Asphalt Pavement Best Practices

APWA Workshop

January 24, 1017

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Objective: Identify “best practices” for paving operation and value engineering

• Discuss purpose of tack coats
• Present principles of paver operation
• Discuss methods and objective of compaction
• Describe “intelligent” compaction
Why Use a Tack Coat?
When Should a Tack Coat Be Used?
Purpose of Tack Coats

• To insure bond between the existing pavement surface and the new asphalt overlay
Good or Poor Application of a Tack Coat?
Tack Coats

4 IN.

SINGLE LAP
DOUBLE LAP
TRIPLE LAP

PERFECT TRIPLE LAP
Tack Applied by Paver
If a little tack is Good, a lot has to be Better (?)
Tack Coats

• Materials for tack coats
  – Emulsified asphalt
  – Performance graded asphalt binders

• Application rate (typical)
  – Based on the plans and specifications
    • 0.05-0.10 gal/sq yd for emulsion
    • 0.03-0.08 gal/sq yd for PG asphalt
  – Consider the actual surface conditions
Typical Tack Application Temperatures

- 120-180°F for emulsion
- 275-350°F for PG asphalt
Application

- Determine area of application in square yards
- True application rate equals gallons used (corrected to 60°F) divided by area of the application
Tack Quantity Calculations

- Volumetric measurement based on temperature of 60°F
- Temperature correction factors
  - 0.00035 per degree F for PG asphalt
  - 0.00025 per degree F for emulsion
Example: Tack Quantity Calculations

• A tack distributor applies 580 gallons of emulsion tack at 150°F
• What is the reported gallons at 60°F?

150°F – 60°F = 90°F

90° x 0.00025 per degree = 0.0225

So, temperature correction factor = 0.0225

580 gallons x 0.0225 = 13 gallons difference

Corrected gallons = 580 – 13 = 567 gallons @ 60°F
Determine Area Covered

EXAMPLE:
Coverage area: length = 7500 ft.; width = 12 ft.

Square yards (sy) = (length X width) / 9 sq. ft / sy

= (7500 ft. X 12 ft.) / 9
= 10,000 sy
Determine Spread Rate

EXAMPLE:

Spread rate = gallons @ 60°F / coverage (sy)

Spread rate = 567 gal / 10,000 sy = 0.06 gal / sy
Objective: Identify “best practices” for paving operation and value engineering

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- Describe “intelligent” compaction
Push Rollers
Tractor
Hopper
Tow Point
Side Arm
Conveyors
Screed
Depth Crank
Augers
The Paver Utilizes a Free Floating Screed Principle

What does that mean?
The Paver Utilizes a Free Floating Screed Principle

The screed is free to float up or down in relation to the forces applied.
Main Forces Acting on Screed

• 1. Speed of paver
• 2. Head of material
• 3. Angle of attack
• 4. Other forces
  – Pre-compaction
  – Screed weight
Tow Point
Grade and Slope Control

Tow Point
Grade Sensor
Grade Controller
Slope Controller
Slope Sensor

Courtesy of Blaw-Knox Ingersoll Rand Paving Products
Contact-less Beam with Ultra-Sonic Sensors

Courtesy of Caterpillar Paving Products
Contact-less Bridge Reference
Screed Reaction Time

• Screed reacts to change in angle of attack over 5 tow arm lengths
• 65% of change occurs in the first tow arm length
• 35% of change occurs in the last four tow arm lengths

Courtesy of Caterpillar Paving Products
Sticking the Mat?
Control Head of Material

Courtesy of Blaw-Knox Ingersoll Rand Paving Products
Correct depth of mat maintained

Screed rises due to excess material forced under nose of screed

Screed settles due to inadequate supporting material

Constant head of material volume

Head of material volume too high

Head of material volume too low
Crown Adjustment

Lead Crown
Tail Crown
Lead Crown: 3 mm (1/8 in)
Greater than Tail Crown

Uniform Texture

Courtesy of Caterpillar Paving Products
Longitudinal Joints
Mix “Bumped” Back to Joint

Uncompacted Mat

Compacted Mat
Centerline Segregation
Segregation Cracks
Conventional Paver Design
Improved Paver Design
Infrared Photo of End Dump

>*>270.0°F

*<68.0°F

100.0
150.0
200.0
250.0

164.8

262.0
Infrared Photo of End Dump Mix Behind Paver
An essential for consistent and high quality asphalt pavement is to use a continuous operation.
Materials Transfer Vehicle
Thermal Image: Continuous Paving
1995 University of California Study

- Compacted specimens at low (1 to 3%), medium (4 to 6%) and high (7 to 9%) air void contents
- Mixtures with the same asphalt content (5%) suffered a 30% of reduction of fatigue life when only air voids were increased by 1%
I-R Bar
Effect of Paver Stop
Warm Mix
What Is the Paver Speed?

• Paving width: 12 feet
• Thickness: 2 inches
• Paver efficiency: 80%
• Production: 1500 tons
• Work day: 9 hours
What Is the Paver Speed?

Rule of thumb: 110 lb/sy per inch of thickness

Paving speed = \( \frac{1500 \, t \times 2000 \, lb/t}{220 \, lb/sy} = 13,636 \, sy \)

\( (13,636 \, sy \times 9 \, sf/sy)/12 \, ft \, wide = 10,227 \, linear \, ft \)

\( 10,227 \, ft \, /(9 \, hr \times 60 \, min/hr) = 18.9 \, ft/min \)

Paver Speed = 18.9 ft/min /80% eff = 23.7 ft/min
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- **Discuss methods and objective of compaction**
- Describe “intelligent” compaction
Roadway Performance Is Greatly Affected by Construction Compaction
Definitions

- Density: measurement of mass per unit volume
- Compaction: process of changing the material’s density
- Pass: movement of a roller over a point on the mat
- Coverage: movement of a roller over the full lane width
Importance of Compaction

• Improves mechanical stability
• Improves resistance to permanent deformation
• Reduces moisture penetration
• Improves fatigue resistance
• Reduces low-temperature cracking potential
In-place Density of Asphalt Pavements

- Recent studies have found many new HMA pavements do not have adequate in-place densities

- NCHRP 9-9(1): 40 projects
  - 55% of projects had average air voids greater than 8%
  - 20% of projects had average air voids greater than 10%

- NCHRP 9-27: 20 projects
  - 70% of projects had average air voids greater than 8%
  - 35% of projects had average air voids greater than 10%
Factors Affecting Compaction

- Mix properties
  - Aggregate
  - Asphalt
  - Mix temperature
- Environmental factors
- Site conditions
Multicool software

• A program to predict the available time to achieve target density during construction
• Available both in mobile and desktop version
• http://www.eng.auburn.edu/users/timmmdav/MultiCool/FinalRelease/Main.html#Disclaimer
Environmental Variables

- Layer thickness
- Air and base temperature
- Mix laydown temperature
- Wind velocity
- Solar flux
Site Conditions

• Layer thickness
  – For coarse graded mixes, the optimum thickness is 4 x NMAS
  – For fine graded mixes, the optimum thickness is 3 x NMAS
Time Available for Compaction
Types of Rollers

• Static steel wheel
• Pneumatic – rubber tired
• Vibratory

Courtesy of Caterpillar Paving Products
Vibratory Rollers

Courtesy of Caterpillar Paving Products
Paving Widths
Amplitude
DIRECTION OF TRAVEL

FREQUENCY

Impact Spacing

Low Frequency  High Frequency
Impacts Per Foot

- Impacts per foot is the frequency divided by the roller speed (feet/min)
- Target is 10 to 12 impacts per foot
Compactive Force of Vibratory Rollers

- Static weight of roller
- Dynamic (impact) force
  - Amplitude “how high”
    - Thick lifts: high amplitude
    - Thin lifts: low amplitude
  - Frequency: how fast drum vibrates
    - Use highest frequency (vpm)
The Tender Zone

TENDER ZONE

240°F

200°F
The Tender Zone

- The mix becomes unstable and rollers begin to cut mat along edge of drums
- Believed to be caused by residual moisture and/or excess binder
- Roller operators must be able to recognize the problem and get off the mat
Pneumatic Rollers

- Kneading action helps seal surface of mat
- Can be very helpful in achieving density for tender mixes
Static Steel Wheel Rollers
Setting Roller Patterns

• Due to the many variables that affect density, a new roller pattern has to be set up for each mix
• Use density gauge to observe change in mat density with each pass for each roller
• This is known as a control strip
Checking Compaction with Density Gauges
Roller Pattern Problem

Compaction Curve

Decreasing Temperature

Compaction (%)

Number of Passes

88
92
96
100
1 2 3 4 5 6 7 8

Compaction Curve
Intelligent Compaction
Rolling Pattern Challenges

Complete pass
Overlap
Fresh mat
Incomplete pass

Maximize efficiency: monitor starts and stops
• Blue indicates the compactor traveling too far onto the previous pass: inefficient
• Red indicates the compactor stopped short of the complete pass: improper pattern
Example of the Benefits of IC

- Pass #1 of pattern
  - **Green**: vibe on
  - **Red**: vibe ramping
  - **Pink**: vibe off
Recorded Data

- Pass #2 of pattern
- Vibe engaged to roll through pass #1 OFF location
Recorded Data

- Pass #3 of pattern
- Note the timing of the vibe OFF location
Recorded Data

- Pass #4 of pattern
- Vibe ON location correct to roll through previous vibe OFF location
Recorded Data

- Pass #5 of pattern
- Beginning of next pattern
- Note the location of previous stops
# Typical Range of Roller Speeds (mi/hour)

<table>
<thead>
<tr>
<th>Type of Roller</th>
<th>Breakdown</th>
<th>Intermediate</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Steel Wheel</td>
<td>2.0 to 3.5</td>
<td>2.5 to 4</td>
<td>3.0 to 5.0</td>
</tr>
<tr>
<td>Pneumatic</td>
<td>2.0 to 3.5</td>
<td>2.5 to 6.4</td>
<td>4.0 to 7.0</td>
</tr>
<tr>
<td>Vibratory</td>
<td>2.0 to 3.0</td>
<td>2.5 to 3.5</td>
<td>-----------</td>
</tr>
</tbody>
</table>
Can Rollers Keep Up?

• Paver Speed = 23.7 ft/min
• Roller Speed = 30.8 ft/min
• Yes, rollers can keep up!
• What are options if roller speed is less than paver speed?
Questions?
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