Thin HMA Overlays for Pavement Preservation

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US Federal Highway Administration
www.TFHRC.gov
Acknowledgments

• Thank Virginia DOT and Superior Paving whose cooperation and assistance were vital to the thin HMA overlay study.
• Also thank laboratory staff at ALF, Mix, and Binder labs at the FHWA Tuner-Fairbank Highway Research Center for their lab tests and data collection.
Outline

1. Project Background
   - Preceding research study at the Accelerated Load Facility (ALF)
   - Motivation for the thin overlay study
2. Thin Overlay Construction
3. ALF Testing and Results
4. Summary and Conclusions
Project Background
FHWA Recommendation to Replace $|G^*| \sin \delta$ for Fatigue Cracking

- Calculated Crack Tip Opening Displacement (CTOD), a notched direct tension test
FHWA Recommendation to Replace $|G^*| \sin \delta$ for Fatigue Cracking

- Calculated Crack Tip Opening Displacement (CTOD), a notched direct tension test
- *Primarily based* on fatigue cracking in un-aged full scale accelerated pavement tests

PLUS

- *Validated and Strengthened* with full scale accelerated aged test sections
Accelerated Aging via Radiant Heaters used for Temperature Control
Less correlation
More Scattered
CTOD is more strongly linked to fatigue cracking even at two distinct levels of aging.
Larger CTOD is MORE crack resistant
Solvent Extraction and Recovery

Smaller CTOD is LESS crack resistant
Solvent Extraction and Recovery

Blue line is lab PAV aged
Solvent Extraction and Recovery

Red line is natural aging
Solvent Extraction and Recovery

Green line is Accelerated aging
Top-Down / Bottom-Up Cracking
Accelerated Aged Sections

<table>
<thead>
<tr>
<th></th>
<th>Total Counts</th>
<th>Bottom-up Cracks</th>
<th>Top-Down Cracks</th>
<th>Full-Depth Cracks</th>
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<td></td>
<td>Counts</td>
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<td>Percentage</td>
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<td>Lane 1 CR-AZ/Control</td>
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<td>3</td>
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<td>Lane 2 Control</td>
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<td>5</td>
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<td>Lane 5 CR-TB</td>
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<td>Lane 6 Reacted Terpolymer</td>
<td>13</td>
<td>5</td>
<td>38%</td>
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Motivation for the Thin Overlay Study
Although the aging experiment was intended to help with the statistics of the original experiment…
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Although the aging experiment was intended to help with the statistics of the original experiment … the concentration of aging at the surface and top-down fatigue cracking performance naturally led the research team to the scenario of pavement preservation….in other words, to what degree could the performance of the aged sections be extended they were renewed with a treatment?
• **Performance #03** - Quantify Performance and Benefits of Various Pavement Preservation Treatments and Develop Pavement Preservation Treatment Performance Models.

• **Performance # 04** - Quantifying the Benefits of Pavement Preservation Treatments

• **Design #02** - Determining Pavement Preservation Treatment Lives and Related Pavement Life Extension

• **Design #06** - Integrating Pavement Preservation into the Design Process

• **Materials #01** - Mechanical Binder Properties to Predict Surface Treatment Performance
Superpave 4.75mm NMAS

- Explored the concept of placing a chip seal, or slurry seal or other approach

- Collaborated with Virginia DOT as they are the closest neighbor to FHWA-TFHRC

- Recommended the experiment use a thin overlay of a trial 4.75mm NMAS Superpave mix that was being considered for preventive maintenance application

- Other benefits:
  - Use of excess fine aggregates
  - Inclusion of RAP
44-foot ALF Wheel Path

22-foot 4.75mm Mix Inlay Placed over Half of ALF Loaded Area
<table>
<thead>
<tr>
<th>Sieves #</th>
<th>Bealton sand</th>
<th>#10</th>
<th>RAP</th>
<th>Nat. Sand</th>
<th>Bag House</th>
<th>Mix Design</th>
<th>Gradation Check</th>
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<td>¾” (19mm)</td>
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<td>3/8” (9.5mm)</td>
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<td>67</td>
<td>98</td>
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<td>50</td>
<td>86</td>
<td>100</td>
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<td>9.3</td>
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<td>10.3</td>
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<td>Specification Criteria</td>
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<tr>
<td>Volumetrics&lt;br&gt;Ndesign = 50 gyrations</td>
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<td>FHWA extracted aggregate $G_{SB} = 2.813$</td>
<td>Contractor’s aggregate $G_{SB} = 2.789$</td>
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<td>VTM&lt;br&gt;Design 5%&lt;br&gt;Production 3% - 6%</td>
<td>4.4%&lt;br&gt;-</td>
<td>4.21% - 3.98%</td>
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<td>VFA&lt;br&gt;Design 70% - 75%</td>
<td>74%&lt;br&gt;-</td>
<td>75.1% - 76.2%&lt;br&gt;74.0% - 75.2%</td>
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<td>VMA&lt;br&gt;16.5%&lt;br&gt;min.</td>
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<td></td>
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<td>$V_{he}$&lt;br&gt;-</td>
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<tr>
<td>Dust to Binder&lt;br&gt;based on effective asphalt</td>
<td>1 – 2</td>
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…Switch to animation of crack maps...
<table>
<thead>
<tr>
<th>Lane 8 Control</th>
<th>Unaged</th>
<th>Aged Thin Overlay</th>
<th>Aged</th>
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<td></td>
<td>Lane 10</td>
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</tr>
<tr>
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<td>Aged Thin Overlay</td>
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</table>
300k

Lane 8 Control

Unaged Thin Overlay

Lane 10
Air Blown

Aged Thin Overlay

Unaged

Aged
Lane 10
Air Blown

A1:B = Effect of Aging on Conventional HMA (no preservation treatment)

A2:C = Effect of "Old" Aged 4.75mm on Aged Pavement

Site 3 Site 4

A2:C = Effect of "Old" Aged 4.75mm on Aged Pavement
A1:B = Effect of Aging on Conventional HMA (no preservation treatment)

A2:C = Effect of “New” unaged 4.75mm on Aged Pavement
Lane 8
Control 70-22

A1:B = Effect of Aging on Conventional HMA (no preservation treatment)

A2:C = Effect of “New” unaged 4.75mm on Aged Pavement
Cores cut from thin overlay section
Lane 8 Aged Control with Unaged Inlay

- Half Section without 4.75mm Inlay
- Half Section WITH 4.75mm Inlay
Summary and Conclusions

• A trial 4.75 mm NMAS mix from VDOT placed as a thin treatment over existing APT sections.
• Full scale accelerated aging and loading used to compare the fatigue cracking performance for four combinations of with and without 4.75 mm NMAS treatment plus with and without aging.
• The unaged 4.75 mm NMAS overlay performed much better in fatigue cracking resistance than the untreated existing pavement in Lane 8.
Summary and Conclusions (Continued)

• The aged 4.75mm NMAS overlay performed almost the same as the untreated existing pavement in Lane 10.
• Therefore, thin 4.75 mm NMAS overlays used as a preservation treatment have the ability to significantly delay the aging related top down cracking, but once such thin layers becomes brittle with age that benefit is lost.
Summary and Conclusions (Continued)

- Pavement cores indicate the top-down cracks become the predominant cracks for the aged sections. Therefore, the accelerated aging has made the pavement more prone to crack in a top-down cracking pattern.
- During the 19°C full-scale fatigue testing, the measured total rut depth of the AC section with the underlying structural mix and thin inlay is less than or equal to the rutting of the section without the treatment.
Discussion & Questions
Dynamic Modulus Master Curves

- 4.75mm NAMS Mix Aged
- 4.75mm NMAS Mix Unaged
- Stiff Unaged ALF (PG70-22 Control)
- Soft Unaged ALF (SBS PG64-40)

Horizontal axis: Frequency, Hz
Vertical axis: $|E'|$, MPa
Measured Stress and Strain in the Fatigue Test
Predicted Fatigue Life for Various Strains