Improving Pavement Durability With Best Practices
Evolution of Traffic

• Interstate highways - 1956
• AASHO Road Test - 1958-62
  • still widely used for pavement design
  • legal truck load - 73,280 lbs.
• Legal load limit to 80,000 lbs. - 1982
  • 10% load increase
  • 40-50% greater stress to pavement
• Radial tires, higher contact pressure
• FAST Act raising load limit to 120,000 lbs. (in select locations)
Led to Rutting in 1980’s

Courtesy of pavementinteractive.org
Which led to... Superpave

- Fixed the rutting problem
- Gyratory compaction lowered binder contents
- Add in higher and higher recycled materials?
Improved Compaction = Improved Performance

A BAD mix with GOOD density out-performed a GOOD mix with POOR density for ride and rutting.

WesTrack Experiment
Effect of In-Place Voids on Life

Washington State DOT Study

In-situ Air Voids, %

Percent Service Life

Compaction Level

93% 92% 91% 90% 89%

7 8 9 10 11
Importance of Tack Coats

• Promotes the bond between pavement layers
  • Prevents slippage between pavement layers
  • All layers working together
  • Vital for structural performance of the pavement
  • Seals all transverse & longitudinal vertical surfaces
Loss of Fatigue Life Examples

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

- Brown & Brunton
  - No Bond = 75% loss of life
  - 30% bond loss = 70% loss of life
What we are talking about:

- *Original Emulsion*—undiluted emulsion consists of a paving grade binder, water, and an emulsifying agent.

- *Diluted Emulsion*—an emulsion that has been diluted with additional water.
  - Critical to sprayed control
  - 1:1 typical (Original Emulsion:Added Water)

- *Residual Asphalt*—the remaining asphalt after an emulsion has set typically 57-70 percent or Original Emulsion
What difference does it make?

If the example spec intended 0.05 gal/yd² of residual asphalt:

To receive Residual Asphalt at 0.05 gal/yd² using an emulsion with 60% residual asphalt, the contractor would need to apply:

0.083 gal/yd² of Original Emulsion or
0.167 gal/yd² of 1:1 Diluted Emulsion
What is going on and why?
What is going on and why?

Days later!

Courtesy of Road Science™
8–10 years est. Interstate Pavement

Courtesy of MoDOT
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

30-100% of Original Pavement Costs
Common Tack Coat Questions

• What is the Optimal Application Rate?
  • Surface Type
  • Surface Condition

• Workshop Recommended Ranges

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Residual Rate (gsy)</th>
<th>Appx. Bar Rate Undiluted* (gsy)</th>
<th>Appx. Bar Rate Diluted 1:1* (gsy)</th>
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</thead>
<tbody>
<tr>
<td>New Asphalt</td>
<td>0.020 – 0.045</td>
<td>0.030 – 0.065</td>
<td>0.060 – 0.130</td>
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<tr>
<td>Existing Asphalt</td>
<td>0.040 – 0.070</td>
<td>0.060 – 0.105</td>
<td>0.120 – 0.210</td>
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<tr>
<td>Milled Surface</td>
<td>0.040 – 0.080</td>
<td>0.060 – 0.120</td>
<td>0.120 – 0.240</td>
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<tr>
<td>Portland Cement</td>
<td>0.030 – 0.050</td>
<td>0.045 – 0.075</td>
<td>0.090 – 0.150</td>
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</tbody>
</table>

*Assume emulsion is 33% water and 67% asphalt.
Tack Coat

Full width of mat to minimize movement of unsupported edge
Common Tack Coat Question

• When to Re-Tack?
  • Tracking
  • Contamination

If in doubt ... Re-Tack
Longitudinal Joint Tacked

Dirty Surface

Light Application
Generally Uniform Application

Missed Line
Don’t We Already Know How To Build a Longitudinal Joint?
UnSupported Edge Will Have Lower Density

“Cold side” is the first paver pass and “Hot side” is the second
Different Types of Longitudinal Joints

- Butt (Vertical) Joint
- Milled or Cutback Joint
- Notched Wedge Joint

Diagram showing different joint types with annotations for each type.
The Best Longitudinal Joint: Echelon Paving

New Jersey

Rolled Hot
Echelon Paving Longitudinal Joint

Joint passes between the quarters
But, the need to maintain traffic limits the opportunities to pave in echelon.

Consequently, most longitudinal joints are built with a cold joint.
First Pass Must be Straight
Avoid Segregation at the Joint

- Don’t delivery segregated mix to the joint area
- Use auger & tunnel extensions
Mill & Pave One Lane at a Time

Photo in IL, Courtesy Hal Wakefield
Paint the Vertical Face

Good: Double Tack with Emulsion
Better: PG Binder
Best: Joint Adhesive
Overlap By 1-inch +/- ½ Inch

- Overlap By 1-inch +/- 1/2
- If milled or cutback joint, then 0.5-inch
- Keep end plate flat
- Set automation to NEVER STARVE THE JOINT!
- Joint Matcher best (versus ski) to match exact amount of material needed at joint
Do NOT Rake Away From the Joint
This lute person is doing a great job
Rolling Unsupported Edge?

Option 1
Hang over 4-6”

Option 2
1st Pass 4”-6” inside

2nd Pass hang over 4”-6”
What We Don’t Want

Rolling Unsupported Edge

With First Roller Pass

(If milled or cutback joint, then...)

Vibratory Roller

If edge of drum is located just inside the unsupported edge, a stress crack can occur here.
Rolling the Confined Edge:

1st pass all on hot mat with roller edge off joint approx 6-12 inches

2nd pass overlaps on cold mat 3-6 inches
IDOT Joint Sealer

Licensed Subcontractor ≈ 11 Trucks
Also Works as a Tack Coat
Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density

Key:
- **Workshop Only (15)**
- **Demonstration projects (10)**

States shaded in yellow indicate locations with Workshop Only projects, while states shaded in blue indicate demonstration projects.
• A 1% increase in field density can increase asphalt pavement service-life +10% (conservatively)

• Today’s compaction target is typically 92% of maximum ($G_{mm}$) (8% air voids),
  - Varying requirements for longitudinal joints

• Increased Density Pavements target a 2% increase across the entire pavement!
  - Just 2% more... makes a huge difference!
Balance the Mix Design

- Strength/Stability
- Rut Resistance
- Shoving
- Flushing Resistant

- Durability
- Crack Resistance
- Raveling
- Permeability

DON’T ATTACK ONE HALF AT THE EXPENSE OF THE OTHER HALF!!
Choosing a Gradation

Finer Gradations  
More Compactable  
More Workable  
Less Permeable

Requires better aggregate  
Higher binder contents

Courtesy of NCAT
Balancing the Paving Operation
Use Best Construction Practices

Uniform Paving Train Operation
• Determine plant production rate
• Plan for sufficient, timely mix delivery
• Establish a constant paver speed
• Assure ample rollers are available
  • Keep water trucks close to the rollers
  • On shoulder or cold mat
Cost of Compaction

- Least expensive part of the paving process
- Aggregates and binders are expensive in comparison
- Compaction adds little to the cost of a ton of asphalt
Lift Thickness’ Effect on Compaction

• Aggregates need room to densify
• Too thin vs. NMAS leads to:
  • Roller bridging
  • Aggregate lockup
  • Aggregate breakage
  • Compaction Difficulties
• NCHRP Report 531 (2004)
  • Fine Graded Mix—Min Thickness = 3 X NMAS
  • Coarse Graded Mix—Min Thickness = 4 X NMAS
  • SMA Mix—Minimum Thickness = 4 X NMAS
• Thicker = More Time for Compaction

• Free tools for estimating compaction time
  • PaveCool—single lift (generation 1)
    • PC
    • iOS App
    • Google App
  • MultiCool—multiple lifts (generation 2)
    • PC
    • Google App
    • Mobile Web
Vibratory Screed Should Always be “ON”

Note: screed operator walking along side
Assume:

- 2-Inch Compacted Mat
- 12-Foot Pull
- 140 lbs/ft³ Compacted Unit Weight

Paver Speed and Output

<table>
<thead>
<tr>
<th>Feet/Minute</th>
<th>Tons/Hour</th>
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<tr>
<td>10</td>
<td>84</td>
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<tr>
<td>15</td>
<td>126</td>
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<td>45</td>
<td>378</td>
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<td>50</td>
<td>420</td>
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Establishing Rolling Pattern

Goal: 93.5% $G_{mm}$

Select: 3 Passes
(Intermediate will get the rest of the density)
Rolling Pattern

- Roller width should overlap 6 inches
- Odd number of passes to advance
- Repeat uniformly

100 - 170 ft
Roller Speed is Critical

Slower = More Compaction/Pass
Vibratory Rollers - Amplitude

- Amplitude too high
- Travel speed too fast
- Vibrating cool mat
  - Roll closer to paver
- Damaged gutter
  - Roll along interface
## Drum Impacts per Foot

<table>
<thead>
<tr>
<th>Frequency</th>
<th>2 MPH</th>
<th>3 MPH</th>
<th>4 MPH</th>
<th>5 MPH</th>
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<tbody>
<tr>
<td>2000 vpm</td>
<td>11.36</td>
<td>7.58</td>
<td>5.68</td>
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<td>2200 vpm</td>
<td>12.50</td>
<td>8.33</td>
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<td>2400 vpm</td>
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<td>22.72</td>
<td>15.16</td>
<td>11.36</td>
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Additional Vibratory Rollers
Maximizing Our R.O.I.

- Infrastructure loads continue to rise
- Budget availability continues to fall
- Increased pavement life can be economically achieved
- Research shows a 10% increase in pavement life can be achieved by increasing compaction by 1%.

What would a 3% increase in compaction do for our industry?
Enhanced Durability Through Increased In-Place Pavement Density
March 28th
Northern Illinois University, Naperville Campus

Airport Pavement Technical Workshop
April 25th - 27th
Rosemont, IL
PDH 22
Thank You!

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