Focusing on What Matters Most - Increasing In-Place Density

OHMPA’s Fall Asphalt Seminar

“Focus Remains the Same - Quality HMA”

Dec 1, 2016
Mark Buncher
FHWA Program: Enhanced Durability Through Increased In-Place Pavement Density

• High priority for FHWA Pavements Office in 2016
  • Premise: Big improvement to performance with minimal cost/effort by using existing technologies and best practices to achieve better compaction
  • AI: develop full-day workshop and deliver to States
  • NCAT: Lit Review on how in-place density relates to performance
  • 10 States: Field demo projects to improve density

Full-day workshop coming to Ontario!
  • Feb 6, 2017
  • Mississauga Convention Center
  • More info soon from OHMPA
FHWA Program: Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density

Key:
- **Yellow**: Durability Workshop Only (2017)
- **Blue**: Durability Workshop and Demonstration Project (2016)
Topics during Full-day Workshop

- Definitions: air voids, density, compaction, durability, etc
- Link density to pavement durability
- How mix design affects compaction and durability
- Factors affecting compaction
- Compactive forces and rollers
- Best practices for roller operations
- Getting good density at longitudinal joints
- Tack coats
- Specifications, measurement, payment
- Improving compaction with technology
Today’s Talk: Some Workshop Pieces
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 1980s

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

• Fixed the rutting problem
• Gyratory compaction lowered binder contents
• Add in higher and higher recycled materials?
Durability Concerns

• Industry concerned with durability
  • Premature cracking and raveling
  • Need for more binder in the mix

• Many State agencies looking for ways to improve durability
  • Minimum binder contents
  • Optimize mix designs
  • Balance rutting with fatigue

Improved compaction has typically not been considered
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%
Note: This CO DOT study analyzed thinner HMA pavements than WA DOT study. Shows even faster deterioration as in-place density lowers.
## FHWA Performance Based Mix Design Study

<table>
<thead>
<tr>
<th></th>
<th>Fatigue Cracking</th>
<th>Rutting</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Design Air Voids</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For every 1% increase</td>
<td>40% increase</td>
<td>22% decrease</td>
</tr>
<tr>
<td><strong>Design VMA</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For every 1% increase</td>
<td>73% decrease</td>
<td>32% increase</td>
</tr>
<tr>
<td><strong>Compaction Density</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>For every 1% lower in-place Air Voids</td>
<td>19% decrease</td>
<td>10% decrease</td>
</tr>
</tbody>
</table>

*Increasing Density Improves Both!*

*Courtesy of Nelson Gibson*
Literature Review on connecting in-place density to performance

- 5 studies cited for fatigue life
- 7 studies cited for rutting
- “A 1% decrease in air voids was estimated to improve the fatigue performance of asphalt pavements between 8.2 and 43.8%, to improve the rutting resistance by 7.3 to 66.3%, and to extend the service life by conservatively 10%.”
...and then there’s permeability

Permeability at the Longitudinal joint

Photo: Wes McNett
Permeability can be Catastrophic
Choosing a Gradation

More Compactable

More Workable

Less Permeable

Finer Gradations

Requires better aggregate
Higher binder contents

Courtesy of NCAT
Finer NMAS mixes less permeable at equivalent air void levels!

From NCAT Report 03-02
Reduce Permeability

Design to a **minimum** lift thickness

- $\geq 3X$ NMAS on fine graded mixtures
- $\geq 4X$ NMAS on coarse graded mixtures

Do not neglect future pavement preservation
Balance the Mix Design

Smooth Quiet Ride
Skid Resistance

DON’T ATTACK ONE HALF AT THE EXPENSE OF THE OTHER HALF!!
Balanced Mix Design Approach

• General Procedure
  • Design and test mix for Rutting
  • Test mix for Cracking and/or Durability
  • Performance Testing

• States that are using this approach
  • Texas
  • Louisiana
  • New Jersey
  • Illinois
  • California
  • Wisconsin
Two critical topics related to better in-place density and overall pavement durability

• Best Practices for Specifying and Constructing Longitudinal Joints

• Tack Coat Best Practices

AI has developed half-day workshops on both of these critical topics and delivered to most States. Recorded workshops, and related info, can be viewed at:

www.asphaltinstitute.org/engineering
Longitudinal Joints
Some States have more challenges than others!
We Know Unsupported Edge Will Have Lower Density

Proper Overlap

Sufficient Material for Roll-Down

Cold (unconfined) side

Hot (confined) side

Low Density Area

Please note Cold side and Hot side, as they are terms used throughout this Workshop.
The Pennsylvania LJ Example
Joint Issues In PA
Increasing density was viewed as key

2007 - began measuring joint density

2008 - method specification of best practices

2008 and 2009 - continued gathering data on joints

2010 - New joint density specification. Transition year with no bonuses or penalties.

2011-2015 – bonuses and penalties on joint density
### PA: How Did it Work?

**In-place Density Summary, Reported by PA DOT**

<table>
<thead>
<tr>
<th>Year</th>
<th># Lots</th>
<th>Avg. Roadway Density, %TMD</th>
<th>Avg. Joint Density, %TMD</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>2007</td>
<td>18</td>
<td>93.9</td>
<td>87.8</td>
<td>begin measuring at Jt.</td>
</tr>
<tr>
<td>2008</td>
<td>43</td>
<td>94.1</td>
<td>88.9</td>
<td>method spec</td>
</tr>
<tr>
<td>2009</td>
<td>29</td>
<td>94.1</td>
<td>89.2</td>
<td>method spec</td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td>No data, transition to PWL spec</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>137</td>
<td>94.1</td>
<td>91.0</td>
<td>PWL, LSL 89%</td>
</tr>
<tr>
<td>2012</td>
<td>162</td>
<td>94.0</td>
<td>91.6</td>
<td>PWL, LSL 89%</td>
</tr>
<tr>
<td>2013</td>
<td>167</td>
<td>93.9</td>
<td>91.4</td>
<td>PWL, LSL 89%</td>
</tr>
<tr>
<td>2014</td>
<td>316</td>
<td>94.1</td>
<td>92.3</td>
<td>PWL, LSL 90%</td>
</tr>
<tr>
<td>2015</td>
<td>493</td>
<td>92.6</td>
<td></td>
<td>PWL, LSL 90%</td>
</tr>
</tbody>
</table>
PA: Increased Projected Life of Joints Due to Improved Joint Density

Percent Service Life

Compaction Level

2007  2009  2010  2011  2012 - 2013  2014

89%  90%  91%  92%  93%
PA: Annual Statewide Totals on Incentives/Disincentives for Joint Density

<table>
<thead>
<tr>
<th>Year</th>
<th>Incentive Payments</th>
<th>Disincentive Payments</th>
</tr>
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<tbody>
<tr>
<td>2011</td>
<td>$268K</td>
<td>$99K</td>
</tr>
<tr>
<td>2012</td>
<td>$489K</td>
<td>$63K</td>
</tr>
<tr>
<td>2013</td>
<td>$588K</td>
<td>$25K</td>
</tr>
<tr>
<td>2014</td>
<td>$1,002K</td>
<td>$127K</td>
</tr>
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</table>

Note: MI and CT have averaged over 91.5%, and AK over 92.0% density at the joint over recent construction seasons.
Why Is Tack Coat So Important

• Bond All Layers to avoid:
  • Slippage
  • Delamination
  • Shoving
  • Increased rutting
  • Difficulty in compaction
  • Reduced fatigue life
    • Up to 75% loss of life
    • Tack ~1% of paving cost

• Poor Bond Exacerbated by:
  • Thinner lifts
  • Higher RAP/RAS

“Perpetual pavement” after 8-10 yrs. Coring revealed debonding.

MO Interstate
Bonded Demonstration

½” Deflection, 60lb Load

¼” Deflection, 160lb Load

Unbonded

Fully Bonded
Far too frequent practices...
Days later!

Courtesy of Road Science
Successful Tack Coat

The Ultimate Goal:
Uniform, complete, and adequate coverage
Proper Tack Coat Application

• Specify and monitor adequate tack coat application
  • Control dilution of emulsion
  • Separate pay item?
• Alternate materials
  • Low Tracking tack
  • Modified materials
  • Paving grade binders

A well compacted pavement section will not perform if it is not properly bonded!!
Improving Quality Control with Intelligent Compaction
Intelligent Compaction

Real-Time Feedback to Roller Operator with On-Board, Color-Coded Mapping using GPS

- Shows # of passes
- Improve roller patterns
- Improve temperature monitoring
- Make smart adjustments “on-the-fly”
- Identify weak support areas
Improved Rolling Patterns

Before

After

IC roller
Increased Compaction = Increased Performance

Better “Return on Investment” for the taxpayers

More Durable Pavements = More Tonnage for the HMA Industry !!!

Thank you!