Polymer-Modified Asphalts – Enhancing HMA Performance

Wilkes-Barre, PA.
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Study Sponsors:

Industry Associations

- The Asphalt Institute
- The Association of Modified Asphalt Producers

Federal Highway Administration

Corporate Sponsors

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- Dynasol LLC
- Goodyear Chemical
- KRATON Polymers
- Polimeri Europas Americas
- Ultrapave
Presentation Overview

1. Study Objectives & Status
2. Overview of *Users Opinions*
3. Performance Comparisons
4. Summary of Initial Findings
Study Objectives

1. Quantify the effect of using PMA as compared to conventional-unmodified HMA mixtures.

2. Identify conditions that maximize effect of PMA to increase HMA pavement & overlay life.
Phase I Tasks:

1. Update literature review.
2. Update contacts with selected agencies.
3. Review test sections with PMA mixes.
4. Select companion PMA & unmodified HMA test sections.

Completed
Phase II Tasks:

5. Predict performance of test sections.
6. Compare performance characteristics of PMA & unmodified HMA pavements.
7. Prepare study documents.

90% Complete
Reason for Using PMA?

- **R** = Rutting
- **T** = Thermal Cracking
- **F** = Fatigue Cracking
- **M** = Moisture Damage or stripping
- **D** = Durability
- **R** = Raveling
- **T** = Tenderness

![Bar chart showing response percentages for various pavement issues](chart.png)

**Response, %**
Is There a Benefit Using PMA?

Yes, **BUT**: Insufficient data to quantify that benefit.
Concern: Short-Term versus Long-Term Benefit?

Data needed to quantify long-term benefit.
Finding & Conclusion

- PMA mixtures do extend the service life of HMA pavements & overlays.

The real issue is:

**QUANTIFICATION OF THE INCREASE IN SERVICE LIFE.**
Selected Pavement Locations for Detailed Analyses in Phase II

Not all LTPP sites located on map.
Test Sections - Experiments

- LTPP: Core & Supplemental Sections
  - SPS-1; SPS-5; SPS-6; SPS-9
  - GPS-1; GPS-2; GPS-6; GPS-7

- MTO Modifier Study

- Accelerated Pavement Tests, examples
  - FHWA ALF, Turner Fairbanks
  - NCAT Test Road
  - California HVS Studies

- Individual State Agency Test Sections
# Experimental Factorial

<table>
<thead>
<tr>
<th>Pavement Cross Section</th>
<th>Foundation</th>
<th>Climate</th>
<th></th>
<th></th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Freeze</td>
<td>Non-Freeze</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wet</td>
<td>Dry</td>
<td>Wet</td>
</tr>
<tr>
<td>Thin HMA</td>
<td>Fine-Grained</td>
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<td>2</td>
<td>4</td>
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<tr>
<td></td>
<td>Coarse-Grained</td>
<td>3</td>
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<tr>
<td>Thick HMA</td>
<td>Fine-Grained</td>
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<tr>
<td></td>
<td>Coarse-Grained</td>
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<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Full-Depth</td>
<td>Fine-Grained</td>
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<tr>
<td></td>
<td>Coarse-Grained</td>
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<td>2</td>
</tr>
<tr>
<td>HMA Overlays</td>
<td>HMA</td>
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<td>3</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>PCC</td>
<td>4</td>
<td>3</td>
<td>4</td>
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<tr>
<td>Total No. PMA Sections</td>
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<td>16</td>
<td>17</td>
<td>26</td>
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</tbody>
</table>
Types of Analyses: PMA Versus Unmodified Mixes

- Comparison of actual distress observations; companion sections
- Mechanistic-empirical analysis of performance history:
  - Fracture, Load Related
  - Distortion, Load Related
Performance Evaluations

- Load Related Cracking
- Rutting
- Thermal Cracking
- IRI, Smoothness
- Other Surface Distress
Load Related Cracking Analysis

Unmodified Mixes Versus PMA Mixes
Load Related Cracking: PMA Versus Unmodified Mixes

One data point represents a PMA & Companion Unmodified Section

Fatigue Cracking - PMA Mixes, %

Fatigue Cracking - Conventional HMA Mixes, %

Line of Equality
Fatigue Cracking Analysis

PDMAP Fatigue Curve initially used in fatigue analysis.

\[
\log(N_f) = 15.947 \beta_{f_1} - 3.291 \beta_{f_2} \log\left(\frac{\varepsilon_t}{10^{-6}}\right) - 0.854 \beta_{f_3} \log\left(\frac{E_{HMA}}{10^3}\right)
\]

\(\beta_f = 1.0\) for initial damage analyses
Importance of Local Calibration

Fatigue Cracking Evaluations
Local = Cell
Cracking versus Damage Index

\[ \text{Damage Index} = \frac{n_{\text{actual}}}{N_f} \]

Line represents Unmodified Mixes
Rutting Analysis

Unmodified Mixes

Versus

PMA Mixes
One data point represents a PMA & Companion Unmodified Section

Line Of Equality
Rutting Evaluation

Permanent-resilient strain ratio used in initial analysis.

\[
\begin{align*}
\log(N_R) &= 4.587\beta_R^{R1} + \frac{\beta_R^{R2} \log\left(\frac{\varepsilon_p}{\varepsilon_r}\right)}{0.4471(\beta_d)} \\
&- 3.491\beta_R^{R3} \log(T)
\end{align*}
\]

\(\beta_R = 1.0\) for initial distortion damage analyses
Importance of Local Calibration

Rut Depth, inches

Distortion Damage Index

Adjusted Distortion Damage Index

Rutting Evaluations
Local = Cell
Rutting versus Damage Index

Line represents Unmodified Mixes
Findings

Field & laboratory investigations of PMA mixes suggest:

- **Enhanced Performance**
  - 25 to 100 % increase in service life
  - 3 to 10 years increase in service life
- **Reduced Maintenance Activities**
  - Crew Safety
  - Traffic Delay
Estimate of Enhanced Performance Based on Damage Analysis

Damage Analysis

Damage Index

Age, years

Conventional HMA Mixtures

PMA Mixtures
Finding

Mechanistic-empirical analysis confirms need for different calibration factors for predicting performance of PMA mixes.
Observation

- Longitudinal cracking in wheel path is much lower in PMA mixes, as compared to conventional-unmodified mixes.
Products from Study

1. Detailed Study Report
2. Executive Summary of Findings
3. Guidelines for Application & Use

- Pavement Structural Design
- Life Cycle Cost Analysis
Thank you for your attention - Any questions?

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