Enhanced Durability Through Increased In-Place Pavement Density

FHWA Asphalt Mixture Expert Task Group (ETG)
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Federal Highway Administration
Part 626.3 Policy.

“Pavement shall be designed to accommodate current and predicted traffic needs in a safe, **durable**, and cost effective manner.”
Premise:

✓ Compaction is essential for long-term pavement performance

✓ There are many compaction enhancements currently in use

✓ Compaction goals can be improved
## Effect of Air Voids on Fatigue Cracking

<table>
<thead>
<tr>
<th>Study</th>
<th>Lab/Field</th>
<th>Mix Type</th>
<th>Air Voids Evaluated</th>
<th>Reduction in Fatigue Life for 1% Void Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>UC Berkeley</td>
<td>Lab</td>
<td>British Std</td>
<td>4 - 14%</td>
<td>20.6%</td>
</tr>
<tr>
<td>(1969)</td>
<td></td>
<td>CA Fine</td>
<td>5 - 8%</td>
<td>43.8%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA Coarse</td>
<td>2.5 – 7%</td>
<td>33.8%</td>
</tr>
<tr>
<td>UCB (1996)</td>
<td>Lab</td>
<td>CA Dense-Graded</td>
<td>1 - 3% 4 - 6% 7 - 9%</td>
<td>15.1%</td>
</tr>
<tr>
<td>WesTrack</td>
<td>Lab</td>
<td>Fine</td>
<td>4, 8, 12%</td>
<td>13.5%</td>
</tr>
<tr>
<td>(2002)</td>
<td></td>
<td>Fine-Plus</td>
<td>4, 8, 12%</td>
<td>13.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coarse</td>
<td>4, 8, 12%</td>
<td>9.0%</td>
</tr>
<tr>
<td></td>
<td>Field</td>
<td>Fine/Fine-Plus</td>
<td>4, 8, 12%</td>
<td>21.3%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coarse</td>
<td>4, 8, 12%</td>
<td>8.2%</td>
</tr>
<tr>
<td>AI (2010)</td>
<td>Lab</td>
<td>9.5 mm Dense</td>
<td>4 – 11.5%</td>
<td>9.2%</td>
</tr>
</tbody>
</table>
Average Reduction in Fatigue Life for 1% increase in Air Voids

- UCB 1969: 27.2%
- UCB 1996: 15.1%
- WesTrack 2002: 8.7%
- Al 2010: 9.2%
## Effect of Air Voids on Permanent Deformation

<table>
<thead>
<tr>
<th>Study</th>
<th>Lab/Field</th>
<th>Mix Type</th>
<th>Air Voids Evaluated</th>
<th>Final Field Rut Depth (mm)</th>
<th>Increase in Rut Depth for 1% Void Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>WesTrack (2002)</td>
<td>Field</td>
<td>Fine/Fine-Plus Original Coarse</td>
<td>4, 8, 12%</td>
<td>9 - 35</td>
<td>11.5%</td>
</tr>
<tr>
<td></td>
<td>Field</td>
<td>Replacement Coarse</td>
<td>4, 8, 12%</td>
<td>13 - 36</td>
<td>9.6%</td>
</tr>
<tr>
<td></td>
<td>Field</td>
<td>Fine/Fine-Plus/Coarse</td>
<td>4, 8, 12%</td>
<td>12 - 26</td>
<td>66.3%</td>
</tr>
<tr>
<td>AI (2010)</td>
<td>Lab</td>
<td>9.5 mm Dense-Graded</td>
<td>4 – 11.5%</td>
<td>N/A</td>
<td>22.7%</td>
</tr>
</tbody>
</table>
Average Increase in Rut Depth for 1% increase in Air Voids

- AI 2010: 22.7%
- WT rc: 10.9%
- WT f/f+ /c: 7.3%
- WT rc: 66.3%
- WT oc: 9.6%
- WT f/f+: 11.5%

WT - 2002 WesTrack
Research from New Jersey

\[ Y(\text{time}) = -1.1 \times \text{Air Voids} + 16.6 \]

\[ R^2 = 0.32 \]
Enhanced Durability through Increased In-Place Pavement Density

- Assumption – Pavement density can be increased with a minimum of additional cost
- Long-Term Objective – States will increase their in-place asphalt pavement density requirements resulting in increased pavement life
Enhanced Durability through Increased In-Place Pavement Density

• A 1% increase in field density (1% less air voids) is claimed to increase asphalt pavement service-life 10+%! (conservatively)

• Today’s compaction target is typically 92% of maximum ($G_{mm}$) (8% air voids), with varying requirements for the area near the longitudinal joint
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![Increased Density Pavements](image)

• **Increased Density Pavements** target a 2% increase across the entire pavement!

• Just 2% more... makes a huge difference!
2003 AASHTO SOM Survey

Number of States

Minimum Mat Density (% of Gmm)

- 89.0%
- 89.5%
- 90.0%
- 90.5%
- 91.0%
- 91.5%
- 92.0%
- 92.5%
- 93.0%
- 93.5%
- 94.0%

FAA
NYSDOT Case Study

50 Series Comparison
2015 vs Previous 13 Year Average

Percentage of Lots

%MMTD

2002-2014
2015
1. Contact FHWA Division Engineers, discuss project goals and identify potential state participants.

2. Fund (FMIS) State Agency trials/reports on feasibility

3. On-site training (AI), Information search (NCAT), Conduct Webinars (NAPA)
Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density

Demonstration projects (10)
Current Specifications (1 of 2)

• 4 States (MN, OK, PA, WI)
  • Minimum lot average
    • Set at 89.5, 90 to 92% of $G_{mm}$

• 2 States (DC, PA)
  • Minimum individual test
    • Set at 90 to 92% of $G_{mm}$
  • Note: $G_{mb}$ used by 1 state
Current Specifications (2 of 2)

- **1 State (VA)**
  - Minimum control strip density
    - Lot average set at 90% of $G_{mm}$

- **5 States (AK, FL, IN, PA, WA)**
  - Percent within Limits (PWL)
  - Setting LSL and USL
    - LSL set at 91 to 92% of $G_{mm}$
    - Average generally 93 to 94% of $G_{mm}$
Experimental Plan

Control Section

Test Section #1

Test Section #2 (optional)
Unique Enhancements

• Support new specification or research (4 states)
• Incentives (3 states)
  • $ to achieve increased density
  • Partnering with contractor
• Mix adjustments (3 states)
• Additional rollers (2 states)
• IC rollers (2 states)
• SHRP2 IR scan (2 states)
• Statistical evaluation (1 state)
Increased Density Pavements

**Planned Schedule**

- By March 2016, 10 State projects were identified
- By December 2016, 10+ State highway agencies will host an “Increased Density” Asphalt Construction Workshop
  - SHA, Contractors, Equipment Supplies, and Academia
- By December 2016, 10 State highway agencies will place a “Increased Density “ Pavement Section
  - FHWA funding evaluations on existing pavement projects
- 2017, document number of states that modify existing standards
  - Goal 10+ states
THANK YOU……

and Questions

Enhanced Durability Through Increased In-Place Pavement Density