Bonded HMA Overlays – a matter of tack materials & method of application

What is a tack coat?

- A light spray application of an asphalt emulsion used to create a bond between an existing pavement surface and the application of a bituminous mixture.
Traditional Tack Coat Materials and Application Rates

- Slow setting emulsions
  - SS-1, SS-1h, CSS-1, CSS-1h
- Usually diluted up to 50% with water to allow more uniform distribution at low application rates
- Rate selected between 0.02 and 0.1 gal/square yard based on undiluted emulsion

How bonded are pavement layers?
- Slippage cracks

Missouri 2010
How bonded are pavement layers?
• Slippage

Utah - 2009

How bonded are pavement layers (cont.)?
• Slippage – Same core hole, a few days later
How bonded are pavement layers (cont.)?

- This pavement had Premature pavement failure (within 1 year)
  - Longitudinal cracking near the wheel path and rutting

Utah - 2008

How bonded are pavement layers (cont.)?

- Premature pavement failure – within 1 year
  - Longitudinal cracking in the wheel path and rutting

Full slip between 2 x 3” layers was a contributing factor to early distress

Utah - 2008
How bonded are pavement layers (cont.)?

- Coring of new asphalt lifts is a routine QC/QA activity to verify in-place density/calibrate nuclear density gage
- How often do cores break at the interface between layers?

Utah - 2008

Tack Coat - Constructability vs Performance

- Construction favors:
  - Low application rates
  - Curing of the tack
  - Traction for paving equipment
  - Use of non-tacky hard binders
  - Reduces Tracking
- Performance favors:
  - Higher, more uniform application rates
  - Higher adhesion materials
  - Polymer modified asphalt emulsions
How Can Higher Tack Rates and Improved Tack Coat Materials be Applied?

• Modify the process to keep all construction equipment and trucks off from the tack during construction
• Replace the distributor with a paving machine equipped with an emulsion tank and spray bar all in one unit

Bonded Overlay Delivery System

• Single pass paving/sealing system
  ▪ **Hot mix** asphalt overlay
  ▪ Polymer modified **emulsion** tack
  ▪ Placed with **spray paver**
    • Paver + distributor
Spray Paver

- 3 Processes
  - Spray emulsion
  - Lay hot mix
  - Smooth the mat

Spray Paver Features

- 60-100 ft/min travel speed
- No tracking of tack
- Uniform application of tack
- No construction traffic on tack
How is a bonded overlay different?

- Improved delivery system and materials
- Composite system
  - HMA + PMEM (Polymer Modified Emulsion Membrane)
- Asphalt content of the system is a gradient
  - Higher binder at the bottom to lower on the top
- Tack coat material and rate can change the performance properties of the overlay system
  - Reduce Rutting
  - Reduce Cracking
  - Increase the Overlay life through improved bonding

Bonded Overlay Features

- Non-tracking tack application reduces public complaints
- Better bond of overlays to existing pavement structure
- Reduced overlay thickness is possible without delamination
- Improved joint compaction resulting in better pavement performance
- Easier compaction results in less damage to the mix
Field Performance Data

Route T, Franklin County, MO

- Constructed: October 2008
- Contractor: N.B. West
- Project length: 3.5 miles (test sections)
- Surface: Composite, HMA over PCC
- Mix: 1 ¾” Bonded BP-1 HMA w/ PG64-22
- Tack:
  - Test sections at 0.1, 0.15, and 0.2 gal/yd² PMAE at 65% AC
  - Test sections at 0.1 gal/yd² thru distributor and 0.1 and 0.15 gal/yd² CSS-1h thru SP-200
- Equipment: RoadTec SP-200 spray paver
MoDOT Route T Project  
– Oct 2008  
1 3/4” BP-1 overlay over composite pavement

MoDOT Route T  
Transverse Crack Length at 41 months  
1 3/4" BP-1 over HMA/PCC Composite

[Graph showing crack length over time]
MoDOT Route T 2008
Transverse Cracking at 41 months
1 ¾" BP-1 over Old HMA/PCC Composite

MoDOT Route T
Longitudinal Crack Length at 41 months
1 ¾" BP-1 over HMA/PCC Composite
Route T Franklin Co Test Sections
11/12
Before & Four Years After

0.14 gal/yd2 residual PMAE Tack
KDOTT US 36 Washington Co.
Project – Sept 2009
1 ½” SR-12.5A over a Milled Surface

<table>
<thead>
<tr>
<th>Test Section 1</th>
<th>Test Section 2</th>
<th>Test Section 4</th>
<th>Test Section 6</th>
<th>Test Section 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>25% RAP</td>
<td>25% RAP</td>
<td>25% RAP</td>
<td>25% RAP</td>
<td>25% RAP</td>
</tr>
<tr>
<td>No Tack</td>
<td>0.08 gal/yd2 CSS-1H</td>
<td>0.16 gal/yd2 CSS-1H</td>
<td>0.20 gal/yd2 CSS-1H</td>
<td>0.12 gal/yd2 CSS-1H</td>
</tr>
</tbody>
</table>

Test Section 2
25% RAP
0.08 gal/yd2 CSS-1H

Test Section 3
25% RAP
0.08 gal/yd2 EBL

Test Section 4
25% RAP
0.16 gal/yd2 CSS-1H

Test Section 5
25% RAP
0.16 gal/yd2 EBL

Test Section 6
25% RAP
0.20 gal/yd2 CSS-1H

Test Section 7
25% RAP
0.20 gal/yd2 EBL

Test Section 8
25% RAP
0.12 gal/yd2 CSS-1H

Test Section 9
25% RAP
0.12 gal/yd2 EBL

Test Section 10
40% RAP
0.25 gal/yd2 EBL

Test Section 11
40% RAP
0.35 gal/yd2 EBL

Transverse Cracking/1000’ test Section

KDOT US 36 Washington Co. 2009
Transverse Cracking at 31 months
1/2” Mill, 1 ½” SR12.5A, PG58-28

Transverse Cracking/1000’ test Section

Tack emulsion rate
- 0 Tack
- 0.08 CSS-1h
- 0.12 CSS-1h
- 0.16 CSS-1h
- 0.20 CSS-1h
- 0.08 EBL
- 0.12 EBL
- 0.16 EBL
- 0.20 EBL

Months

0 8 19 31
KDOT US 36 Washington Co. 2009
Transverse Cracking at 31 months
½" Mill, 1 ½" SR12.5A, PG58-28

Transverse Cracking/1000’ Test Section

Months

0 8 16 24 32

0 10 20 30 40 50 60 70

Tack emulsion rate
- 0.08 CSS-1h
- 0.12 EBL

KDOT US 36 Washington Co. 2009
Longitudinal Cracking at 31 month
½" Mill, 1 ½" SR12.5A, PG58-28

Longitudinal Cracking ft/1000’ section

Months

0 5 10 15 20 25 30 35

0 50 100 150 200 250

Tack emulsion rate
- 0.08 CSS-1h
- 0.12 CSS-1h
- 0.16 CSS-1h
- 0.20 CSS-1h
- 0.08 EBL
- 0.12 EBL
- 0.16 EBL
- 0.20 EBL
**KDOT US 36 Washington Co. 2009**

Longitudinal Cracking at 31 months

½" Mill, 1 ½" SR12.5A, PG58-28

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**No tack over a milled surface**

- US 36 Washington County, KS - 2 years old
- Fatigue cracking in the inside wheel path
- Effect of unbonded overlay
KDOT US 81 Cloud County 2011

WMA over PCC

- 2 – 1 ½” WMA lifts over PCC
- 3 Spray paver sections
  - Sec 1, 0.135 gal/yd² residual PMAE
  - Sec 2, 0.20 gal/yd² residual PMAE
  - Sec 3, 0.095 gal/yd² residual PMAE
- Distributor section
  - Sec 4, 0.026 gal/yd² residual SS-1hP (lower polymer content)
May 2003
During Installation

May 2006
3 Years Later

2001 BEFORE BWC

6 YEARS LATER
Summary

• Lack of bond between pavement layers leads to pavement distress and reduced pavement life
• Traditional tack coat materials and rates may yield inconsistent bonding between pavement layers over time
• Tack coat materials and rates can have an effect on the overall overlay performance
  ▪ Higher than traditional application rates improve performance
  ▪ Higher elasticity and higher adhesive tack coat materials can improve performance

Summary

• Spray Paver can deliver both the tack coat and HMA mix in one pass, allows
  ▪ heavier tack coats than conventional application rate without tracking or traction issues
  ▪ undiluted Polymer Modified Emulsion Membrane (PMEM), PMAE, EBL, etc.

• Need QC to quantify degree of bonding achieved in the field. (Another discussion)
Thank you!
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QUESTIONS?

Effect of Poor Bond between Pavement Layers
Is Applying a Tack Coat Important?

- Pavement design assumes 100% bond to existing surface
- Full bond versus partial bond can change the pavement service life by 2.6 times, for a 2” overlay*
- Loss of bond creates high tensile stress at the bottom of the overlay, creating:
  - Delamination
  - Slippage
  - Cracking

*ESAL's to failure based on TAI rebound equation

A Bonded Overlay Requires:

- An application of a hot mix asphalt concrete
  - Open-graded, gap-graded or dense-graded
- Well-bonded to an existing asphalt or PCC pavement surface
- Bonded by means of a uniform and uncontaminated application of an asphalt tack coat
  - Usually polymer modified
How Does a Bonded Overlay Differ From the Traditional Paving Methods used Today?

- Conventional tack and overlay creates issues of constructability vs performance
- Improved delivery system and materials replace construction methods which have been troublesome
  - No tracking of tack coat or paver friction issues
- Better bond from better materials
  - Higher amounts of tack coat emulsion can be applied
  - Polymer modified tack coat materials
    - Higher polymer content
    - Undiluted emulsion

Examples of Bonded Overlay Systems

- Ultrathin Bonded Asphalt Wearing Course
  - Example, Novachip® UTBWC
- Bonded Dense-Graded HMA
- All placed by means of a spray paver delivery system
**BondTekk® Bonded Dense-Graded HMA Overlay System**

- Bonded DG-HMA is a hot mix asphalt overlay applied using a spray paver delivery system to provide a uniform application of a tack coat material. The tack may be conventional or polymer modified asphalt emulsion.
- The asphalt mixture is a dense-graded type:
  - Marshall design
  - Superpave design
  - SMA design

**Summary**

- Other improved features:
  - Enhanced cracking resistance
  - Improved compaction
  - Increased overlay life/reduced distresses
  - Increased structure value over traditional tack (Another Discussion)

Road Science is a resource for you if you have further questions or interest in Bonding all of your Hot Mix Pavements.