51st Annual Idaho Asphalt Conference
October 27, 2011

Modified Asphalt Binders – Enhancing Pavement Performance

Harold L. Von Quintus, P.E.
Focus

- Overview the effect of modified asphalt binders for enhancing pavement performance – extending the service life of new pavements and overlays.
Effect of Binder on Performance

1. Thermal Cracking
2. Fatigue Cracking
3. Rutting

Most, if not all agencies in U.S. have adopted the P-G specifications & many have reported reduced distress; especially thermal cracking.
Effect of Binder on Performance

Improved pavement performance observations after implementing P-G binder specification

- Ministry of Transportation, Ontario
- Colorado
- Michigan
- Missouri
- Utah

**BUT**, other changes made:
- Gyratory compactor, use of polymer modified asphalt, revised QA specifications, pavement preservation, etc.
Michigan: Distress Index – systematic reduction over time.
Effect of Binder

- Difficult to quantify because multiple changes made or materials implemented within the same time period.

- Asphalt binders by themselves will not **significantly** improve performance – *my opinion*.

**HISTORY:** Many laboratory studies have shown PMA enhances fracture and distortion resistant properties – **BUT** field quantification of benefit is limited.
Performance Comparisons: Neat versus Modified Binders

Quantification of the Effects of Polymer-Modified Asphalt to Enhancing HMA Performance, Sponsored by the Affiliate Committee, Asphalt Institute.
Distress Comparison for Companion Sections

1. Fatigue Cracking; Area & longitudinal combined
2. Rutting
3. Thermal Cracking

Companion Sections – Two sections where the only difference is the asphalt binder.
PMA Versus Neat Sections

- Comparison of Actual Distresses
  - Rutting
  - Fatigue Cracking
  - Transverse Cracking

- M-E Analysis of Performance
  - Distortion
  - Fracture

M-E Based Procedure normalizes any difference between companion sections.
Rutting

Neat Mixes
Versus
PMA Mixes
What is the time difference between different rut depths?

Years for equal rutting?
Distortion Analysis

- Vertical strain at specific depths
- Neat sections individually calibrated & used to predict PMA rutting.

\[
RD = \sum_{i=1}^{n} \left[ 5.37 \times 10^{-7} (C_{r1})(N)^{0.4289}(C_{r2}) \right] \\
\left[ (T)^{2.5896}(V_{beff})^{1.0057}(V_a)^{0.5213} \right] \\
\left[ (C_3)(\varepsilon_r)(t) \right]_i
\]

\[
DI = \frac{n}{N_R}
\]
Rutting – Neat Vs PMA

- Companion Sections
- Line of Equality
- Modified Sections

Graph showing the comparison between predicted rut depth (local calibration, inches) and measured rut depth (inches). The graph includes data points for companion sections and modified sections. The line of equality is also displayed for reference.
Cracking Neat Mixes Versus PMA Mixes
What is the time difference between different amounts of cracking?

Years for equal cracking?
Fracture Damage Analysis

- Tensile strain at bottom of HMA layer.
- Neat sections individually calibrated & used to predict PMA cracking.

\[
N_f = 0.00432 \left(C_{f1}\right) (10)^M \left(\varepsilon_t\right)^{-3.291} (E)^{-0.854}
\]

\[
M = 4.84 \left(\frac{V_{beff}}{V_a + V_{beff}}\right) - 0.69
\]

- Tensile strain at bottom of HMA layer.
- Neat sections individually calibrated & used to predict PMA cracking.
Fatigue Cracks – Neat Vs PMA

![Graph showing predicted vs measured fatigue cracking for companion sites with modified mixtures and sites with modified mixtures, with a line of equality.](attachment:fatigue_cracks_graph.png)
Transverse Cracking – Neat Vs PMA

![Graph showing transverse cracking comparison between Neat and PMA sections. The x-axis represents PMA sections in feet, and the y-axis represents companion sections in feet. The graph includes data points and a trend line indicating a positive correlation.](image-url)
Enhanced Performance Based on Damage Analysis

Material related distress.

Conventional HMA Mixtures

PMA Mixtures

Damage Index

Age, years
## Expected Increase in Service Life, yrs

<table>
<thead>
<tr>
<th>Site Factor</th>
<th>Condition Description</th>
<th>Added Life</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Foundation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Expansive</td>
<td></td>
<td>5-10</td>
</tr>
<tr>
<td>Expansive</td>
<td></td>
<td>2-5</td>
</tr>
<tr>
<td>Frost Susceptible – Cold Climate</td>
<td></td>
<td>2-5</td>
</tr>
<tr>
<td><strong>Water Table &amp; Drainage</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deep</td>
<td></td>
<td>5-10</td>
</tr>
<tr>
<td>Shallow; Adequate</td>
<td></td>
<td>5-8</td>
</tr>
<tr>
<td>Shallow; Inadequate</td>
<td></td>
<td>0-2</td>
</tr>
<tr>
<td><strong>Existing Pavement Condition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HMA Good</td>
<td></td>
<td>5-10</td>
</tr>
<tr>
<td>Poor-Extensive Cracking</td>
<td></td>
<td>1-3</td>
</tr>
<tr>
<td>PCC Good</td>
<td></td>
<td>3-6</td>
</tr>
<tr>
<td>Poor-Faulting &amp; Cracking</td>
<td></td>
<td>0-2</td>
</tr>
</tbody>
</table>
## Expected Increase in Service Life, yrs

<table>
<thead>
<tr>
<th>Site Factor</th>
<th>Condition Description</th>
<th>Added Life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate; Temp. Fluctuations</td>
<td>Hot Hot Extremes</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>Mild</td>
<td>2-5</td>
</tr>
<tr>
<td></td>
<td>Cold Cold Extremes</td>
<td>3-6</td>
</tr>
<tr>
<td>Traffic, Truck Volumes</td>
<td>Low Intersections</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>Thoroughfares</td>
<td>3-6</td>
</tr>
<tr>
<td></td>
<td>Heavy Loads</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>Moderate</td>
<td>5-10</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>5-10</td>
</tr>
</tbody>
</table>
Summary

- Use of PMA reduces distress in pavements & overlays
  - Less Fatigue Cracking
  - Fewer Transverse Cracks
  - Smaller Ruts
Summary

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
  - Eliminate Traffic Delays
Summary

- Quality of Construction – STILL IMPORTANT, IF NOT THE MOST IMPORTANT FACTOR.
- Many M-E Transfer Functions are stiffness based for binder & mix – OTHER MATERIAL PROPERTIES ARE MORE IMPORTANT.
Thank you for your attention - Any questions?
Finding from Colorado Study

Use of PMA mixes extended the overlay service life over neat HMA mixes by:
- 3 years – 75 percentile value
- 6 years – 50 percentile value