Use of Reclaimed Asphalt Pavement from Ultra-Thin Bonded Asphalt Layer in Superpave Mixtures

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Presentation Outline

• Introduction
• Objective
• Experimental Design
• Material Properties
• Laboratory Mix Design
• Performance Tests
• Conclusions
Introduction

• Ultra-thin bonded asphalt surface (UBAS or Novachip) is a thin gap-graded hot mix which is bonded to the existing surface with a polymer-modified emulsion membrane

• UBAS has been found to reduce noise, minimize back spray and increase visibility

• The Kansas Department of Transportation (KDOT) has been using UBAS since 2001
Introduction (contd.)

• KDOT is currently extending its use from the treatment of existing surface to in conjunction with some sort of surface preparation such as, surface recycling.

• UBAS layer is gap or open graded, conventional overlay might result in moisture trapping in the layer causing stripping of the underlying layers
Objective

• To evaluate the effect of reclaimed UBAS millings on the performance of the Superpave mixtures
Experimental Design

• 12.5-mm Nominal Maximum Aggregate Size (NMAS) mix designs have been developed in the laboratory.

• Three different percentages (0%, 10%, and 20%) of reclaimed UBAS millings.

• One asphalt binder grade PG 70-22
Experimental Design (contd.)

• Performance tests
  – Hamburg Wheel Tracking Device
  – Modified Lottman Test
Material Properties

• Ignition oven test was conducted on the reclaimed UBAS millings.

• The percent asphalt binder in the reclaimed UBAS millings is 3.4%

• PG binder grade of the reclaimed UBAS millings is PG 84-18
• Gradations of the aggregates extracted from the UBAS millings
• Gradations of the aggregates used in the mix designs
Laboratory Mix Design
• The 20-year design Equivalent Single Axle Loads (ESALs) : 0.3 to ≤ 3 millions.

• Mixing Temperature (deg.F) : 300-312

• Compaction Temperature (deg. F) : 262-272

• Gyratory Compactive Effort :
  – Nini: 7
  – Ndes: 75
  – Nmax: 115
Gradations of the aggregate blends used in the 12.5 NMAS mixtures
# KDOT Superpave Volumetric Mixture Design Requirements

<table>
<thead>
<tr>
<th>Mixture Type</th>
<th>% Air voids at Ndes</th>
<th>Minimum VMA%</th>
<th>Design VFA%</th>
<th>% Gmm at Nini</th>
<th>% Gmm at Nf</th>
<th>Dust to Binder Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM-12.5A</td>
<td>4</td>
<td>14</td>
<td>65-78</td>
<td>≤90.5</td>
<td>&lt;98</td>
<td>0.6-1.2</td>
</tr>
<tr>
<td>SR-12.5A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Volumetric Properties of the 12.5-mm NMAS Superpave mixtures

<table>
<thead>
<tr>
<th>Mixture Type</th>
<th>% UBAS milling</th>
<th>Total Asphalt Content %</th>
<th>Virgin Asphalt Content %</th>
<th>% Air voids @ Ndes</th>
<th>%VMA</th>
<th>%VFA</th>
<th>Dust to Binder Ratio</th>
<th>% Gmm @ Nini</th>
<th>% Gmm @ Nf</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM-12.5A</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>4.2</td>
<td>14.1</td>
<td>70.4</td>
<td>0.68</td>
<td>89.2</td>
<td>96.7</td>
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<tr>
<td>SR-12.5A</td>
<td>10</td>
<td>4.8</td>
<td>4.48</td>
<td>4.5</td>
<td>14</td>
<td>67.8</td>
<td>0.7</td>
<td>88.9</td>
<td>96.4</td>
</tr>
<tr>
<td>SR-12.5A</td>
<td>20</td>
<td>4.7</td>
<td>4.05</td>
<td>4.3</td>
<td>14</td>
<td>69</td>
<td>0.68</td>
<td>88.8</td>
<td>96.6</td>
</tr>
</tbody>
</table>
Performance Tests
Hamburg wheel tracking device (HWTD)

- 150-mm diameter and 62-mm tall plugs compacted to 7±1 percent air voids

- Pair of wheels having a diameter of 203.6 mm and width of 47 mm.

- Load of 705±22 N, approx 50 wheel passes/min

- Specimens submerged in a water bath held at 50 deg C
• Rut depth is measured automatically and continuously at 11 different points along the wheel path of each sample with an LVDT

• Test ends if the preset number of cycles is reached or if the rut depth measured reached a value of 20 mm
Typical Hamburg plot showing the test parameters
Performance of 12.5-mm NMAS laboratory mixes in the HWTD tests

<table>
<thead>
<tr>
<th>Mixture Type</th>
<th>%UBAS millings</th>
<th>% Air Voids</th>
<th>Rut depth (mm)</th>
<th>Avg. No. of wheel passes</th>
<th>Creep slope (passes/mm)</th>
<th>Stripping slope (passes/mm)</th>
<th>Stripping inflection point (passes)</th>
<th>Post compaction @ 1000 passes (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM-12.5A</td>
<td>0</td>
<td>6.43</td>
<td>20</td>
<td>19,686</td>
<td>3,008</td>
<td>391</td>
<td>14,408</td>
<td>1.73</td>
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<tr>
<td>SR-12.5A</td>
<td>10</td>
<td>6.73</td>
<td>20</td>
<td>28,085</td>
<td>4,333</td>
<td>568</td>
<td>20,283</td>
<td>1.75</td>
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<tr>
<td>SR-12.5A</td>
<td>20</td>
<td>7.26</td>
<td>18</td>
<td>33,049</td>
<td>4,833</td>
<td>779</td>
<td>26,867</td>
<td>1.83</td>
</tr>
</tbody>
</table>
Modified Lottman test

- Kansas test method KT-56; Resistance of compacted asphalt mixtures to moisture induced damage

- KDOT and Superpave criteria for acceptable minimum tensile strength ratio is 80%

- 150-mm diameter and 95-mm tall plugs compacted to 7±0.5 percent air voids

- 3 conditioned and 3 unconditioned samples
• Conditioning of the samples
  – Partial vacuum saturation of 70 to 80% of air voids
  – Freeze cycle for a minimum of 16 hours at -18° C
  – Thawing in water bath for 24±1 hours at 60° C

• Specimens placed in a water bath for 2 hours at 25° C.

• Loading rate of 51mm/minute, peak loads recorded.
• Tensile strength is computed using the equation:
  \[ S = \frac{2000 \times P}{\pi \times t \times D} \]

• Tensile strength ratio in percent is calculated as
  \[ \frac{S_2}{S_1} \times 100 \]
Modified Lottman Test (KT-56) Results

Graphs showing the Modified Lottman Test results for a 12.5-mm NMAS mix.

- **Avg. Strength (kPa):**
  - Unconditioned strength
  - Conditioned strength

- **TSR (%):**
  - Percent of specimens passing the test with various percentages.
Conclusions

• The mix design data illustrates that volumetric properties of all mixes with UBAS RAP met all requirements

• Based on the HWTD results the rutting performance of the mixes improved with the addition of UBAS RAP

• The KT-56 results show that the average tensile strengths of the mixes increased with an increase in UBAS RAP content illustrating that the stiffness of the mix is increased with addition of RAP

• All mixes met the minimum TSR values specified by KDOT.
Acknowledgements

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Thank You!