Testing of Bond Coat Emulsions

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Testing of Tack/Bond Emulsions

• Presentation Outline
  – Definition of a bond (tack) coat
    • Typical Products and Application
    • Review of two Bond Coat Studies
  – Something Old and Something New
    • Emulsion and Residue Testing
    • Performance Related Testing
      ❖ Tracking
      ❖ Bond Strength
Tack/Bond Coat Definition

• Basic Asphalt Emulsion Manual (Fourth Edition)
  – A bond coat is a very light spray application of diluted asphalt emulsion. It is used to promote a bond between the existing surface and the new asphalt application.
Types of emulsions used

- CSS-1h, CSS-1, SS-1h, SS-1
  - These emulsions chosen for their stability and miscibility with dilution to water.
  - The base asphalt is chosen for the climate conditions and is usually similar, to slightly harder (more viscous), than the paving grade.
  - Polymers traditionally not used do to the lack of understanding as to what they could provide for the application
    - Cost/benefit
    - Polymers too sticky and create tracking scenarios
Tack Coat Emulsion Testing

• What does the emulsion need to do?
  – Be low enough viscosity to spray and cover properly
  – Meet Sieve (oversized particle) testing to not plug spray nozzles
  – Storage Stability/Settlement – to allow storage for the time required
  – Breaking time to allow paving in the required time frame
Tack/Bond Coat

What to look for – rates and precautions

• Typical Rates
  – Application rate (emulsion) is usually 0.05-0.10 Gal/yd$^2$ of a 30-50% residue emulsion (diluted just prior to application)

• Precautions
  – Dry/clean pavement
  – Application rate for a thin uniform coating of emulsion
  – Dilution of emulsion to aid in the uniform distribution
  – Emulsion should be broken (brown to black in color), usually determined by application rate and environmental conditions.
Tack/Bond Coat
What to look for – rates and precautions

• Precautions – More on application rate
  – Proper amount for the surface
    • Is it asphalt rich or dry?
    • Is it a milled surface?
Tack/Bond Coat Application

Proper Spraying - Even

Uneven or “Stripped”
Illinois Tack Coat Study - 2009

- SS-1hP, RC-70, & PG64-22
- Application rates (residual)  
  - 0.02, 0.04, and 0.09 gal/yd$^2$
- Highlighted Findings:  
  - Recommended 0.04 gal/yd$^2$ residual application rate  
  - SS-1hP and PG64-22 showed better rut resistance than RC-70  
  - Uneven tack coat showed worse rut resistance
The Influence of Asphalt Tack Coat Materials on the Interface Shear Strength

- CRS-2P, CSS-1, SS-1, & SS-1h + 2 binders – PG64-22 & PG7622M
- Application rates (residual)
  - 0, 0.02, 0.05, 0.1 & 0.2 gal/yd²
- Highlighted Findings:
  - 25 and 55°C Test Temperatures
  - CRS-2P was the best tack coat type, for both temperatures, at an application rate of 0.02 gal/yd².
Tack Coat Residue Testing
Traditional

ASTM Evaporation or Distillation Procedures

<table>
<thead>
<tr>
<th>Test</th>
<th>CSS-1</th>
<th>CSS-1h</th>
<th>Modified</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penetration @ 25°C, dmm</td>
<td>100 - 250</td>
<td>40 - 90</td>
<td>40 - 90</td>
</tr>
<tr>
<td>Ductility @ 25°C, cm</td>
<td>40 min.</td>
<td>40 min.</td>
<td></td>
</tr>
<tr>
<td>Softening point, ºC</td>
<td></td>
<td></td>
<td>60 min.</td>
</tr>
<tr>
<td>Elastic Recovery @ 10ºC, %</td>
<td></td>
<td></td>
<td>50 min.</td>
</tr>
</tbody>
</table>
Tack Coat Residue Testing
DSR – Low Temperature Evaporation

<table>
<thead>
<tr>
<th>Sample Id.</th>
<th>Method A</th>
<th>Method B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase Angle (delta)</td>
<td>64</td>
<td><strong>72.2</strong></td>
</tr>
<tr>
<td>G*/sin delta @ 10 rad/sec,kPa</td>
<td>64</td>
<td>1.0 min.</td>
</tr>
<tr>
<td>Phase Angle (delta)</td>
<td>70</td>
<td><strong>75.0</strong></td>
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<tr>
<td>G*/sin delta @ 10 rad/sec,kPa</td>
<td>70</td>
<td>1.0 min.</td>
</tr>
<tr>
<td>Phase Angle (delta)</td>
<td>76</td>
<td><strong>77.5</strong></td>
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<tr>
<td>G*/sin delta @ 10 rad/sec,kPa</td>
<td>76</td>
<td>1.0 min.</td>
</tr>
<tr>
<td>Phase Angle (delta)</td>
<td>82</td>
<td><strong>79.6</strong></td>
</tr>
<tr>
<td>G*/sin delta @ 10 rad/sec,kPa</td>
<td>82</td>
<td>1.0 min.</td>
</tr>
<tr>
<td>Phase Angle (delta)</td>
<td>88</td>
<td><strong>81.0</strong></td>
</tr>
<tr>
<td>G*/sin delta @ 10 rad/sec,kPa</td>
<td>88</td>
<td>1.0 min.</td>
</tr>
</tbody>
</table>

Method A - 24 hours at 25°C – 24 hours at 60°C
Method B – thin film – 6 hours at 60°C
Tracking Test Procedures

What is being looked at?

• Variation on ASTM D711
  – Information regarding Virginia DOT procedure
• Modifications to improve the procedure
  – Wheel changes
  – Drawdown adjustment
  – Felt paper consistency issues
Tracking Testing
Example of ASTM D711 Equipment

Tracking Wheel

Drawdown Apparatus

Information from VADOT TRB Paper: Clark, Rorrer & McGhee
Tracking Test Procedure
Modified to reduce variability

• Procedure
  – 30 lb roofing felt is glued to a particle board using a spray adhesive
  – 0.015” thickness of emulsion is drawn down on the felt paper – wide enough for three test times
  – Sample is cured at a specific temperature and time intervals prior to testing
  – At testing interval, 10 lb wheel with 4” diameter rubber (cam-lock) rings are rolled across the tack coat onto poster board paper placed on the same thickness of particle board

• Measurement
  – Visually determine the degree of tracking at each time interval and the time that no tracking appears
Tracking Testing – Original Procedure
Bond Coat Emulsion with CRS Chemistry

25°C Curing – 10, 20 and 30 Minutes
Prior to modification of felt paper to particle board and wider drawdown
Tracking Test Procedure

- **Draw Down Apparatus**
  - Can be adjusted easily for varying thicknesses, and wide enough for at least three measurements with the wheel.

<table>
<thead>
<tr>
<th>Distributor</th>
<th>Film Thickness</th>
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<tbody>
<tr>
<td>0.02 gal/yd²</td>
<td>0.0036 in.</td>
</tr>
<tr>
<td>0.05 gal/yd²</td>
<td>0.0089 in.</td>
</tr>
<tr>
<td>0.10 gal/yd²</td>
<td>0.0180 in.</td>
</tr>
</tbody>
</table>
Tracking Test Procedure

- Tracking Wheel
  - Ten pound stainless wheel that can accommodate two four inch square (cam-lock) o-rings
# Tracking Testing at various temperatures

Bond Coat Emulsion with CRS Chemistry

<table>
<thead>
<tr>
<th>Temperature</th>
<th>10 Min</th>
<th>20 Min</th>
<th>30 Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient – 25°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35°C</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50°C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Tracking Testing at 50ºC (122ºF)
PG58-28 Base – CRS Chemistry

Without Modification

With Modification
Tracking Testing at 60°C (140°F)
PG58-28 Base – Modified & CRS Chemistry

Bond Coat on felt and paper
Bond Strength Testing

• **Types of Bond strength testing**
  – Shear or tensile
    • Shear testing applies a horizontal force to the pavement section to “shear” the specimen
    • Tensile testing “pulls” the top section away from the existing pavement

• **How strong do you need a bond to be?**
  – Just like gluing or welding two materials together, the strength of the bond needs to be greater than the materials being bonded.
Bond Strength Testing
Florida procedure

• PG58-28 based emulsion
  – Tack coat at 0.1 Gallon/yd²
  – Tested at 25°C
  – Bond Strength
    • 182.1 psi (1.26 MPa)
Bond Strength Testing
Florida procedure

- **PG64-22 – Based Emulsion**
  - Tack coat at 0.1 gallon/yd²
  - Tested at 25°C
  - Bond Strength
    - 207.9 psi (1.43MPa)
Bond Strength Testing
Louisiana Interlayer Shear Strength Tester

• Test Apparatus

- Loading Frame
- Reaction Frame
- Vertical Sensors
- Horizontal Sensor
- Normal Load Actuator

Taken from Louay Mohammad's Draft Test Procedure
Bond Strength Testing
Louisiana Interlayer Shear Strength Tester

- PG58-28 and PG64-22 based cationic emulsion
  - 4, 25 and 60°C Temperatures – 0.05 gal/yd²
Bond Strength Comparison
Florida vs. LISST Procedure

• Similar Emulsion Manufactured for both
  – Converted to MPa for both

### Table: Bond Tester Comparison @ 25ºC

<table>
<thead>
<tr>
<th>Emulsion Base</th>
<th>PG58-28 MPa</th>
<th>PG64-22 MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Florida</td>
<td>1.26</td>
<td>1.43</td>
</tr>
<tr>
<td>LISST</td>
<td>1.21</td>
<td>2.08</td>
</tr>
</tbody>
</table>

Florida Data converted to MPa
1 MPa = 145 lb/in²
Additional Resources

• Basic Asphalt Emulsion Manual
  – Gives general guidance

• Asphalt Institute MS-4 (7th Edition)
  – Gives some information on tack/bond coat applications

• SFERB Bitumen Emulsions
  – Chapter 11 deals exclusively with Bond coats
  – Discusses polymer modified and rapid-setting bond coat emulsions, as well as the use of breaking agents.
Questions??

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