Field Investigation of Polyphosphoric Acid Modified Binders at MnROAD

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Polyphosphoric Acid Workshop
April 8, 2009
Research Partners

- Mn/DOT
- Federal Highway Administration
- MTE Services, Inc.
- Innophos
- ICL Performance Products
- Marathon Petroleum Company
- Dupont
- Paragon Technical Services
- Western Research Institute
PPA Study Background

- Stiffen asphalt at high temperatures
- No effect at low temps
- More cost-effective than polymers
- FHWA lab studies
- Field validation needed
# Test Cell Designs

- PPA Only
- PPA + SBS
- SBS Only
- PPA + Elvaloy

- Level 3 Superpave
- PG 58-34 Binder
- No RAP
- Limited Limestone
- Hydrated Lime
- Liquid Antistrip

<table>
<thead>
<tr>
<th>77</th>
<th>78</th>
<th>79</th>
<th>33</th>
<th>34</th>
<th>35</th>
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<tbody>
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<tr>
<td>58-34</td>
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<td>58-34</td>
</tr>
<tr>
<td>Elvaloy + PPA</td>
<td>Elvaloy + PPA</td>
<td>Elvaloy + PPA</td>
<td>PPA</td>
<td>SBS + PPA</td>
<td>SBS</td>
</tr>
<tr>
<td>8&quot; Full Depth Reclam.</td>
<td>8&quot; Class 6</td>
<td>8&quot; Full Depth Reclam. + Fly Ash</td>
<td>12&quot; Class 6</td>
<td>12&quot; Class 6</td>
<td>12&quot; Class 6</td>
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<tr>
<td>Clay</td>
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Challenges Encountered

1904
Extra and Force Account Work
Extra Work performed in accordance with 1403 will be paid for on a negotiated or Force Account basis. The Contractor shall accept the following compensation provisions as payment in full for Extra and Force Account Work.

If an agreement cannot be reached to pay for the Extra Work on a unit price or lump sum basis, or if those methods are impracticable, the
Instrumentation

- Thermocouple
- ECH2O-TE
- Time Domain Reflectometer
- Lysimeter
- Loop Detector
- Soil Compression Gauge
- Dynamic Pressure Gauge
- Asphalt Dynamic Strain Gauge
Field Data
As-Constructed Air Voids

In Place Air Voids, %

- PPA
  - Cell 33
- PPA + SBS
  - Cell 34
- SBS
  - Cell 35
- PPA + Elvaloy
  - Cell 77
- PPA + Elvaloy
  - Cell 79
### Early FWD Results

<table>
<thead>
<tr>
<th>Cell 33</th>
<th>Subgrade</th>
<th>Average Stiffness, MPa</th>
<th>Coefficient of Variation</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>56.4</td>
<td>15.1%</td>
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<tr>
<td></td>
<td>Base</td>
<td>147.9</td>
<td>15.1%</td>
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<tr>
<td></td>
<td>HMA</td>
<td>1331.3</td>
<td>13.7%</td>
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<table>
<thead>
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<th>Cell 34</th>
<th>Subgrade</th>
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<tr>
<td></td>
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<td>52.3</td>
<td>11.2%</td>
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<tr>
<td></td>
<td>Base</td>
<td>137.4</td>
<td>11.2%</td>
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<tr>
<td></td>
<td>HMA</td>
<td>1250.8</td>
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<tr>
<td></td>
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<td>58.5</td>
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<td></td>
<td>Base</td>
<td>153.6</td>
<td>15.2%</td>
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<tr>
<td></td>
<td>HMA</td>
<td>1380.3</td>
<td>12.2%</td>
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<tr>
<td>LANE</td>
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<td>Outside</td>
<td>Inside</td>
</tr>
<tr>
<td>------</td>
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<td>---------</td>
<td>--------</td>
</tr>
<tr>
<td>CELL</td>
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</table>

Avg. Rut Depth, inches

- Fall 2007
- Spring 2008
- June 2008
- July 2008
March 2009 Field Inspection

Safety First!
Transverse Strain

Cell 33
Cell 34
Cell 35
April 3, 2009
PPA
PPA + SBS
SBS

Transverse Microstrain

April 3, 2009
Laboratory Data
High Temperature PG Grade

- Original
- RTFO
- Extracted

Graph showing the High Temp PG Grade for different grades and treatments:
- 58-34 SBS
- 58-34 SBS + PPA
- 58-34 PPA
- 58-34 Elvaloy + PPA
% Recovery @ 58°C, 3.2 kPa

- 58-34 SBS
- 58-34 SBS + PPA
- 58-34 PPA
- 58-34 Elvaloy + PPA

Graph showing % Recovery at 58°C, 3.2 kPa for different materials.
Jnr @ 58°C, 3.2 kPa

![Graph showing Jnr values at 58°C, 3.2 kPa for different materials.

- **58-34 SBS**
- **58-34 SBS + PPA**
- **58-34 PPA**
- **58-34 Elvaloy + PPA**

Legend:
- **RTFO**
- **Extracted**]
Rut Testing

APA

APC

Hamburg
| Reduced Frequency (Hz) | |E*| (MPa) |
|-----------------------|------------------|
| 100                   | 100              |
| 1000                  | 1000             |
| 10000                 | 10000            |
| 1.0E-03               | 1.0E-01          |
| 1.0E+01               | 1.0E+03          |

Dynamic Modulus
Summary

- All 4 PPA mixes performing well since 2007
- Field samples showed excellent rutting and stripping performance in lab tests
  - Low Temperature Cracking test results coming soon.
- PPA + Polymer generally performed better than either modifier along
- Test sections will continue to be monitored for 5 years
Thank You!