Effect of Tack Coat Material type and Application Rate on the Bond Strength

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Outline

- Laboratory Controlled Study
  - Background
  - Objective
  - Scope
  - Methodology
  - Results
  - Conclusions

- NCHRP Project 9-40
  - Update
Acknowledgement

- Louisiana DOTD
- FHWA
- NCHRP
What is a Tack Coat?

- A light application of asphalt, usually asphalt diluted with water. It is used to ensure a bond between the surface being paved and the overlying course.
What is NOT A BOND?

Loss of **ADHESION** and/or **INTERLOCK** at the interface:

Long term pavement **performance** and **durability** can be affected by Debonding as well as Rutting and Cracking.
Common Tack Coat Materials

- Hot AC (AC-20, AC-30, …)
- Emulsified Asphalts (SS-1, SS-1h, CRS-2, CSS-1h, …)
- Cutback Asphalts (RC-70, RC-250, …)
Why is it Used?

- Tack coat is used to bind two pavement layers
- Monolithic structure to withstand/transfer shear stresses from traffic loading
- A strong tack coat binding between the layers is critical to transfer shear stresses into the entire pavement structure
- Lack of bond
  - slippage
  - activate distress mechanisms and rapidly lead to total failure
The Question Is?

1. What Material Should Be Used?
2. What should be the optimum residual application rates?
Objective

- Evaluate the current practice of using tack coats through controlled laboratory shear tests
- Examine the influence of tack coat types, application rates, and test temperatures on interface shear strength
**Scope**

- 19 mm Mix

**Tack Coat Materials**

<table>
<thead>
<tr>
<th>Emulsions</th>
<th>CRS-2P</th>
<th>SS-1</th>
<th>CSS-1</th>
<th>SS-1h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Cements</td>
<td>PG 64-22</td>
<td>PG 76-22M</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Application Rates**

<table>
<thead>
<tr>
<th>l/m²</th>
<th>gal/yd²</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.09</td>
<td>0.02</td>
</tr>
<tr>
<td>0.23</td>
<td>0.05</td>
</tr>
<tr>
<td>0.45</td>
<td>0.10</td>
</tr>
<tr>
<td>0.90</td>
<td>0.20</td>
</tr>
</tbody>
</table>

**Test Temperatures**

<table>
<thead>
<tr>
<th>℃</th>
<th>℉</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>77</td>
</tr>
<tr>
<td>55</td>
<td>131</td>
</tr>
</tbody>
</table>

- Triplicate samples
- 156 samples
Viscosities of Tack Coats at 135°C

<table>
<thead>
<tr>
<th>Tack Coat Type</th>
<th>Viscosity (Pa-s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PG 64-22</td>
<td>0.54</td>
</tr>
<tr>
<td>PG 76-22M</td>
<td>1.23</td>
</tr>
<tr>
<td>CRS-2P</td>
<td>2.03</td>
</tr>
<tr>
<td>SS-1</td>
<td>0.26</td>
</tr>
<tr>
<td>CSS-1</td>
<td>0.3</td>
</tr>
<tr>
<td>SS-1h</td>
<td>0.58</td>
</tr>
</tbody>
</table>
**Test Procedure**

Shear Stress vs. Displacement

Test Temperature 55°C

Displacement (mm)

0 2 4 6 8 10 12

Shear Stress (kpa)

50 lb/min until failure
Data Analysis

- A multiple comparison procedure
  - Fisher’s Least Significant Difference
  - 95% confidence interval
  - Ranking
Variation of Shear Strength Versus Application Rate at 25°C

Shear Strength (kPa)

Application Rate (l/m²), gsy

- PG 64-22
- PG 76-22M
- CRS-2P
- SS-1
- CSS-1
- SS-1h
Variation of Shear Strength Versus Application Rate at 55°C

Shear Strength (kPa)

Application Rate (l/m²)

PG 64-22
PG 76-22M
CRS-2P
SS-1
CSS-1
SS-1h
Maximum Interface Shear Strength

Test Temperature 25°C

Max Shear Strength (Kpa)

Tack Coat Type

PG 64-22
PG 76-22M
CRS-2P
SS-1
CSS-1
SS-1h

0.09 l/m²
0.23 l/m²
Maximum Interface Shear Strength

Test Temperature 55°C

Max Shear Strength (Kpa)

Tack Coat Type

PG 64-22
PG 76-22M
CRS-2P
SS-1
CSS-1
SS-1h

0.09 l/m²
0.23 l/m²
0.45 l/m²
0.90 l/m²
Summary and Conclusions

- Controlled laboratory simple shear tests
  - optimum application rate
- The influence of tack coat types, application rates, and test temperatures on the interface shear strength
- Among the six different tack coat materials used, CRS 2P emulsion was identified as the best performer
- Optimum application rate for CRS 2P emulsion was 0.09 l/m² (0.02 gal/yd²)
- At 25°C, increasing the tack coats application rates generally resulted in a decrease in interface shear strength
- At 55°C, the interface shear strength was not sensitive to the application rate
- CRS 2P at the optimum application rate provided only 83 percent of the monolithic mixture shear strength
- Suggests that the construction of flexible pavements in multiple layers introduces weak zones at these interfaces
NCHRP Project 9-40
Optimization of Tack coat for HMA Placement

- Determine for the various uses of tack coats
  - optimum application methods,
  - equipment type and calibration procedures,
  - application rates, and
  - asphalt binder materials

- Recommend revisions to relevant AASHTO methods and practices related to tack coats
NCHRP Project 9-40
Optimization of Tack coat for HMA Placement

PHASE I
- Task 1 - Conduct a review of the worldwide state of practice
- Task 2 - Design a comprehensive experiment
- Task 3 - Interim Report

PHASE II
- Task 4 - Conduct Experiment Approved In Task 3
- Task 5 - Recommend Test Methods, Criteria, and Construction Guidelines
- Task 6 - Demonstrate the Use of Recommended Test Methods and Construction Guidelines
- Task 7 - Prepare Instructional Materials for a Training Course
- Task 8 - Prepare And Submit Final Report
NCHRP Project 9-40
Factors

- Pavement surface types
  - existing HMA, milled HMA, PCC
- Two tack coat material types:
  - hot AC and emulsion
- Pavement surface coverages by tack coat:
  - 100% and 50%
- Three application rates
  - high, medium, low
- Two surface textures:
  - high and low
- Two permeability levels:
  - high and low
- Two surface cleanliness:
  - clean and dirty/dusty
NCHRP Project 9-40
Field-Laboratory Experiment

[Diagram showing a layout of a pavement research facility with different sections labeled as ALF Testing Area, Lane 4-1 B, Lane 4-2 B, Lane 4-3 B, and other sections for testing and sampling.]
Characterization

Tack Coat Quality

- Tack Coat Quality

Torsion

Tension
Characterization
Interlayer & Tack Coat Quality

- Interlayer Bond Strength
- Tack Coat Quality

Direct Shear  
Torsion  
Tension

Torsion  
Tension
Characterization of Tack Coat Interface Bond Strength Tests

- Candidates
- Direct Shear

Overlay Bond Strength Tester

LTRC Shear Test

NCAT Direct Shear Test
Characterization of Interface Bond Strength
Louisiana Interlayer Shear Strength Tester
Characterization of Tack Coat Film Quality Tests

- Candidate
- Modified ATacker
LSU NO. 1!