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

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TRB Webinar: The Optimization of Tack Coat for HMA Placement

January 12, 2012,
2:00 PM - 4:00 PM EST
Sponsored by: TRB AFK40 Committee on Characteristics Of Asphalt-Aggregate Combinations To Meet Surface Requirements
My Story

- Overview of NCHPR Project 9-40
  - Completed 12/30/2011
  - NCHRP Report Number

- Evaluation of Tack Coat Materials
  - Quality
  - Interlayer bond strength

- Experiment

- Results

- Performance-based criteria
  - Tack coat material

- Summary and Conclusions
What is a Tack Coat?

- 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

● 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
Objectives

- 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
  - Tack Coat Quality
  - Interlayer Bond Strength
Ascertain Performance of Tack Coat Materials

- Identify Laboratory and Field Test Devices
  - Tack coat spray application quality
  - Interface Bond Strength
- Develop Experiments To Evaluate Performance of Tack Coats
Characterization of Tack Coat Quality
Louisiana Tack Coat Quality Tester -- LTCQT

Proposed Standard Method of Test for

DETERMINING THE TACK COAT QUALITY OF ASPHALT PAVEMENT IN THE FIELD OR LABORATORY

AASHTO Designation: TP XX-XX

Proposed test method under review before submitting to AASHTO Subcommittee on Materials

American Association of State Highway and Transportation Officials
444 North Capitol Street N.W., Suite 249
Washington, D.C. 20001
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

Characterization of Interface Bond Strength

- Interface Bond Strength

Direct Shear

Torsion

Supply > Demand
Factors considered in the development of Test Method

- Simple, repeatable, easily-calibrated,
- quick, not requiring highly-trained personnel,
- utilizing low-cost equipment.
- Based on measuring fundamental properties
  - relate to interface performance
- Sensitive to subtle changes in tack coat properties
Direct Shear Test Device
Louisiana Interlayer Shear Strength Tester (LISST)

- Two Main Parts
  - Shearing frame,
  - Reaction frame
  - Frictionless linear bearing
    - Maintain vertical travel
  - accommodate sensors
    - measure the vertical and horizontal displacements
  - specimen locking mechanism
  - consistent normal loads
  - accommodate both 100 and 150-mm sample diameter

- Easy to use
- Portable
- Adoptable to exiting load frames
- Reasonable cost
- Comparison
  - Superpave Shear Tester
Direct Shear Test Device – Summary of Test Method
Louisiana Interlayer Shear Strength Tester (LISST)

- Load is applied to the shearing frame at displacement rate
  - 2.54 mm (0.1 in.) per min
- Vertical displacement & load
  - Continuously recorded
  - failure

\[
ISS = \frac{P_{\text{ultimate}}}{\pi D^2} \frac{1}{4}
\]
Louisiana Interlayer Shear Strength Tester Set Up
Louisiana Interlayer Shear Strength Tester Set Up
Louisiana Interlayer Shear Strength Tester
Set Up
Louisiana Interlayer Shear Strength Tester
Set Up
Louisiana Interlayer Shear Strength Tester
Set Up
Interface Shear Strength (ISS) Test Results

- Interface Shear Strength
  - ISS
  - % CV < 15%
Proposed Standard Method of Test for

DETERMINING THE INTERLAYER SHEAR STRENGTH OF ASPHALT PAVEMENT LAYERS

AASHTO Designation: TP XX-XX

Proposed test method under review before submitting to AASHTO Subcommittee on Materials
<table>
<thead>
<tr>
<th>Variable</th>
<th>Content</th>
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</tr>
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<tbody>
<tr>
<td>Tack Coat Material</td>
<td>CRS-1, Trackless, SS-1h, SS-1, PG 64-22</td>
<td>5</td>
</tr>
<tr>
<td>Residual Application Rate (l/m², gsy)</td>
<td>0.00-, 0.14-, 0.28-, 0.70- (0.00-, 0.031-, 0.062, 0.155)</td>
<td>4</td>
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<tr>
<td>Pavement Surface</td>
<td>HMA: Old, Milled, New PCC: Existing</td>
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<tr>
<td>Surface Coverage (by tack coat)</td>
<td>50%, 100%</td>
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<tr>
<td>Surface Condition (Cleanliness)</td>
<td>Clean, Dirty</td>
<td>2</td>
</tr>
<tr>
<td>Wet (Rain) Condition</td>
<td>Wet, Dry</td>
<td>2</td>
</tr>
<tr>
<td>Specimen Preparation Method</td>
<td>LL, PF</td>
<td>2</td>
</tr>
<tr>
<td>Testing Temperature</td>
<td>25°C</td>
<td>1</td>
</tr>
<tr>
<td>Testing Confinement Pressure</td>
<td>0-, 138 KPa (0-, 20 Psi)</td>
<td>2</td>
</tr>
<tr>
<td>Testing Replicates</td>
<td>3</td>
<td>3</td>
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## Testing Factorial – Temperature Experiment

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Specimen Type

- Laboratory mixed/Laboratory compacted
  - LL specimen
- Plant mixed/Field compacted
  - PF specimen
Sample Preparation

- LL specimen
- PF Specimen
  - Plant
  - conventional paving equipment
    » computerized tack coat distributor truck
  - Test sections
  - LTRC Pavement Research Facility
    » 6 Acres
    » 9 test sections
Spray Application of Tack Coat
Existing HMA Surface Type
100% Coverage

0.14 l/m²
Low

0.28 l/m²
Medium

0.70 l/m²
High
Verification of Spray Rates

- Geotextile Pad layout
  - ASTM 2995
  - One transverse
  - Two longitudinal

![Diagram of Geotextile Pad layout](image-url)
Effect of Residual Application Rates on ISS: Pavement Surface: Existing HMA

Sample failed during coring
0 Application Rate – All materials
Effect of Residual Application Rates on ISS: Pavement Surface: Existing PCC

- Sample failed during coring
- 0.14 l/m² SS-1
Effect of Residual Application Rates on ISS: Pavement Surface: Milled HMA
Relationship between ISS (0.70 l/m²) vs. Rheology Test Results

- **Rotational Viscosity at 135 C (Pa-s)**
  - $R^2 = 0.95$

- **Softening Point (°C)**
  - $R^2 = 0.97$

- **$G^*/Sin\,\theta$, 64 C (kPa)**
  - $R^2 = 0.96$
Effect of Spray Coverage SS-1h

[Graph showing the effect of spray coverage on Interface Shear Strength (psi) at different Residual Application Rates (gsy)].

- 100%
- 50%
Effect of Sample Preparation Method on ISS Tack Coat Materials: SS-1h

![Graph showing the effect of sample preparation method on ISS tack coat materials: SS-1h. The graph plots Interface Shear Strength (kPa) against Residual Application Rate (l/m²). Two lines are shown: one for Lab-Fabricated samples and another for Field-Cored samples. The Lab-Fabricated samples show a decrease in Interface Shear Strength with increasing Residual Application Rate, while the Field-Cored samples show an increase.]
**Effect of Dusty Condition of HMA Surface on ISS -- Confinement**

![Graph showing the effect of dusty condition on HMA surface interface shear strength](image-url)

- **SS-1h**
  - Clean/Dry
  - Dirty/Dry

- **CRS-1**
  - Clean/Dry
  - Dirty/Dry

- **Trackless**
  - Clean/Dry
  - Dirty/Dry

*Note: Values marked with an asterisk (*) indicate significant differences.*
Effect of Wet Condition of Milled HMA Surface on ISS -- SS-1h, Clean

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

- **Interface Shear Strength (kPa)**
- **Residual Application Rate (l/m²)**
  - 0.14
  - 0.28
  - 0.70

- **Legend**
  - Yellow: Wet / Clean
  - Red: Dry / Clean

*Note: Data marked with an asterisk indicates a significant difference.*
Effect of Temperature Experiment

- Direct Shear Test Device: LISST

- Loading System: Cox & Sons Universal Test Machine with Temperature Chamber
  - Capacity: -10 to 80°C, 111.2 kN

Temperature Conditioning about 4 hrs

Assemblage of Specimen to LISST

Temperature Conditioning about 15-30 min

Load Application
## Testing Factorial – Temperature Experiment

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ISS vs Residual Application Rate at Various Temperature – CRS-1

Interface Shear Strength (kPa)

Residual Application Rate Rate (l/m²)
ISS vs Residual Application Rate at Various Temperature – Trackless

![Graph showing the relationship between Interface Shear Strength (kPa) and Residual Application Rate (l/m²) at different temperatures. The graph includes lines for -10, 0, 10, 20, 30, 40, 50, and 60 degrees temperature, with different markers and colors for each temperature level.](image-url)
**ISS Ratio of Trackless to CRS-1**

![Graph showing the ratio of Trackless to CRS-1 temperature.]
ISS Ratio of Trackless to CRS-1

Temperature (°C)

ISS_{Trackless} / ISS_{CRS-1}

-10 0 10 20 30

0.14 0.28 0.70
40°C - 60°C:
CRS-1 produced zero or very low ISS
Development of Performance Based Criteria

- **Critical shear stress**
  - interface is the calculated at the bottom of the asphalt mixture overlay.

- **Two-dimensional (2D) Finite Element (FE) approach**
  - Constitutive formulation
    - Asphalt mixture layers
      - viscoelastic material using a Generalized Kelvin model
    - Base and subgrade materials
      - elastic
  - Load = 9,000 lbf
  - Tire pressure = 105 psi
  - Load cycle 0.1 second

<table>
<thead>
<tr>
<th>Material Description</th>
<th>Constitutive Behavior</th>
<th>Elastic Modulus (psi)</th>
<th>Poisson’s ratio</th>
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<tbody>
<tr>
<td>HMA Overlay</td>
<td>Viscoelastic</td>
<td>650,000</td>
<td>0.25</td>
</tr>
<tr>
<td>Old HMA</td>
<td>Viscoelastic</td>
<td>500,000</td>
<td>0.25</td>
</tr>
<tr>
<td>Base</td>
<td>Elastic</td>
<td>40,000</td>
<td>0.30</td>
</tr>
<tr>
<td>Subgrade</td>
<td>Elastic</td>
<td>6,000</td>
<td>0.35</td>
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</tbody>
</table>
CRS-1, 0.031 gsy, failed due to single load application
Pavements are subjected to repeated vehicular loads.

Fatigue failure occurs due to cumulative damage of shear response.

Stress ratio (SR) = $\tau_{\text{calculated}} / \text{ISS}$

- SR < 0.50
  » Pavement structure offers acceptable performance
  » no fatigue-related distress at the interface

- SR > 0.50
  » Pavement structure offers unacceptable performance

- SR = 0.50
  » Common assumption laboratory fatigue testing of asphalt mixtures as well as tacked interface as an indication of failure

Development of Performance Based Criteria

$\tau_{\text{calculated}}$ vs. ISS

- Pavement structure offers acceptable performance
- no fatigue-related distress at the interface
- Pavement structure offers unacceptable performance
- Common assumption laboratory fatigue testing of asphalt mixtures as well as tacked interface as an indication of failure.
Development of Performance Based Criteria

\( \tau_{\text{calculated}} \) vs. ISS – Cumulative Damage

![Bar Chart]

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

**Application Rate (g/sy)**

0.031 0.062 0.155 0.031 0.062 0.155 0.031 0.062 0.155 0.031 0.062 0.155

**Shear Stress Ratio**

0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4

Structure A

![Structure Diagram]
Development of Performance Based Criteria  
$\tau_{\text{calculated}}$ vs. ISS – Single Load Application

![Graph showing the relationship between Shear Stress Ratio and ISS (psi) for Design A. The equation $y = 15.514x^{-1.035}$ and $R^2 = 0.99$.](image)

Structure A
Theoretical Investigation
Develop ISS Criteria

- Develop of performance-based guidelines
  - selection of tack coat materials

- Single ISS value of 40 psi
  - Safety factor of 1.4 against variability in measurements and in construction
Summary & Conclusions

- Developed Louisiana Tack Coat Quality Tester (LTCQT)/Test Procedure
  - evaluate the quality of tack coat spray application
  - viable methods for evaluating tack coat quality in the field.
  - could serve as a valuable tool for highway agencies to perform comparative evaluations of various tack coat materials and application methods and rates in the field. Repeatability of measurements using the LTCQT was acceptable, with an average coefficient of variation of less than 11%.

- Developed Louisiana Interlayer Shear Strength Tester (LISST)/Test Procedure
  - Characterize the of interface shear strength in the laboratory
  - Preliminary criteria of ISS of 40 psi
Summary & Conclusions

With respect to the interface shear strength in the field

- **Effect of tack coat type**
  - trackless tack coat exhibited the highest shear strength, and CRS-1 resulted in the lowest strength.
  - These results relate directly to the viscosity of the residual binders at the test temperature (25°C).

- **Effect of application rate**
  - all tack coat materials showed the highest shear strength at an application rate of 0.155 gsy.
  - Within the tested application rate range, it was difficult to determine the optimum residual application rate. This may be attributed to the highly-oxidized HMA surface at the LTRC site, which required greater optimum tack coat rates than expected.
  - It may also indicate that, under actual field conditions, optimum application rates are greater than what is commonly predicted from laboratory-based experiments.
  - It is noted, however, that while higher application rates may increase interface shear strength, excessive tack coat may migrate into the new asphalt mat during compaction causing a decrease in the air void content of the mix.
Summary & Conclusions

*With respect to the interface shear strength in the field*

- Effect of dust,
  - Majority of the cases showed a statistically significant difference between clean and dusty conditions.
  - Dusty conditions exhibited greater ISS than clean conditions, especially when tested with a confining pressure.
  - Note that these results are based on using a uniform and clean sand to simulate dusty conditions.
  - *Cleaning and sweeping of the existing pavement surface is recommended to avoid negative effects of dusty conditions*
Summary & Conclusions

With respect to the interface shear strength in the field

- **Effect of water on the tacked interface,**
  - Majority of the cases showed no statistically significant difference between dry and wet conditions.
  - This data indicates that a small amount of water can be flashed away by the hot HMA mat and thus have inconsequential effects on the quality of the tack coat.
  - This study used only hot mix as the overlay material; the use of warm mix may change this finding
  - *Dry and clean surface is recommended to avoid the negative effects of water on the bonding at the interface*

- **Effect of surface type,**
  - Direct relationship was observed between the roughness of the existing surface and the shear strength at the interface.
    » Milled HMA surface provided the greatest interface shear strength followed by PCC, old HMA, and new HMA surface
Summary & Conclusions

With respect to the interface shear strength in the field

- **Effect of preparation method,**
  - LL specimens grossly overestimated the interface shear strength when compared to pavement cores.
  - In addition, when increasing tack application rate, a decreasing trend in ISS was observed in laboratory-prepared specimens, while an increasing trend was observed in the field

- **Effect of temperature (from -10 to 60°C),**
  - ISS increased with the decrease in temperature.
    » In addition, the bonding performance, as measured by the interface shear strength of the trackless emulsion, was superior to that of the CRS-1 emulsion, especially at temperatures greater than 40°C.

- **Based on the results of the FE analysis,**
  - minimum laboratory-measured interface shear strength in the LISST device that provides acceptable performance is 40 psi
Recommended Implementation from NCHRP Project 9-40

- Distributor calibration
- Bond testing of cores using direct shear test method
  - draft test method
  - QA cores
Recommended Implementation from NCHRP Project 9-40

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Residual Application Rate Gal/Sq yd</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Asphalt Mixture</td>
<td>0.035</td>
</tr>
<tr>
<td>Old Asphalt Mixture</td>
<td>0.055</td>
</tr>
<tr>
<td>Cold Planed/Milled Asphalt Mixture</td>
<td>0.055</td>
</tr>
<tr>
<td>Portland Cement Concrete</td>
<td>0.046</td>
</tr>
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</table>
The Dos and Don’ts of Tack Coat Spray Application
**Sprayed Asphalt Terminology**

- *Prime Coat* - asphalt material sprayed onto a compacted base
- *Tack Coat* - thin film of asphalt material sprayed onto an existing pavement before overlaying
- *Seal Coat* – thick film of asphalt material sprayed onto an existing pavement to seal cracks + aggregate
- *Surface Treatment* - asphalt material sprayed onto a compacted base as the paving surface + aggregates
Purpose of a Tack Coat:

- To enhance the bond between the existing pavement and a new asphalt concrete overlay

- Existing pavement may be:
  - asphalt concrete
  - portland cement concrete
  - a surface treatment
  - a seal coat
Importance of Interfacial Bond

Interfacial bond is necessary to transmit traffic loads down through the whole pavement structure. If surface layer is not properly bonded to the underlying pavement layer, horizontal shear forces at the interface between the layers will increase the tendency for:

- Cracking,
- Debonding (delamination/slippage/sliding), and/or
- Fatigue cracking
- …and thus failure in the new overlay
Importance of Interfacial Bond, cont’d

- Tack coat is a relatively inexpensive portion of the overall pavement construction
- However, tack coat failure is extremely $$$
- Thus, to construct a durable, long-lasting asphalt concrete overlay, always apply the proper type and amount of tack coat between the new and old pavement layers…
Types of Tack Coat Materials
Types of Tack Coat Materials

Three basic types of asphalt materials are used as tack coat:

- *Performance Graded (PG)* - 100% asphalt cement
- *Emulsion* – asphalt suspension in water
- *Cutback* - asphalt dissolved in solvent (cutter stock)
  – rarely used as tack coat
Residual Asphalt Application Rate

- **Residual Asphalt**: The quantity of asphalt tack coat that remains on the pavement surface.

- **PG Asphalt** – application rate and residual rate are always equivalent.

- **Emulsified & Cutback Asphalts** – residual rates are less than application rates because of water or cutter stock that evaporates.
Performance-Graded Asphalt Tack Coat

- Typically, same PG as that in the paving mixture
- Example: PG 64-22
- If polymer-modified asphalt use in HMA, unmodified will likely be used as tack
- Recall: residual rate for PG is same as application rate
Emulsified Asphalt

By far, emulsions are most used as tack coat:

- Anionic, cationic, or non-ionic
- Rapid set (RS), medium set (MS), or slow set (SS)
- High float (HF), hard base asphalt (h)
- Examples: RS-1, SS-1h, CSS-1, HFRS
- SS emulsions most used as tack coat
Trackless Tack Coat Emulsions

- Polymer-modified asphalt in the emulsion
- Hard base binder, i.e., low penetration AC
- Usually breaks/sets* faster than standard SS tack coat emulsions
- Hard asphalt & quick set reduces tracking by haul trucks and paving machine – a significant advantage to a successful tack coat
Cutback Asphalts

- Only occasionally used for tack coat
- Diluents or cutter stock:
  - Rapid Cure - gasoline or naphtha
  - Medium Cure - kerosene
  - Slow Cure - diesel or fuel oil
- Must compute tack coat application rate from the desired residual rate...much like emulsified asphalt
Residual Asphalt Binder in Emulsion
Residual Asphalt Binder in Emulsion

- Slow set emulsion = typically ~2/3 asphalt + 1/3 water
- For tack coat – 67% asphalt + 33% water
- Generally, use this ratio for the majority of asphalt emulsions used as tack coat to result in a calculation of residual asphalt tack coat that is “close enough”
- *Residual asphalt* is critical: It is the amount of actual tack coat that remains on the pavement after water or solvents have evaporated
Calculation of Application Rate for Emulsion

- It is the *Residual* asphalt content that creates the bond between the pavement layers
- Residual binder amount is the starting point for calculating the tack coat application rate for asphalt emulsion
- Calculations must work backward from the residual amount of tack coat to obtain the proper application rate
Calculation of Application Rate for Emulsion

Based on a ratio of 2/3 asphalt and 1/3 water, the required *application* amount of asphalt binder in an asphalt emulsion will be 1.5 times greater than the residual amount.

Application Rate = 1.5 x Desired Residual Asphalt
For example:

If the residual amount of asphalt tack coat on a particular existing pavement surface is to be 0.06 gallons per square yard, the application rate of the asphalt emulsion will need to be 0.09 gallons per square yard.

\[ 0.06 \text{ gal./sq. yd.} \times 1.5 = 0.09 \text{ gal./sq. yd.} \]
SS emulsions are often diluted with additional water to provide more uniform application of tack.

Greater volume of liquid provides more consistent spray pattern from the nozzles on the distributor truck.

Common dilution rate is 1:1 (50% emul + 50% water).

Dilution may occur at (1) terminal or (2) job site.

Dilution rate must be accurately known to ensure adequate residual tack.
Application Rate for Diluted Emulsion

- Based on a ratio of 1 part asphalt emulsion and 1 part additional water, a diluted asphalt emulsion will have a residual binder content of only 1/3 of the weight of the emulsion.

- So, you must apply three times (3x) more diluted emulsion than the desired residual tack coat rate.
For example:

If the desired residual asphalt tack on a particular pavement surface is 0.06 gallons per square yard, the application rate of 1:1 diluted asphalt emulsion will need to be 0.18 gallons per square yard.

\[ 0.06 \text{ gal./sq. yd.} \times 3.0 = 0.18 \text{ gal./sq. yd.} \]
Optimum Amount of Tack Coat Depends on Conditions of Existing Pavement Surface
Conditions of Pavement Surface

- Residual tack rate should vary depending on conditions of the pavement surface
- Objective: apply a thin, uniform coating of asphalt over the existing pavement
Tack Coat Rate Must Depend on Surface Conditions

- New pavement surface
- Old, aged pavement
- Dusty or dirty surface
- Texture of the surface (Ex: seal coat)
- Milled pavement
- Bleeding surface
- Portland cement concrete
New Pavement Surface

- **Common Perception**: Tack coat is not needed on a new asphalt concrete pavement
- NCHRP Project 9-40 indicated a tack is **NEEDED** to provide sufficient interfacial bonding
- However, residual tack rate can be reduced
- Typically, about ½ that required for an old, oxidized surface
New Asphalt Pavement Surface

- A new HMA pavement will typically not absorb a significant amount of tack coat material.
- The amount of residual tack normally needed will be significantly less than that needed for an old, aged surface.
- For a new layer placed one day and a second layer placed within a day two, the residual asphalt remaining on the surface should be ~ 0.03 to 0.04 gal./sq. yd.
Aged, Crazed Asphalt Pavement

- If surface is aged, dry, or exhibits extensive cracking / raveling, must increase tack coat rate
- Diluted emulsified tack can flow into crevices
- Minimize flow by using PG or undiluted emulsion (However, be sure to use appropriate nozzle size to ensure proper coverage when using a low application rate (esp. with PG)
- The residual amount of asphalt binder should be ~0.04 to 0.06 gal./sq. yd.
Dust and Dirt

- Tack must be applied to a clean surface
- *Cleaning*: brooming, flushing with water, or blowing with high-pressure air
- A higher tack rate will NOT compensate for dust; may actually contribute to slippage
- *Poor Bonding* – Ex: Sliding failures often occur at locations where traffic decelerates, accelerates, or makes turning movements
Texture of Surface

- Texture may be natural (Ex: seal coat) or induced (Ex: milled surface)
- NCHRP Project 9-40 demonstrated that higher texture requires higher tack coat rates
- Typical range is from 0.04 to 0.08 gal./sq. yd.- residual
Milled Pavement Surface

- *Common Perception:* A milled surface does not need a tack coat, however…
- NCHRP Project 9-40 indicated **OPPOSITE**
- Typically, ~ 0.04 – 0.08 gal/sq. yd.
Milled Surface

- Debris must be removed from grooves in a milled surface (broom, water, / compressed air)
- If not, it can build up on sticky tires of construction equipment
- Tack is unavailable for binding new overlay
Bleeding Surface

- The application rate must be reduced to account for the excessive asphalt already on the pavement surface.
- Application rate may have to be adjusted for different pavement surface conditions transversely across a traffic lane.
- It may be necessary to mill a bleeding surface, if the application rates cannot be adjusted correctly.
Portland Cement Concrete Surface

- Amount of residual tack coat is ~same as for existing HMA pavement surfaces, as long as the PCC pavement surface is in good condition

- If the PCC pavement surface has been diamond ground, a slight increase in the tack rate may be necessary to account for the additional texture

- A milled PCC surface must be thoroughly cleaned before applying tack coat and overlay
Damp Surface

A small amount of water on the existing pavement surface due to a passing shower is not normally detrimental to the long-term function of a tack coat.
## Typical Residual Tack Coat Rates

<table>
<thead>
<tr>
<th>Condition of Pavement Surface</th>
<th>Residual Asphalt Binder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dusty or Dirty</td>
<td>Clean the Surface</td>
</tr>
<tr>
<td>New Asphalt</td>
<td>0.03 to 0.04 g/sy</td>
</tr>
<tr>
<td>Old, Aged Asphalt</td>
<td>0.04 to 0.06 g/sy</td>
</tr>
<tr>
<td>Milled Asphalt</td>
<td>0.04 to 0.08 g/sy</td>
</tr>
<tr>
<td>Portland Cement Concrete</td>
<td>0.04 to 0.06 g/sy</td>
</tr>
</tbody>
</table>
- Emulsified Asphalt -

Break and Set Time


Emulsion Break and Set Time

- When first applied as tack coat, emulsion is brown in color – indicating that it is still in emulsified form

- Break: When the emulsion changes from brown to black, the emulsion has “broken” or the asphalt binder particles have separated from the water and coalesced

- Set: When all of the water has evaporated, the emulsion has “set,” and all that is left is asphalt binder
Example of Emulsion Break

Unbroken Emulsion  After Breaking
Factors Affecting Break and Set Time

- Ambient air temperature
- Relative humidity
- Wind speed
- Temperature of the pavement surface
- Temperature of the tack coat material
- Application rate of the tack coat material
- Dilution rate of an asphalt emulsion (if diluted)
- Type of emulsifying agent (controls break > set)
Factors Affecting Break and Set Time

- In most cases, depending on its application rate and dilution rate, emulsion will break in 10 or 20 minutes.
- Emulsion will change from brown to black in color.
- It will take 30 minutes to more than 2 hours to completely set, depending upon conditions.
- Before the tack coat sets, it can be picked up on tires of the trucks delivering the HMA to the project.
Tack Coat
Construction Issues
Three most common problems

- Lack of uniformity of the tack coat application
- Pick up of the tack coat on construction equipment before the tack coat material is set
- The need to pave over the emulsion tack coat before it is broken and/or set
Uniformity of Tack Coat Application

- Tack coat must be applied uniformly to ensure that a consistent bond is achieved

- Poor uniformity can be due to several factors:
  - Nozzles too large for low tack coat application rate
  - One or more spray nozzles may be set at an improper angle to the axis of the spray bar
  - One or more nozzles can be of a different size compared to the other nozzles
Uniformity of Tack Coat Application

- When properly applying tack coat, all nozzles on the spray bar are open and functioning correctly
- All nozzles are the proper size for tack coat
- All nozzles are set at same angle to axis of spray bar
- Height of the spray bar is adjusted to provide a triple-overlap of spray from adjacent nozzles
Construction Issues

Uniformity of the Tack Coat Application

Non-uniform Application

Proper Application

[Images of non-uniform and proper tack coat application]
Uniformity of the Tack Coat Application – Blocked Nozzles

- If a nozzle is blocked, no tack coat is being applied
- Distributor needs to be stopped, and the blocked nozzles removed and cleaned
- Nozzles should be replaced on the spray bar before the tack application is continued
- Ideally, keep spare nozzles available so blocked nozzles can be quickly replaced and cleaned later
**Construction Issues**

Uniformity of the Tack Coat Application

Tack application with blocked nozzles AND no overlap of nozzle spray fan.

Nozzles may be too large.
Construction Issues

Uniformity of the Tack Coat Application

Excessive Tack Coat (A serious problem; may require removal before overlaying)
Construction Issues

Tack Coat Adherence to Truck Tires

- Until it is fully cured and all water is evaporated, tack coat is sticky.
- Tack will adhere to truck tires and be carried off of the roadway.
- This means it will not provide the bond needed in the most critical place on the roadway – the wheel paths.
- Tack picked up by truck tires will be deposited on adjacent pavements and reduce friction, esp. during wet weather.
Construction Problems

Tack Coat Adherence to Truck Tires
Pick Up of Tack Coat Material by Construction Traffic
Construction Issues

Tack Coat Adherence to Truck Tires

- The best way to avoid adherence to tires is to let the tack coat fully set before construction vehicles are allowed on the material.

- Set times for different types of tack coats vary, so you should know the approximate set time.

- It could take up to 2 hours for some tack coat material to set so that it will not be picked up by truck tires.

- Using a material transfer device, in the lane adjacent to the one being paved, can avoid having trucks on the tacked surface.
Types of Tack Coat Failures

There are three primary types of pavement failure related to tack coat application:

- Inadequate bond between the old and new layers
- Delamination, with time and traffic, of the new asphalt overlay from the underlying pavement course
- Slippage failure, where the new overlay slides horizontally, producing crescent shaped cracks
Types of Tack Coat Failures

- The presence or absence of good bond between pavement layers depends on:
  - Residual rate of tack coat
  - Uniformity of the application
  - Cleanliness of the underlying pavement surface
  - Exposure of the tacked surface to traffic

- Usually, with time and traffic, a sufficient bond will develop between layers.
Types of Tack Coat Failures

Delamination of Pavement Layers

- Delamination is generally caused by poor bond between layers
- Delamination can be due to excessive deflection of the pavement structure under the load
- Delamination can cause the lower layer of pavement to bend under load and crack
- Repeated deflection, over time, causes “alligator” cracking
Types of Tack Coat Failures

– Delamination of overlay from underlying pavement
Types of Tack Coat Failures

Sliding Failures

- Sliding or slippage failures are usually caused by tack coat-related problems
- In most cases, sliding failures are directly related to the lack of uniformity of the tack coat
- Lack of Cleanliness of the pavement, at the time of tack application, could also be a factor
Types of Tack Coat Failures

Sliding Failures
Proper Application of Tack Coat

Proper size nozzles, all functioning, proper angle, good overlap of fans, proper spray bar height
Successful Tack Coat

The Ultimate Goal:
Uniform, complete, and adequate coverage
Remember…

It costs nothing extra to properly apply a tack coat. Attention to the few basic issues mentioned in this course will result in an asphaltic concrete overlay that performs as expected under traffic.

IT COSTS NOTHING TO DO IT RIGHT AND DO IT RIGHT THE FIRST TIME!
Thank you for your attention!