Tack Coat Best Practices

Tack Coat Best Practices Outline

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• Consequences of Poor Bond
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• Tack Coat Field Operations
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Tack Coat Best Practices Outline

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• Spray Pavers
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Purpose of Tack Coats

• To promote the bond between pavement layers.
  • Prevent slippage/shoving failures
  • Full bond is vital for structural performance of the pavement
  • When bonded, all layers working together
  • Critical that tack materials are applied uniformly at appropriate rate
  • Apply tack coat on all surfaces including vertical surfaces.

Why do we use Tack Coats?
Far too frequent practices

Key Factors for Tack Coat Success

• Condition of Existing Pavement
• Tack Coat Application Rate
• Residual Binder Content
• Proper Distributor Operation
• Emulsion Break and Set Times
Terminology

- **Tack Coat**—sprayed application of liquid asphalt 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 (emulsified asphalt)**—an undiluted emulsion which consists of a mixture of 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)

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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 (cure)**—when all the water has evaporated, leaving only the residual asphalt. Some refer to this as completely broken.
Emulsion Breaking & Setting

Emulsions are asphalt droplets suspended in water
- **Breaking**
  - Contact with surface changes pH; reducing charge
- **Setting**
  - Evaporation leads to coalescence
  - Original asphalt characteristics return

Consequences of Poor Bonding

- Poor pavement performance
  - Slippage cracks
  - Shoving
  - Early fatigue cracking
    - Bottom up
    - Top down
- Costly pavement repairs
  - Repair of isolated area relatively inexpensive
  - Removal and replacement of a portion or the entire pavement structure is very expensive
  - Shorter than expected pavement life can be devastating for agency budgets
Days later!

Courtesy of Road Science

Consequences of Poor Bonding

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

Direction of traffic?
Pavement Behavior

Load Distributed by Tire

Shear Transfer?

Compression

Stress Distribution

Tension

Aggregate Base

Soil Subgrade

Courtesy of Rich May

Bonding Demonstration

½” Deflection, 60# Load

¼” Deflection, 160# Load

Unbonded

Fully Bonded
Bonding Demonstration Highlights

• 5 unbonded layers deflected 4x more than 5 bonded with the same loading.

• 2 bonded layers had less deflection than 5 unbonded with the same loading.

• 5 bonded layers with over 2½x the load deflected half as much as 5 unbonded.

Loss of Fatigue Life Research

• 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

Courtesy of MODOT

Bonding Failures

Courtesy of MODOT
What Does It Cost?

**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**
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
- Reduced or Non-tracking Emulsions

States - Reduced Tracking Tack Mat’ls
Handling of Emulsions

• Dilution
  • Verify if it is allowed.
  • If allowed, where?
    • Supplier only?
    • Contractor?
  • Control amount of water added.
    • 1:1 typical (Original Emulsion: Added Water)
  • Use acceptable/approved water.
  • Terminal added or field diluted.
  • Always add water to emulsion.

Tack Coat
Field Operations
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.

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Manuals of Practice

- *Tack Coats: How and what to apply!* Colorado Asphalt Pavement Association (CAPA) (2011)
Tack Coat Application

Tack Coat Challenges

• Contractor
  • Variable application rates
  • Consistency of application
  • Tack coat pick-up or tracking by construction vehicles
  • Breaking/setting time prior to paving
• Agency
  • Acceptance (method or performance)
  • Bond quality testing
  • Dilution?
  • Visual inspection
  • Application rate measurement
Best Practices

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

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 selection
  - Nozzle angle
  - Thermometers
  - Volumeter
  - Application rate
Calculating field application rates

- There are three primary methods of determining field application rates.
  - Determination by volume.
  - Determination by weight or mass.
  - Determination by direct measurement, ASTM D2995

Direct Measurement using ASTM D2995

- Field Measurement of Application Rate
  - Longitudinally
  - Transversely
  - Units of Gallons/Yard$^2$ (Liters/Meter$^2$)
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
Nozzle Selection

- Consult with distributor truck manufacturer to match the material to the nozzle.
- ONE SIZE DOES NOT FIT ALL

Effect of Nozzle Orientation

Proper nozzle angle of 15-30% assures proper overlap between nozzles without interference of tack streams.
Spray Bar/Nozzles

Nozzles are clogged, but triple overlap covering the gap.

Note: not a tack coat, but principle applies.
Key Items for Inspectors

• Check truck setup.
  • Spray bar height (~12”)
  • Appropriate nozzles
  • Nozzle orientation (15-30°)
  • Check application rate gauge in truck
  • Check application temperature
  • Collect samples.

• Know the desired application and residual rates.

• Visually inspect application

• Verify application.
  • Volume
  • Mass
  • ASTM D2995
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
  • 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
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.

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

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**Common Tack Coat Questions**

• “When can I pave on the emulsion?”
  • Has emulsion broken?
  • Does it need to be set?
  • Asphalt Institute recommends paving begin after the emulsion has broken.

• “How can I prevent tack pull-up/tracking?”
  • Make sure tack coat is broken
  • Use emulsions with hard base asphalt (CSS-1h)
  • Use a proprietary reduced-tracking emulsion
  • Use a spray paver
Spray Pavers

• Spray pavers are an engineered system that consists of a paver with built-in emulsion application systems that applies tack just prior to asphalt laydown.
• Emulsions used in spray pavers are designed to perform without break/set.
• No tack coat tracking or pull-up
Spray Paver Illustrations

Roadtec SP 200 Spray Paver

Courtesy of Roadtec
Vögele: Spray Jet

Purported Spray Paver Benefits

- No tracking of the tack
- Better bonding of overlays
  - Increased Overlay life
  - Reduce Rutting
  - Reduce Cracking
- Improved bond = easier compaction

Courtesy of Road Science
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>

- 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.

  **Limit dilution to supplier.**
Areas of Known Agreement

- Layer Bonding is Vital
- Surface Preparation
  - Clean
  - Dry
- Milling 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
Areas of Known Agreement

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

**Successful Tack Coat**

The Ultimate Goal:
Uniform tack coat coverage
Free 4-hour workshop requested through FHWA divisional offices

Questions?

Free webinar: