Evaluation of Superpave Mixtures Containing Hydrated Lime

Shadi Saadeh
Louay Mohammad

2007 Louisiana Transportation Engineering Conference
February 12–14, 2007
Baton Rouge, Louisiana
OUTLINE

- Objectives
- Scope
- Experimental Factorial
- Materials Characterization
- Results
- Conclusions
OBJECTIVE

• Evaluate the fundamental engineering properties of HMA mixtures containing hydrated lime to a conventional mixture designed to meet the current Louisiana Superpave specifications

• Evaluate the influence of the method of addition of hydrated lime on the mechanical properties of the resulting HMA mixtures.
OBJECTIVE

- Is HMA Mixture Containing Hydrated Lime With PG 70-22M Similar To Conventional Mixtures With PG 76-22M?
**SCOPE**

- Six 19.0 mm Level 2 HMA mixtures
- Siliceous limestone aggregates
  - commonly used in Louisiana
- Mixture 1
  - No hydrated lime
  - PG 76-22M
  - M76CO
  - Conventional one, as a control mixture
- Mixture 2
  - Contains hydrated lime (1.5%)
  - Lime addition: wet ("paste")
    - simulates hydrated lime addition to wet aggregate in a pug mill
  - PG 76-22M
  - M76LS
- Mixture 3
  - Contains hydrated lime (1.5%)
  - Lime addition: dry ("no paste")
    - simulates hydrated lime injected into the drum mixer
  - PG 76-22M + HL(1.5%)
  - M76LM
- Mixture 4
  - No hydrated lime
  - PG 70-22M
  - M70CO
  - Conventional one, as a control mixture
- Mixture 5
  - Contains hydrated lime (1.5%)
  - Lime addition: wet ("paste")
    - simulates hydrated lime addition to wet aggregate in a pug mill
  - PG 70-22M
  - M70LS
- Mixture 6
  - Contains hydrated lime (1.5%)
  - Lime addition: dry ("no paste")
    - simulates hydrated lime injected into the drum mixer
  - PG 70-22M + HL(1.5%)
  - M70LM
# Aggregate Gradation

<table>
<thead>
<tr>
<th></th>
<th>M76CO/M70CO</th>
<th>M76LM/M70LM</th>
<th>M76LS/M70LS</th>
<th>Spec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>#67 LS, %</td>
<td>37</td>
<td>38</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>#78 LS, %</td>
<td>25</td>
<td>25.5</td>
<td>25.5</td>
<td></td>
</tr>
<tr>
<td>#11 LS, %</td>
<td>29</td>
<td>21</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>CS, %</td>
<td>9</td>
<td>14</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Lime, %</td>
<td>--</td>
<td>1.5</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>%AC</td>
<td>4.0</td>
<td>3.6</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>%Air Voids</td>
<td>3.7</td>
<td>3.6</td>
<td>3.6</td>
<td>2.5-3.5</td>
</tr>
<tr>
<td>%VMA</td>
<td>12</td>
<td>12</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>%VFA</td>
<td>68</td>
<td>69</td>
<td>69</td>
<td>68-78</td>
</tr>
<tr>
<td>Film Thickness, Micron</td>
<td>7.9</td>
<td>7.2</td>
<td>7.2</td>
<td></td>
</tr>
</tbody>
</table>
Aggregate Gradation

![Graph showing percent passing for Control and Lime treatments with different particle sizes.](image-url)
Binder/Mixture Characterization

Binder
- PG Grading
- Frequency Sweep

Mixture
- Permanent Deformation
  - Dynamic Modulus Test
  - Flow Number
  - Loaded Wheel Tracking Test
- Durability
  - Semi Circular Bend Test
  - Indirect Tensile Strength Test
  - Loaded Wheel Tracking Test
- Triplicate
- AV = 7.0% ± 0.5
Sample Preparation
Sample Preparation -- $|E^*|$, $F_N$
Sample Preparation – ITS, LWT

Kneading Compactor

100mm x 63.5mm

320 x 260 x 80 mm
Sample Preparation – SCB

150mm x 57mm
SAMPLE PREPARATION – Wet

- 1.5% lime
- 3% water by the wt. of lime
- “No Paste”
SAMPLE PREPARATION - Dry

- 1.5% lime
- 160C
- 20 minutes
- “Paste”
RESULTS
Binder Characterization

- PG Grading
  - PG 76-22M
    » M76CO
  - PG 76-22M+1.5%HL
    » PG 88-16M*
    » M76LM
  - PG 70-22M
    » M70CO
  - PG 70-22M+1.5%HL
    » PG 76-16M*
    » M70LM

*Did not meet Spec for G*Sinδ
Binder Characterization – Master Curves
**ITS Test Results**

![Bar charts showing ITS test results for different materials (M76CO, M76LS, M76LM, M70CO, M70LS, M70LM).]
SCB Test Results

- Unaged
- Aged for 5 days @ 85 °C
SCB Test Results – Aging Index

Jc Aging Index, Aged/Unaged

M76CO M70CO M76LS M70LS M76LM M70LM
LWT Test Results

LWT Rut Depth @ 20K Cycle, mm

- M76CO
- M70LS
- M70LM
Test Results – Master Curves

Master Curves

Dynamic Modulus $|E^*|$ (MPa)

Reduced Frequency (Hz)
<table>
<thead>
<tr>
<th>Dynamic Modulus</th>
<th>E*</th>
<th>Test Temperatures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-10°C</td>
<td>4.4°C</td>
</tr>
<tr>
<td>M76LM</td>
<td>M76LM</td>
<td>M76LS</td>
</tr>
<tr>
<td>M70LM</td>
<td>M70LM</td>
<td>M70LS</td>
</tr>
<tr>
<td>M76LS</td>
<td>M76LS</td>
<td>M76LM</td>
</tr>
<tr>
<td>M70LS</td>
<td>M70LS</td>
<td>M76CO</td>
</tr>
<tr>
<td>M76CO</td>
<td>M76CO</td>
<td>M70LM</td>
</tr>
<tr>
<td>M70CO</td>
<td>M70CO</td>
<td>M70CO</td>
</tr>
</tbody>
</table>
Average Ratio of $E^*$ to M76C0 $E^*$ Values

- Temperature (C):
  - -10
  - 4.4
  - 25
  - 37.8
  - 54.4

- Ratio of $E^*$:
  - 70CO
  - 70LS
  - 70LM
  - 76LS
  - 76LM
Repeated Load Permanent Deformation Test -- $F_N$
Conclusion

- Is HMA Mixture Containing **Hydrated Lime** With PG 70-22M Similar To Conventional Mixtures With PG 76-22M?
  - **Hydrated Lime**: Yes
- The influence of the method of addition of hydrated lime on the mechanical properties of the resulting HMA mixtures
  - **Paste (Slurry)** presented better performance properties than No Paste
- **Aging**
  - Mixes w/ HL showed less aging than those w/ no HL