Asphalt Pavement Construction: Best Practices

57th Annual Illinois Bituminous Paving Conference
December 12-13, 2016

Effect of In-Place Voids on Life
Washington State DOT Study

![Graph showing the effect of in-place voids on percent service life. The graph indicates that as in-situ air voids increase, percent service life decreases. At 93% compaction, the percent service life is near 100, while at 89% compaction, the percent service life drops to around 60%.](image)
• A 1% increase in field density can increase asphalt pavement service-life +10% (conservatively)

• Today’s compaction target is typically 92% of maximum (Gmm) (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!

**Enhanced Durability**

“A 1% decrease in air voids was estimated to improve:
• Fatigue performance between 8.2 and 43.8%
• The rutting resistance by 7.3 to 66.3%
• Extend the service life by conservatively 10%.”
**DENSITY VS. PERMEABILITY**

**12.5 mm WEARING COURSE**

<table>
<thead>
<tr>
<th>Density (%)</th>
<th>Coefficient of Permeability (K) (cm x 10^{-5} / sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>98.0%</td>
<td>0</td>
</tr>
<tr>
<td>96.0%</td>
<td>500</td>
</tr>
<tr>
<td>94.0%</td>
<td>1000</td>
</tr>
<tr>
<td>92.0%</td>
<td>1500</td>
</tr>
<tr>
<td>90.0%</td>
<td>2000</td>
</tr>
<tr>
<td>88.0%</td>
<td>2500</td>
</tr>
<tr>
<td>86.0%</td>
<td>3000</td>
</tr>
</tbody>
</table>

**LONGITUDINAL JOINTS**

**MAT**

**Importance of Tack Coats**

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

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

• Roffe & Chaignon
  • No bond = 60% loss of life

• Brown & Brunton
  • No Bond = 75% loss of life
  • 30% bond loss = 70% loss of life

Everyone MUST be on the same page

What we are talking about:

• Original Emulsion—one 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!

8–10 years est. Interstate Pavement
What The 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

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 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>
</tr>
</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>
</tr>
<tr>
<td>Existing Asphalt</td>
<td>0.040 – 0.070</td>
<td>0.060 – 0.105</td>
<td>0.120 – 0.210</td>
</tr>
<tr>
<td>Milled Surface</td>
<td>0.040 – 0.080</td>
<td>0.060 – 0.120</td>
<td>0.120 – 0.240</td>
</tr>
<tr>
<td>Portland Cement Concrete</td>
<td>0.030 – 0.050</td>
<td>0.045 – 0.075</td>
<td>0.090 – 0.150</td>
</tr>
</tbody>
</table>

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

Triple Lap Coverage

12″
Spray Bar/Nozzles

Nozzle Selection
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
How To Build a Longitudinal Joint?
Unsupported Edge Will Have Lower Density

Proper Overlap

Sufficient Material for Roll-Down

Cold (unconfined) side

Hot (confined) side

Low Density Area

“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

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

- Don't deliver segregated mix to the joint area
- Use auger & tunnel extensions

Avoid Segregation at the Joint
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
Mill & Pave One Lane at a Time

Photo in IL, Courtesy Hal Wakefield

Do NOT Rake Away From the Joint
Lute the Longitudinal 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
Improved Durability

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!!

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

Relative cost comparison between asphalt pavement components

Cost

High
Low
Component
Aggregate
Asphalt
Compaction

52
Lift Thickness’ Effect on Compaction

- Aggregates need room to densify
- Too thin vs. NMAS leads to:
  - Roller bridging
  - Aggregate lockup
  - Aggregate breakage
  - Compaction Difficulties

  - Fine Graded Mix—Min Thickness = 3 X NMAS
  - Coarse Graded Mix—Min Thickness = 4 X NMAS
  - SMA Mix—Minimum Thickness = 4 X NMAS

Material Cooling

- 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

Paver Speed and Output

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

<table>
<thead>
<tr>
<th>Feet/Minute</th>
<th>Tons/Hour</th>
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<tbody>
<tr>
<td>10</td>
<td>84</td>
</tr>
<tr>
<td>15</td>
<td>126</td>
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<tr>
<td>20</td>
<td>168</td>
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<td>25</td>
<td>210</td>
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<td>40</td>
<td>336</td>
</tr>
<tr>
<td>45</td>
<td>378</td>
</tr>
<tr>
<td>50</td>
<td>420</td>
</tr>
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</table>
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
Roller Speed is Critical

![Graph showing density vs number of passes for 2 MPH and 4 MPH roller speeds.](image)

- 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>
</tr>
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<tbody>
<tr>
<td>2000 vpm</td>
<td>11.36</td>
<td>7.58</td>
<td>5.68</td>
<td>4.55</td>
</tr>
<tr>
<td>2200 vpm</td>
<td>12.50</td>
<td>8.33</td>
<td>6.25</td>
<td>5.00</td>
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<tr>
<td>2400 vpm</td>
<td>13.64</td>
<td>9.09</td>
<td>6.82</td>
<td>5.45</td>
</tr>
<tr>
<td>2600 vpm</td>
<td>14.77</td>
<td>9.84</td>
<td>7.39</td>
<td>5.91</td>
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<tr>
<td>2800 vpm</td>
<td>15.91</td>
<td>10.61</td>
<td>7.95</td>
<td>6.36</td>
</tr>
<tr>
<td>3000 vpm</td>
<td>17.05</td>
<td>11.36</td>
<td>8.52</td>
<td>6.82</td>
</tr>
<tr>
<td>3200 vpm</td>
<td>18.18</td>
<td>12.12</td>
<td>9.09</td>
<td>7.27</td>
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<td>3400 vpm</td>
<td>19.32</td>
<td>12.88</td>
<td>9.66</td>
<td>7.72</td>
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<tr>
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<td>13.64</td>
<td>10.22</td>
<td>8.18</td>
</tr>
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<td>14.39</td>
<td>10.80</td>
<td>8.63</td>
</tr>
<tr>
<td>4000 vpm</td>
<td>22.72</td>
<td>15.16</td>
<td>11.36</td>
<td>9.10</td>
</tr>
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</table>

### 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?

www.asphaltinstitute.org

Constructing Quality Pavements
March 28th
NIU Naperville Campus
PDH 7.5

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

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