Asphalt Pavement Construction: Best Practices

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Effect of In-Place Voids on Life

Washington State DOT Study

[Graph showing the relationship between In-situ Air Voids and Percent Service Life]
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!
DENSITY VS. PERMEABILITY
12.5 mm WEARING COURSE

Density (% Gmm)

Coefficient of Permeability (K) (cm x 10^{-5} / sec)

LONGITUDINAL JOINTS

MAT

Dean Maurer, P.E.

Permeable Below 92% Density
“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%.”
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

![Graph showing the relationship between bond loss and loss of life](image-url)
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?
Days later!
8–10 years est. Interstate Pavement
What's 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>
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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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<tr>
<td>Concrete</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

Full width of mat to minimize movement of unsupported edge
Triple Lap Coverage
Spray Bar/Nozzles

NOZZLE ANGLE SETTING: 15 TO 30 DEGREES

SPRAY BAR AXIS
Nozzle Selection
Common Tack Coat Question

• When to Re-Tack?
  • Tracking
  • Contamination

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

Dirty Surface

Light Application
How To Build a Longitudinal Joint?
Unsupported Edge Will Have Lower Density

Proper Overlap
Sufficient Material for Roll-Down

Cold (unconfined) side
Low Density Area
Hot (confined) side

“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
Mill & Pave One Lane at a Time

Photo in IL, Courtesy Hal Wakefield
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
Uniform head of material across entire screed to joint

...Do Not Overload Auger
Paint the Vertical Face

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

- 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
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 edge of drum is located just inside the unsupported edge, a stress crack can occur here.

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

Vibratory Roller
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
Overbanding the L.J. Frequently Done in AK and PA
Licensed Subcontractor ≈ 11 Trucks
Also Works as a Tack Coat
Balance the Mix Design

Smooth Quiet Ride
Skid Resistance

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
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
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
Roller Operations - Temperature Zones

Temperature Ranges
- 300° - 260°F: Breakdown
- 250° - 220°F: Intermediate
- 200 - 180°F: Finish
Assume:
- 2-Inch Compacted Mat
- 12-Foot Pull
- 140 lbs/ft³ Compacted Unit Weight

### Paver Speed and Output

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<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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<tr>
<td>20</td>
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<td>336</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
# 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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<tr>
<td>2000 vpm</td>
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<td>7.58</td>
<td>5.68</td>
<td>4.55</td>
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<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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<td>2400 vpm</td>
<td>13.64</td>
<td>9.09</td>
<td>6.82</td>
<td>5.45</td>
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<tr>
<td>2600 vpm</td>
<td>14.77</td>
<td>9.84</td>
<td>7.39</td>
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<td>10.61</td>
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<td>3000 vpm</td>
<td>17.05</td>
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<td>8.52</td>
<td>6.82</td>
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<tr>
<td>3200 vpm</td>
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<td>9.09</td>
<td>7.27</td>
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<tr>
<td>4000 vpm</td>
<td>22.72</td>
<td>15.16</td>
<td>11.36</td>
<td>9.10</td>
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Additional Vibratory Rollers
Vibratory Rollers - Amplitude

- Amplitude too high
- Travel speed too fast
- Vibrating cool mat
  - Roll closer to paver
- Damaged gutter
  - Roll along interface
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?
Thank You!

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