Tack Coat Best Practices
FHWA Cooperative Agreement Subtask
Longitudinal Joints
Intelligent Compaction

Tack coat? Who needs Tack?
Or Rollers?

OK – here’s a little tack for you!
OK, OK, we’ll use the distributor

OK, OK, we’ll use the spray bar

You want tack – we’ll give you tack
Terminology

- **Tack Coat**—sprayed application of asphalt cement upon an existing asphalt or Portland cement concrete pavement which may or may not have been milled before an overlay, or between layers of fresh asphalt concrete.
- **Original Emulsion**—an undiluted emulsion which consists of a paving grade binder, water, and an emulsifying agent.
- **Diluted Emulsion**—an emulsion that has been diluted with additional water.
  - Critical to control
  - 1:1 typical (Original Emulsion:Added Water)
Terminology

- **Residual Asphalt**—the remaining asphalt after an emulsion has set typically 57-70 percent.
- **Tack Coat Break**—the moment when water separates enough from the asphalt showing a color change from brown to black.
- **Tack Coat Set**—when all the water has evaporated, leaving only the residual asphalt. Some refer to this as completely broke.

Purpose of Tack Coats

- **To promote the bond between old and new pavement layers.**
  - To prevent slippage between pavement layers.
  - Vital for structural performance of the pavement.
  - All layers working together.
  - To be applied along all transverse and longitudinal vertical surfaces.

Bonded Demonstration

- Mini Michael Jackson- ~60 lbs
- 11 sheets of plywood: 48" x 8" x 11/32" each
- Measure deflection over 36" span
- Compare effect of full-slip versus fully bonded plywood sheets

Courtesy of Wayne Felix
Bonded Demonstration

Unbonded
Fully Bonded

21 Fold Difference

Consequences of Poor Bonding

- Layer independence
- Reduced fatigue life
- Increased rutting
- Slippage
- Shoving
- Compaction difficulty

Direction of traffic?

Loss of Fatigue Life Examples

- May and King:
  - 10% bond loss = 50% less fatigue life

- Roffe and Chaignon
  - No bond = 60% loss of life

- Brown and Brunton
  - No Bond = 75% loss of life
  - 30% bond loss = 70% loss of life
Pavement Behavior

Shear Transfer?

- Stress Distribution
- Compression
- Tension
- Aggregate Base
- Soil Subgrade

Courtesy of Rich May

So is it worth it to apply a tack coat?

Cost of Tack Coat

- New or Reconstruction
  - About 0.1-0.2% of Project Total
  - About 1.0-1.5% of Pavement Total Cost

- Mill and Overlay
  - About 1.0-2.0% of Project Total
  - About 1.0-2.5% of Pavement Total Cost

Estimated Cost of Bond Failure in Only the Top Lift

- Assume no inflation for materials
- Estimated traffic control
- Used project plans for thicknesses
- Used bid tabs for:
  - Milling
  - Material costs
  - Replaced pavement markings

30-100% of Original Pavement Costs
• Emulsified Asphalt
  • Most common option
    • SS-1, SS-1H
    • CSS-1, CSS-1H
    • RS-1, RS-1H, RS-2
    • CRS-1, CRS-2
    • PMAE
• PG Graded Binders
  • Neat Binders
    • PG 58-28
    • PG 64-22
  • Polymer Modified
• Reduced or Non-tracking Emulsions

Common Tack Coat Materials
(NCHPR Report 712)

17 States Known to Allow Reduced Tracking Tack Materials

• Alabama
• Florida
• Georgia
• Illinois
• Louisiana
• Maryland
• Mississippi
• Pennsylvania
• New York
• North Carolina
• Ohio
• Oklahoma
• South Carolina
• Tennessee
• Virginia
• West Virginia
• Texas
Material Selection

- State approved products lists
  - Online at most DOT websites
  - Asphalt Institute State Emulsion Data Base
- Material availability
- Local experience
- Dynamic area

Storage Options

- Tank—long-term storage
- Tanker—short-term storage
- Distributor Truck—short-term storage

Storage Tanks

- Long-term storage.
- Vertical generally preferred.
- Heated.
  - Store toward lowest pumpable temperature
- Agitation.
  - Low-shear
  - Every 2-3 days
- Hoses.
  - Keep clean
Tanker Storage
• Short-term storage.
• Generally not heated.
• Generally cannot agitate.

Distributor Storage
• Short-term storage
• Heated
• Pump circulation

Tack Coat
Field Operations
Tack Coat Challenges

- Contractor
  - Application Rate
  - Consistency of Application
  - Tack Coat Pickup or Tracking By Vehicles
  - Traction for Construction Equipment
  - Breaking/Settling Time
- Agency
  - Acceptance
  - Dilution?
  - Application Measurement
  - Bond Quality
  - Tort Claims
  - Pulling Up of Pavement

Manuals of Practice

- Asphalt Institute
  - MS-22 Construction of Hot Mix Asphalt Pavements, 2nd Edition
- Comments
  - AI has a long history of promoting the proper use of tack coats.

Manuals of Practice

- Tack Coat Guidelines, Caltrans (2009)
- Tack Coats: How and what to apply! Colorado Asphalt Pavement Association (CAPA) (2011)
Current Research

- SHRP II
- Colorado
- Illinois
- Louisiana
- NCAT
- Texas
- Wisconsin
- International

NCHRP Report 712

- Looked at numerous test methods (shear, tension, torsion)
- Many tack materials
- Four application rates (gsy residual)
  - 0.00
  - 0.031
  - 0.062
  - 0.155
- International survey
- Variety of surfaces both AC and PCC
  - New
  - Old
  - Milled
  - Unmilled
  - Dry
  - Wet
  - Clean
  - Dirty
- Eight test temps.
  - -10—60°C

NCHRP Report 712 Conclusions

- Recommends Shear Testing
- Stiffer based asphalts performed better
- 0.155 gal/yr² (residual) best results for all materials
- Current common rates may be too light
- Milled surfaces performed better
- Very good training appendix
- Application rate recommendations for different surfaces
712 Recommended Application Rates

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Residual Application Rate (g/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Asphalt</td>
<td>0.035</td>
</tr>
<tr>
<td>Existing Asphalt</td>
<td>0.055</td>
</tr>
<tr>
<td>Milled Asphalt</td>
<td>0.055</td>
</tr>
<tr>
<td>Portland Cement Concrete</td>
<td>0.045</td>
</tr>
</tbody>
</table>

Testing Methods

- Materials
  - Emulsion
  - Paving grade asphalt
- Field/Laboratory Bond Testing
  - Shear Testing
  - Torsion Testing
  - Pull-Off Testing (tension)
  - Cyclic

Shear Testing

- Cores or Lab Specimens
- 4 or 6-inch
- Common for Product Approval
- Alabama Example
  - ALDOT-430
  - Six-inch core or specimens
  - Placed in shear head
  - Typically tested on Marshall Stability test apparatus
    - 2 inches per minute of movement
  - Tested at 77°F
  - Record maximum load
  - NCAT recommended 100 psi minimum
**Tension Testing**

- Most typically a field test
- May be a modified ACI-301 or
- Direct Tensile Bond Test: ASTM C-1583
- Procedures identified in Texas and Kansas
- AASHTO TP 91-11
  - Asphalt Bond Strength Test
  - Lab tension test

**Tension Testing**

- Texas Example
  - Tex-243-F
  - Field test
  - 5-inch testing area
  - Tack cures for 30 minutes
  - 40-lb seating load for 10 minutes
  - Remove load
  - Using a torque wrench, determine maximum torque to separation
  - Calculate strength
  - Currently being modified

**Comments on Testing Options**

- **Shear Testing**
  - Lab test
  - Quick
  - Repeatable
  - Most widely promoted
  - Uses common lab equipment
  - Cleanly ranks materials

- **Torsional Testing**
  - Lab or field test
  - Quick
  - Proper repeatability (manually ran)

- **Tension Testing**
  - Lab or field test
  - Quick
  - Repeatable
  - Cleanly ranks materials

- **Cyclic Testing**
  - Lab test
  - More time consuming
  - Repeatable
  - Cleanly ranks materials
Best Practices for getting the material on the road!

- Surfaces need to be clean and dry.
- Uniform application.
- All surfaces are tacked.
- Tack should not be tracked off the road.

Note: not a tack coat, but principle applies.

Nozzles are clogged, but triple overlap covering the gap.
Best Practices

- Match application to conditions.
  - Materials
  - Residual rate
- Verify application rate.
- Resist tacking too far ahead of paver.

Distributor Truck Setup

- Liquid temperature
  - Monitor and match to material
- Calibrate distributor truck
  - Spray bar height
  - Spray bar pressure
  - Nozzle angle
  - Nozzle selection
  - Thermometers
  - Volumeter
Spray Bar/Nozzles

Effect of Nozzle Orientation

Nozzle Selection
Dilution rates are critical in determining final application rates.
- Temperature is important in determining accurate volumetric calculated rates.
  - Higher than 60°F, need to spray more emulsion.
  - Lower than 60°F, need to spray less emulsion.
- Uniform application spreads in distributing tack on the surface of the road.
- Samples of emulsion from the spray bar are only good for estimating dilution rates and residual binder properties.
**Application of Diluted Emulsion**

<table>
<thead>
<tr>
<th>Specified Residual Rate (qsy)</th>
<th>(57% residual emulsion) Application Rate (gallons)</th>
<th>Rate of Dilution with Water</th>
<th>1:1*</th>
<th>1:2*</th>
<th>1:3*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Appl. Rate</td>
<td></td>
<td>Appl. Rate</td>
<td>Appl. Rate</td>
<td>Appl. Rate</td>
</tr>
<tr>
<td>0.014</td>
<td>0.025</td>
<td>0.50</td>
<td>0.075</td>
<td>0.10</td>
<td></td>
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<tr>
<td>0.029</td>
<td>0.05</td>
<td>0.10</td>
<td>0.15</td>
<td>0.20</td>
<td></td>
</tr>
<tr>
<td>0.043</td>
<td>0.075</td>
<td>0.15</td>
<td>0.225</td>
<td>0.30</td>
<td></td>
</tr>
</tbody>
</table>

* Dilution Ratios = parts of emulsion : parts of water

- The above stated rates are all at 60°F gallons per sq. yd.
- Application temperatures must be determined and accounted for in order to obtain the exact rate of application.

**Dilution Allowance Information (NCHRP Report 712)**

<table>
<thead>
<tr>
<th>Allowable Dilution Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Allowed</td>
</tr>
</tbody>
</table>

**Correcting for temperature**

- Asphalt and water expands and contracts when temperatures deviate from 60°F.
- As temperatures rise above 60°F expansion occurs and the resulting density (#/gal.) decreases.
- As temperatures cool below 60°F contraction occurs and the density increases.
- A Temperature–Volume correction table for asphalt emulsion is available in MS-19, page 91.
There are three primary methods of determining field application rates.

- Determination by volume.
- Determination by weight or mass.
- Determination by direct measurement, ASTM D2995

We will first look at determination by volume.

The rate of material applied is calculated by determining the volume of material distributed. Either by:

- Using a tank stick method where the depth of material is measured in the tank and the volume is calculated or by the use of a pre-calibrated stick.
- Or, by observation and recordation of an onboard volume meter or gauge

Dipstick Method

- Measure Asphalt Volume in Truck
- Record Asphalt Temperature
- Spray Tack Coat Over Known Area
- Measure Asphalt Volume in Truck
- Correct Volume for Temperature Variation from 60°F
Dipstick Equation:

\[ \frac{9 \times \text{Gallons Applied}}{\text{Width} \times \text{Length}} \]

Note: 9 to convert from square feet to square yards. Use as required.

Calculating rates by Weight (Mass)

- Calculating an application rate by weight is the most accurate method.
- Bill of lading from the supplier should contain a 60°F wt. per gallon.
- Weight measurements are not affected by temperature.
- However constant weighing after each shot can be complicated.
- Recommend using this method for full load applications, calibration, etc.

Direct Measurement using ASTM D2995

Standard Practice for Estimating Application Rate of Bituminous Distributors
• Field Measurement of Application Rate
  • Longitudinally
  • Transversely
  • Units of Gallons/Yard² (Liters/Meter²)

Direct Measurement using ASTM D2995

Method A—Weighing Pads
  • Pre-weigh pads
  • Secure pads to surface
  • Apply tack coat
  • Reweigh pads
  • Calculate application rate

Method B—Volume-Based Calculations
  • Spray tack coat into containers for a set time period
  • Determine volume collected for each nozzle
  • Calculate transverse uniformity
  • Calculate longitudinal rate incorporating truck’s velocity

Photos courtesy of TxDOT, Maintenance Division
Spray Pavers/Bonded Overlays

- Spray Paver-Single Pass Paving and Sealing
  - Hot mix asphalt overlay
  - Polymer modified emulsion tack
  - Placed with spray paver
    - Paver & Distributor
  - High Application Rates
    - 0.08-0.20 gsy residual
- Examples
  - BondTekk®—bonded overlay
  - Novachip®—thin bonded overlay

Purported Spray Paver Benefits

- No tracking of the tack
- Better bonding of overlays
  - Increased Overlay life
  - Reduce Rutting
  - Reduce Cracking
- Improved joint compaction
- Easier compaction

Review and Summary
Common Tack Coat Questions

• Experts commonly disagree
• “Do I still need to tack...”
  • Milled Surface
  • “Fresh” Pavement
  • Late season/cooler days
• Asphalt Institute recommends tacking all surfaces

Common Tack Coat Questions

• “When can I pave on the emulsion?”
  • Has it Broke?
  • Does it need to be Set?
  • Fresh—spray pavers
• Asphalt Institute recommends paving begin after the emulsion has broke.
• Spray pavers are an engineered system that are designed to perform without emulsion break.

Common Tack Coat Questions

• What is the Optimal Application Rate?
  • Surface Type
  • Surface Condition
• Asphalt Institute Recommended Ranges

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<th>Residual Application Rate (g/y)</th>
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<tr>
<td>New Asphalt</td>
<td>0.020 – 0.045</td>
</tr>
<tr>
<td>Existing Asphalt</td>
<td>0.040 – 0.070</td>
</tr>
<tr>
<td>Milled Surface</td>
<td>0.040 – 0.080</td>
</tr>
<tr>
<td>Portland Cement Concrete</td>
<td>0.030 – 0.050</td>
</tr>
</tbody>
</table>
Common Tack Coat Questions

- When to Re-Tack?
  - Tracking
  - Contamination
- Re-Tack when in doubt.

- Is Dilution okay?
  - Follow state specs
  - Verify dilution amount
  - Can not be used to "stretch" tack as residual value is key.

Common Tack Coat Questions

- What Type of Bond Testing?
  - Shear
  - Torsion
  - Pull off
  - Cyclic
- All have advantages and disadvantages
- Further research and acceptance will likely lead to a generally preferred method.

Areas of Known Agreement

- Layer Bonding is Vital
- Surface Preparation
  - Clean
  - Dry
- Millings Improves Field Performance
  - Shear
  - Cleaning
Areas of Known Agreement

• Application Quality Vital
  • Proper Rate
  • Consistency
• Distributor Truck
  • Setup
  • Calibration/Verification
  • Maintenance
• Tacking of Longitudinal Joints
  • Bonding
  • Confinement
• Excessive Tack is Bad
• Thicker/Stiffer Lifts Less Prone to Slippage

Areas of Known Agreement

• Tack Coat Rate Depends on Surface Condition
  • Fresh
  • Weathered
  • Raveled
  • Milled
• Need for Research
  • Field Performance
  • Field Testing
    • Bond strength
    • Application amount
• Treat Tack as Separate Pay Item vs. Incidental Item

Free 4-hour workshop requested through FHWA divisional offices.

Questions?

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