Tack Coat Best Practices

FHWA Cooperative Agreement Subtask
Tack? 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
Tack Coat Best Practices Outline

- Terminology
- Purpose of Tack Coats
- Consequences of Poor Bond
- Relative Cost for Tack Coat
- Tack Coat Difficulties
  - Contractor
  - Agency
- Materials
  - Traditional
  - New Materials
  - Selection
Tack Coat Best Practices Outline

- Handling and Storage of Tack
- Tack Coat Field Operations
  - Manuals of Practice
  - Research / Bond Strength Testing
  - Best Practices
    - Surface Preparation
    - Truck Setup
- Tack Coat Application Calculations
- Spray Pavers
- Review and Summary
  - Common Tack Coat Questions
  - Areas of Known Agreement
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

I am redoing this demonstration as the hand placements on the next slide are a potential problem. Dave

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
8 - 10 years (est.) Interstate Pavement
Cores Showing Debonding

Bonding Failures
Forensic Investigations of Debonding at the NCAT Test Track

Dr. David Timm
N7 vs N8

N7

N8 - Trench
Strain Investigation

Strain Ratio = \( \text{Strain}_{7''} / \text{Strain}_{5''} \)
Measured Strain vs Theoretical – N8
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
Common Tack Coat Materials

- 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
    - PG 67–22
  - Polymer Modified
## Standard Emulsion Specifications

- **Anionic Emulsion Specifications**
  - AASHTO M 140–8
  - ASTM D 977–05

<table>
<thead>
<tr>
<th>Pen Values 100–200 +</th>
<th>Pen Values 40 – 90</th>
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<tr>
<td>RS–1</td>
<td>RS–2</td>
</tr>
<tr>
<td>MS–1</td>
<td>MS–2</td>
</tr>
<tr>
<td>HFMS–1</td>
<td>HFMS–2</td>
</tr>
<tr>
<td>SS–1</td>
<td></td>
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</table>
Standard Emulsion Specifications

- Cationic Emulsion Specifications
  - AASHTO M 208–01
  - ASTM D 2397–02

<table>
<thead>
<tr>
<th>Pen 100–250</th>
<th>Pen 40–90</th>
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</thead>
<tbody>
<tr>
<td>CRS–1</td>
<td>CMS–1h</td>
</tr>
<tr>
<td>CRS–2</td>
<td>CSS–1h</td>
</tr>
<tr>
<td>CMS–2</td>
<td>CQS–1h</td>
</tr>
<tr>
<td>CSS–1</td>
<td></td>
</tr>
</tbody>
</table>
Concern Over Proprietary Products

- Promote competition...
- But, innovative products that could perform better than traditional options
- 23 CFR 635.411
- FHWA Guidance:
  - State DOT may specify proprietary products
  - State DOT certifies that there is no suitable alternative product or that the product is needed for synchronization.
  - FHWA must approve through a public interest finding.
Reduced Tracking Materials

- **TRACKLESS™ (NTSS–1HM)**
  - Blacklidge Emulsions Product
  - Patented Product
  - Anionic Emulsion
  - 0–20 Pen Base Asphalt

- **CAT–TAC (CNTT)**
  - Hunt Refining Company Product
  - Patent Pending
  - Cationic Emulsion
  - 45–90 Pen Base Asphalt
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
Handling of Emulsions

- Do NOT mix anionic and cationic emulsions.
- Vertical tanks preferred—skin formation.
- Protect from freezing.
- Avoid overheating—typically <180°F.
- Minimal low-shear pumping.
Asphalt Institute Burn Information

KEEP COOL
DO NOT PANIC OR DELAY
ON-SCENE FIRST AID
FOR ASPHALT BURNS

- Immediately address any Airway, Breathing or Circulation concerns and START COOLING with water
- Do NOT try to remove asphalt from skin
- Quickly place affected area under running/flowing water (ice or cold packs may be used in the event water is unavailable)
- Leave the asphalt burn area uncovered
- Notify others
- CALL FOR HELP!

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Skin (Do NOT delay)
- Immediately place the affected skin under running/flowing water for at least 20 minutes
- Prolonged flushing/cooling is necessary

Eyes (Do NOT delay)
- Lay the person on their back
- Remove contact lenses (medical personnel only)
- Flush with running/flowing water for at least 20 minutes by allowing the water to flow over the bridge of the nose to the eyes

After cooling, urgent medical attention is required for burns to the face, eyes, hands, feet, genitalia and for circumferential or large burn areas.

FOR EMERGENCY ASSISTANCE
CAL: ________
Storage Options

- Tank—long-term storage
- Tanker—short-term storage
- Distributor Truck—short-term storage
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/Setting 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.
Current Research

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

- **Materials**
  - Emulsion
  - Paving grade asphalt

- **Field/Laboratory Bond Testing**
  - Shear Testing
  - Torsion Testing
  - Pull-Off Testing (tension)
  - Cyclic
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
  - Repeatable
  - Poorer repeatability (manually ran)

- **Tension Testing**
  - Lab or field test
  - Quick
  - Repeatable
  - Cleanly ranks materials
  - Used in Texas and Kansas

- **Cyclic Testing**
  - Lab test
  - More time consuming
  - Repeatable
  - Cleanly ranks materials
Best Practices for getting the material on the road!
Distributor Truck Setup
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
Tack Coat Application
Application Calculations

Student Exercises
Dilution Allowance Information (NCHRP Report 712)

Allowable Dilution Sites

Responses

- Not Allowed
- Supplier's Terminal
- Contractor's Storage Tank
- In the Distributor Tank
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.
Application Verification (NCHRP Report 712)
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:

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

Note: 9 to convert from square feet to square yards. Use as required.
Calculating rates by Volume

- When using a tank volume method for determining the quantity of material distributed, the temperature must be determined and the volume of material corrected to 60°F.

- Let's work an Example Problem
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.
Field Measurement of Application Rate
- Longitudinally
- Transversely
- Units of Gallons/Yard$^2$ (Liters/Meter$^2$)

Photos courtesy of Dr. Louay Mohamad
Direct Measurement using ASTM D2995

- Method A—Weighing Pads
  - Pre-weigh pads
  - Secure pads to surface
  - Apply tack coat
  - Reweigh pads
  - Calculate application rate
Direct Measurement using ASTM D2995

- 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

Photo courtesy of TxDOT, Maintenance Division
Inconsistent Application

<table>
<thead>
<tr>
<th>Location</th>
<th>Application Rate</th>
<th>Residual Rate</th>
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</thead>
<tbody>
<tr>
<td>Left Wheel Path</td>
<td>0.075</td>
<td>0.051</td>
</tr>
<tr>
<td>Center of Lane</td>
<td>0.047</td>
<td>0.032</td>
</tr>
</tbody>
</table>

Photo courtesy of MODOT
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.
Tracking and Pickup

Pictures courtesy of Road Science™
Spray Pavers
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
Spray Pavers/Bonded Overlays

- Vögele: Spray Jet attachment
- Roadtec: SP 200 Spray Paver
- Limited Number of States Specifying
- Europe
- Specialty Emulsion—Using a Standard Distributor
  - UltraFuse Bond Coat
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

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Residual Application Rate (gsy)</th>
</tr>
</thead>
<tbody>
<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.
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
Questions?