, stripping, or other anomalies beneath the pavement surface.
- Output from procedure can be used directly in new mechanistic-empirical design guide.
Conclusions – Phase I

- Widespread moisture damage exists within the intermediate (binder) layer at a depth of 4 to 8 inches.

- While little of this damage has progressed to full-blown stripping, the integrity of the material has been compromised to the extent that rehabilitation design strategies will be impacted.

- Remove top 8 inches as a part of the rehabilitation strategy.
Conclusions – Phase II

- Moisture damage is isolated to localized areas.
- The GPR survey suggests that moisture is present along the entire length of the pilot project.
- GPR and seismic comparison shows that
  - Moisture is primarily confined to the interfaces between layers.
  - Moisture has reduced bond between layers, but has not affected the integrity of the HMA
- Most mix disintegration has occurred near the lower portion of the base layer.
- With the exception of a couple of isolated locations, any damaged material is far enough below the surface so that it should not influence the rehabilitation strategy.
Recommended Survey Strategy

1. Review the construction history.
2. Review the surface condition.
3. Estimate the threshold values of dynamic modulus.
4. Perform a complete GPR survey on the roadway and determine the UI along the project.
5. Segment the roadway based on the UI values by identifying areas where variability exceeds normal construction/materials variation.
6. Conduct seismic tests in each segmented area.
7. Develop a field sampling plan to take cores within each of the different segmented areas.
8. Compare the GPR UI, seismic modulus, and core condition.
9. Validate by performing laboratory tests from each segmented area.
10. Designate the areas with various levels of moisture damage for use in rehabilitation design.
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