Results of NCHRP Project 9-40: Tacking Your Way to Performance

Louay Mohammad, Ph.D.
Louisiana Transportation Research Center
Louisiana State University

2010 NCAUPG Hot Mix Asphalt Technical Conference
February 3-4, 2010
Overland Park, Kansas
What is a Tack Coat?

- An application of asphalt onto a pavement surface
  - HMA, PCC
  - Emulsion
  - Hot AC
- Used to ensure a bond between the surface being paved and the underlying course
**Background**

- **Experience and empirical judgment**
  - Selection of tack coat material type, application rate, and placement

- **Quality control and quality assurance testing**
  - rarely conducted
  - resulting in the possibility of unacceptable performance at the interface,
  - premature failure.

- **NCHRP Project 9-40**
  - Optimization of Tack Coat for HMA Placement
  - develop a procedure to evaluate the tack coat quality in the field
  - bonding characteristics testing
Tack Coat Material Approaches to Test Strength

- Interlayer Bond Strength
- Tack Coat Quality

Torsion
Direct Shear
Torsion
Torsion
Tension
Tack Coat Material
Approaches to Test Strength

- Tack Coat Quality

Torsion
Tension
Field Pull-off Test for Tack Coat Evaluation

- Apply adhesive material on the pavement surface
- Contact plate is pushed into the pavement surface with a specific pressure
- The plate is then pulled off
- Tensile strength between the plate and tack coat surface is measured
Characterization of Tack Coat Quality
Louisiana Tack Coat Quality Tester -- LTCQT

- Developed equipment
  - Tack coat quality -- residual
  - Tension
- User friendly, Easy to use
- Laboratory and field
- Draft test method in AASHTO format
- Tensile load
  - Displacement
  - Tensile Force
  - Time
Summary

- LTCQT could serve as a valuable tool for highway agencies to perform comparative evaluations of various tack coat materials and application rates in the field.
- Repeatability of measurements
  - average coefficient of variation of less than 14%

Reference

Evaluate the Effectiveness of Tack Coat Materials

- Interface Bond Strength

Direct Shear

Torsion
Objective

- Evaluate the interface shear strength of tack coat materials under a wide range of testing conditions commonly encountered in field applications
  - effect of tacked surface type;
  - effect of tack coat materials type;
  - effect of application rate;
  - Construction condition;
    » effect of wetness (rain).
<table>
<thead>
<tr>
<th>Variable</th>
<th>Content</th>
<th>Number of Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tack Coat Material</td>
<td>CRS-1, SS-1h, SS-1, Trackless, PG 64-22</td>
<td>5</td>
</tr>
<tr>
<td>Residual Application Rate</td>
<td>0.00-, 0.14-, 0.28-, 0.70- (0.00-, 0.031-, 0.062, 0.155)</td>
<td>4</td>
</tr>
<tr>
<td>Pavement Surface</td>
<td>HMA: Existing, Milled, New PCC: Existing</td>
<td>4</td>
</tr>
<tr>
<td>Wet (Rain) Condition</td>
<td>Wet, Dry</td>
<td>2</td>
</tr>
<tr>
<td>Testing Temperature</td>
<td>25°C</td>
<td>1</td>
</tr>
<tr>
<td>Testing Replicates</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

**Total Number of Tested Specimens**: 375
Specimen Type

- Laboratory mixed/compacted
- Field mixed/compacted
Sample Preparation

- Laboratory mixed/compacted

Shear
Sample Preparation

- Laboratory mixed/compacted
- Field mixed/compacted
  - Field test sections
  - LTRC Pavement Research Facility
  - Computerized tack coat distributor truck
  - Conventional paving equipment
**Surface Texture**

- LTRC Pavement Research Facility
- Surface texture measurement
  - ASTM E1845
  - HMA New: 0.63 mm
  - HMA Existing: 1.05 mm
  - HMA Milled: 1.25 mm
  - PCC: 1.19 mm
### Lane Layout – Existing HMA Surface

<table>
<thead>
<tr>
<th></th>
<th>Access Section</th>
<th>Access Section</th>
<th>Access Section</th>
<th>Access Section</th>
<th>Access Section</th>
<th>Access Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRS-1</td>
<td>15.2 m</td>
<td>15.2 m</td>
<td>10.7 m</td>
<td>10.7 m</td>
<td>16.8 m</td>
<td>16.8 m</td>
</tr>
<tr>
<td>CRS-1</td>
<td>0.14 l/m²</td>
<td>0.28 l/m²</td>
<td>0.70 l/m²</td>
<td>0.70 l/m²</td>
<td>0.14 l/m²</td>
<td>0.14 l/m²</td>
</tr>
<tr>
<td>CRS-1</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
</tr>
<tr>
<td>Trackless</td>
<td>15.2 m</td>
<td>15.2 m</td>
<td>10.7 m</td>
<td>10.7 m</td>
<td>16.8 m</td>
<td>16.8 m</td>
</tr>
<tr>
<td>Trackless</td>
<td>0.14 l/m²</td>
<td>0.28 l/m²</td>
<td>0.70 l/m²</td>
<td>0.70 l/m²</td>
<td>0.14 l/m²</td>
<td>0.14 l/m²</td>
</tr>
<tr>
<td>Trackless</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
</tr>
<tr>
<td>SS-1h</td>
<td>15.2 m</td>
<td>15.2 m</td>
<td>15.2 m</td>
<td>15.2 m</td>
<td>22.9 m</td>
<td>22.9 m</td>
</tr>
<tr>
<td>SS-1h</td>
<td>0.14 l/m²</td>
<td>0.28 l/m²</td>
<td>0.28 l/m²</td>
<td>0.28 l/m²</td>
<td>0.14 l/m²</td>
<td>0.14 l/m²</td>
</tr>
<tr>
<td>SS-1h</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
<td>Dry-Clean</td>
</tr>
<tr>
<td>SS-1h</td>
<td>0.14 l/m²</td>
<td>0.28 l/m²</td>
<td>0.28 l/m²</td>
<td>0.28 l/m²</td>
<td>0.14 l/m²</td>
<td>0.14 l/m²</td>
</tr>
<tr>
<td>SS-1h</td>
<td>Wet-Clean</td>
<td>Wet-Clean</td>
<td>Wet-Clean</td>
<td>Wet-Clean</td>
<td>Wet-Clean</td>
<td>Wet-Clean</td>
</tr>
<tr>
<td>SS-1h</td>
<td>0.14 l/m²</td>
<td>0.28 l/m²</td>
<td>0.28 l/m²</td>
<td>0.28 l/m²</td>
<td>0.14 l/m²</td>
<td>0.14 l/m²</td>
</tr>
<tr>
<td>SS-1h</td>
<td>Wet-Clean</td>
<td>Wet-Clean</td>
<td>Wet-Clean</td>
<td>Wet-Clean</td>
<td>Wet-Clean</td>
<td>Wet-Clean</td>
</tr>
</tbody>
</table>

**Direction of Tack Coat Application**

- **PG 64-22**
  - 0.14 l/m²
  - 0.28 l/m²
  - 0.70 l/m²
  - Dry-Dirty
  - Wet-Dirty
  - Dry-Clean
  - Wet-Clean

- **CRS-1**
  - 0.14 l/m²
  - 0.28 l/m²
  - 0.70 l/m²
  - Dry-Clean

- **Trackless**
  - 0.14 l/m²
  - 0.28 l/m²
  - 0.70 l/m²
  - Dry-Clean

- **SS-1h**
  - 0.14 l/m²
  - 0.28 l/m²
  - 0.70 l/m²
  - Dry-Clean
  - Wet-Clean

**Note:** All quantities in l/m².
Spray Application of Tack Coat

- Equipments
  - Etnyre, Model 2000
  - Computerized tack coat distributor truck
Verification of Spray Rates

- Geotextile Pad layout
  - ASTM 2995
  - One transverse direction
Spray Application of Tack Coat
Existing HMA Surface Type
100% Coverage

0.14 l/m²    0.28 l/m²    0.70 l/m²
Low          Medium      High
Typical Calibration Results
Milled Surface: SS-1h, SS-1
Construction Condition -- Wet

Rate $= 0.27 \text{ L/m}^2$
Overlay Construction

Material Transfer Vehicle
Coring Process

Shear
Direct Shear Test Device
Louisiana Interlayer Shear Strength Tester (LISST)

- Two Main Parts
  - Shearing frame,
  - Reaction frame
  - Frictionless linear bearing
    - Maintain vertical travel

- Easy to use
- Portable
- Adoptable to existing load frames
- Reasonable cost
- Accommodate both 100 and 150-mm sample diameter

- Comparison
  - Superpave Shear Tester
Interface Shear Strength (ISS) Test Results

- Interface Shear Strength
  - ISS
  - % CV < 15%
Effect of Residual Application Rates on ISS: Pavement Surface: Existing HMA Clean and Dry Condition, No Confinement

Sample failed during coring
0 Application Rate – All materials
Effect of Residual Application Rates on ISS: Pavement Surface: Existing PCC
Clean and Dry Condition, No Confinement

Sample failed during coring
0.14 l/m² SS-1
Effect of Residual Application Rates on ISS: Pavement Surface: Milled HMA
Clean and Dry Condition, No Confinement

![Graph showing the effect of residual application rates on interface shear strength](Image)
Effect of Pavement Surface Type on ISS Tack Coat Materials: SS-1h
Clean and Dry Condition, No Confinement

![Graph showing the relationship between residual application rate and interface shear strength for different types of pavement surfaces.](image)
Effect of Pavement Surface Type on ISS Tack Coat Materials: PG 64-22
Clean and Dry Condition, No Confinement

![Graph showing the effect of residual application rate on interface shear strength for Existing HMA and PCC. The graph indicates a positive correlation between the residual application rate and interface shear strength for both materials.](image-url)
Effect of Pavement Surface Type on ISS Tack Coat Materials: Trackless Clean and Dry Condition, No Confinement

![Graph showing the relationship between Residual Application Rate (l/m²) and Interface Shear Strength (kPa) for Existing HMA and PCC.]
Effect of Wet Condition of Existing HMA Surface on ISS -- Clean

![Graph showing the effect of wet condition on ISS](image)

- SS-1h
- PG 64-22

**Interface Shear Strength (kPa)**

- Wet / Clean
- Dry / Clean

**Residual Application Rate (l/m²)**

- 0.14
- 0.28
- 0.70

* indicates significant difference.
Effect of Wet Condition of PCC Surface on ISS -- Clean Condition

Interface Shear Strength (kPa)

Residual Application Rate (l/m²)

Wet / Clean
Dry / Clean

Trackless
SS-1h
PG 64-22
SS-1

*
Effect of Wet Condition of Milled HMA Surface on ISS -- SS-1h, Clean

![Graph showing the effect of wet condition on ISS. The graph compares interface shear strength (kPa) against residual application rate (l/m²) for wet/clean and dry/clean conditions. The graph highlights a significant difference at a certain application rate marked with an asterisk (*).]
Effect of Sample Preparation Method on ISS Tack Coat Materials: SS-1h
Clean and Dry Condition, No Confinement, New on New
Conclusions

- **Effect of tack coat materials type**
  - trackless exhibited the highest ISS at all application rates
    - Existing HMA, PCC
  - CRS-1 resulted in the lowest ISS
    - Existing HMA
  - SS-1 presented lowest ISS
    - PCC

- **Effect of application rate**
  - In general, ISS increased with an increase in the application rate
    - Existing HMA
      - Rate of increase: Trackless, SS-1h, PG 64-22, and CRS-1
    - PCC
      - Rate of increase: Trackless, SS-1h, SS-1
        - Except PG 64-22: Decrease
  - Milled HMA
    - ISS is not sensitive to increase in application rate
    - Texture is more dominant
Conclusions

● Effect of wetness condition
  – Majority of the cases: no statistically significant difference b/w dry and wet conditions.
  – Small amount of water can be flashed away by the hot HMA mat
    » inconsequential effects on the quality of the tack coat.

● Preparation method
  – Laboratory-prepared samples grossly overestimated the interface shear strength when compared to pavement cores.
  – While a decreasing trend was observed in the laboratory, an increasing trend in the measured interface shear strength was observed in the field.
Acknowledgement

- NCHRP
  - Project 9-40
    - Optimization of Tack Coat for HMA Placement
  - Technical Review Panel

- LDOTD

- Asphalt Products Unlimited
  - Distributor Truck
    - SS-1h, CRS-1

- Coastal Bridge
  - HMA
  - Construction

- Blacklidge
  - Trackless
Saints 28
Colts 17