FHWA’s Demonstration Project for Enhanced Durability Through Increased Density

Courtesy Asphalt Institute

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FHWA
Achieving Increased In-place Density

1. Density is Important
2. Gold Medal Examples
3. Density Demonstration Projects
Density Is Important

- Compaction is the single most important factor that affects pavement performance in terms of durability, fatigue life, resistance to deformation, strength and moisture damage.
- Geller, M. Synthesis 152
  - "Compaction is the most economical alternative for achieving an increase in the life expectancy of new and rehabilitated pavement."
  - "The amount of voids in an asphalt mixture is probably the single most important factor that affects performance throughout the life of an asphalt pavement. The voids are primarily controlled by asphalt content, compactive effort during construction, and additional compaction under traffic."

From an FHWA document
Cracking
- To improve fatigue cracking resistance
- To improve thermal cracking resistance

Rutting
- To minimize/prevent further consolidation
- To provide shear strength and resistance to rutting

Moisture Damage
- To ensure the mixture is waterproof (impermeable)

Aging
- To minimize oxidation of the asphalt binder

Density is important, but not a cure-all
How Much Density (%G$_{mm}$) is Enough? Loss of Pavement Service Life

Thicker Pavements  TRR 1217, 1989

Typical Pavements  CDOT 2013-4, 2013

Reduced in-place density at the time of construction results in significant loss of service life!
How Much Density ($G_{mm}$) is Enough?

NCAT Permeability Study

Finer NMAS mixes generally less permeable at equivalent air void levels!

From NCAT Report 03-02
“A 1% decrease in air voids was estimated to:

• **improve fatigue** performance by 8.2 and 43.8%
• **improve the rutting** resistance by 7.3 to 66.3%
• **extend the service life** by conservatively 10%”
Achieving Increased In-place Density

1. Density is Important

2. Gold Medal Examples

3. Density Demonstration Projects
Some “Gold Medal” Density ($\% G_{mm}$) Specifications

Purpose

- Identify density ($\% G_{mm}$) specifications that are success stories.
- Since this is an Olympic year, these success stories are considered “gold medal” examples.
Some “Gold Medal” Density ($\%G_{mm}$) Specifications

- Alaska DOT&PF
- Maine DOT
- Maryland DOT SHA
- Michigan DOT
- New York State DOT
- Pennsylvania DOT
- Tennessee DOT

Note: There are likely more. Contact me if you think you have one.
Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density

"Gold Medal" Density (%Gmm) Specifications
<table>
<thead>
<tr>
<th>State D</th>
<th>AK</th>
<th>ME</th>
<th>MD</th>
<th>MI</th>
<th>NY</th>
<th>PA</th>
<th>TN</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year(s) of Data Analyzed</strong></td>
<td>2016</td>
<td>2015</td>
<td>2013 to 2017</td>
<td>2017</td>
<td>2015</td>
<td>2017</td>
<td>2017</td>
</tr>
<tr>
<td><strong>Mix Type</strong></td>
<td>Type C</td>
<td>Type II 9.5, 12.5, and 19 mm &amp; Superpave 12.5 mm</td>
<td>Dense Graded 9.5, 12.5, and 19 mm</td>
<td>Series 50 9.5, 12.5, and 19 mm</td>
<td>High level wearing surface 9.5, 12.5 &amp; 19 mm</td>
<td>D-mix (3/8” NMAS)</td>
<td></td>
</tr>
<tr>
<td><strong>Type of Projects</strong></td>
<td>N/A</td>
<td>Interstate and principal arterial</td>
<td>All mainline projects</td>
<td>All projects&gt;5,000 tons</td>
<td>Full or partially controlled roadways</td>
<td>Interstate and SR Freeways</td>
<td></td>
</tr>
<tr>
<td><strong>Acceptance Testing</strong></td>
<td>Agency only</td>
<td>Agency only</td>
<td>Agency only</td>
<td>Contractor validated by agency</td>
<td>Agency only</td>
<td>Agency only</td>
<td>Agency only</td>
</tr>
</tbody>
</table>
Maine DOT
Statewide Results 2013 to 2017

Avg. = 94.5%

5.8% below 92%
Michigan DOT
Statewide Results from 2015

Avg. = 94.4%

5.5% below 92%
State D
Statewide Results from 2016

Avg. = 92.6%

25.3% below 92%
State D
Statewide Results from 2016

41.0% below 92.4%

Avg. = 92.6%

Number of Records

Density (% Gmm)

Density (% Gmm)
Arizona DOT
Statewide Results from 2017

Avg. = 93.2%

20.0% below 92%

Density (% Gmm)

Number of Records
Arizona DOT
Two Demonstration Projects in 2018

**Average = 94.0%**

5.7% below 92%
<table>
<thead>
<tr>
<th>Specification Comparison</th>
<th>2017 Standard</th>
<th>2018 Demonstration Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>PWL</td>
<td></td>
<td>PWL</td>
</tr>
<tr>
<td>USL = 9.0 %</td>
<td></td>
<td>USL = 8.0 %</td>
</tr>
<tr>
<td>Average Air Voids = 6.8%</td>
<td></td>
<td>Average Air Voids = 6.0%</td>
</tr>
<tr>
<td>Lot Standard Deviation = 1.36</td>
<td></td>
<td>Lot Standard Deviation = 0.86</td>
</tr>
<tr>
<td>&gt; 8% Air Voids = 20.0%</td>
<td></td>
<td>&gt; 8% Air Voids = 5.7%</td>
</tr>
</tbody>
</table>
Gold Medal Density (% \( G_{mm} \)) Specifications

<table>
<thead>
<tr>
<th>Specification/Criteria/Results</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>AK</td>
</tr>
<tr>
<td><strong>Type of Specification</strong></td>
<td>PWL</td>
</tr>
<tr>
<td><strong>Limits (% ( G_{mm} ))</strong></td>
<td>93.0 to 100.0</td>
</tr>
<tr>
<td><strong>Incentive for Only Density</strong></td>
<td>5.0%</td>
</tr>
<tr>
<td><strong>Max. Incent. (% ( G_{mm} ))</strong></td>
<td>≈96.0</td>
</tr>
<tr>
<td><strong>Avg. (% ( G_{mm} ))</strong></td>
<td>94.9</td>
</tr>
<tr>
<td><strong>Std. Dev. of Lots</strong></td>
<td>1.76</td>
</tr>
<tr>
<td><strong>&lt; 92% ( G_{mm} )</strong></td>
<td>5.6%</td>
</tr>
</tbody>
</table>
## Gold Medal Density ($G_{\text{mm}}$) Specifications

### Specification/Criteria/Results

<table>
<thead>
<tr>
<th>Type of Specification</th>
<th>State D</th>
<th>AK</th>
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<th>TN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limits ($G_{\text{mm}}$)</td>
<td>Lot Avg.</td>
<td>PWL</td>
<td>PWL</td>
<td>Lot Avg. &amp; Ind. Sublot</td>
<td>PWL</td>
<td>PWL</td>
<td>PWL</td>
<td>Lot Avg.</td>
</tr>
<tr>
<td>Incentive for Only Density</td>
<td>1.5%</td>
<td>5.0%</td>
<td>2.5%</td>
<td>5.0%</td>
<td>2.0%</td>
<td>5.0%</td>
<td>2.0%</td>
<td>2.0%</td>
</tr>
<tr>
<td>Max. Incent. ($G_{\text{mm}}$)</td>
<td>92.75</td>
<td>≈96.0</td>
<td>≈93.5</td>
<td>94.0</td>
<td>≈94.5</td>
<td>≈94.0</td>
<td>≈94.0</td>
<td>94.0</td>
</tr>
<tr>
<td>Avg. ($G_{\text{mm}}$)</td>
<td>92.6</td>
<td>94.9</td>
<td>94.5</td>
<td>94.0</td>
<td>94.4</td>
<td>94.2</td>
<td>94.4</td>
<td>93.9</td>
</tr>
<tr>
<td>Std. Dev. of Lots</td>
<td>N/A</td>
<td>1.76</td>
<td>1.20</td>
<td>1.03</td>
<td>1.03</td>
<td>1.01</td>
<td>1.46</td>
<td>N/A</td>
</tr>
<tr>
<td>&lt; 92% $G_{\text{mm}}$</td>
<td>25.3%</td>
<td>5.6%</td>
<td>5.8%</td>
<td>5.3%</td>
<td>5.5%</td>
<td>5.0%</td>
<td>3.1%</td>
<td>11.0%</td>
</tr>
</tbody>
</table>
# Gold Medal Density ($G_{mm}$) Specifications

## Specification/Criteria/Results

### Longitudinal Joint

<table>
<thead>
<tr>
<th>State</th>
<th>AK</th>
<th>ME</th>
<th>MD</th>
<th>MI</th>
<th>NY</th>
<th>PA</th>
<th>TN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Specification</td>
<td>None</td>
<td>Lot Avg.</td>
<td>PWL</td>
<td>None</td>
<td>Lot Avg.</td>
<td>Under Development</td>
<td>PWL</td>
</tr>
<tr>
<td>Limits ($G_{mm}$)</td>
<td>---</td>
<td>&gt;91.0</td>
<td>&gt;91.0</td>
<td>---</td>
<td>&gt;90.5</td>
<td>---</td>
<td>&gt;90.0</td>
</tr>
<tr>
<td>Incentive for Only Joint Density</td>
<td>---</td>
<td>$1.50 per L.F. ($≈6.25%)$</td>
<td>2.0%</td>
<td>---</td>
<td>$1.00 per L.F. ($≈4.0%)$</td>
<td>---</td>
<td>$5000 per Lot ($≈2.5%)$</td>
</tr>
</tbody>
</table>
Achieving Increased In-place Density

1. Density is Important

2. Gold Medal Examples

3. Density Demonstration Projects
Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density

Workshops

28 States
Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density

Demonstration Projects

- Phase 1 (10 states)

Mobile Asphalt Testing Trailer (2)
Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density

Demonstration Projects

- **Phase 1 (10 states)**
- **Phase 2 (9 states)**

Mobile Asphalt Testing Trailer (3)
Enhanced Durability of Asphalt Pavements through Increased In-Place Pavement Density

Demonstration Projects

- **Phase 1 (10 states)**
- **Phase 2 (9 states)**
- **Phase 3 (10 states)**

Mobile Asphalt Testing Trailer (3)
# Demonstration Project Status

<table>
<thead>
<tr>
<th>Phase</th>
<th>Year</th>
<th>States</th>
<th>Constructed</th>
<th>State Reports</th>
<th>Summary Report</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2016</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>July 2017</td>
</tr>
<tr>
<td>2</td>
<td>2017-2018</td>
<td>9</td>
<td>8</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(2 re-do’s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2018</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Updated: Nov. 1, 2018
Can We Achieve Increased In-place Density?

**YES!**

- Test sections had increased density (% Gmm):
  - 8 of 10 States achieved > 1.0% increase
  - 7 of 10 States achieved > 94.0% Gmm
  - 6 of 10 States achieved > 95.0% Gmm

- Will there be changes?
  - 8 of 10 States are changing specifications
Agency Changes (1 of 2)

- Measuring density (1)
- Reference density (1)
- Density of pavement to meet requirements (4)
  - Some at 90 to 91% Gmm
  - Others at 94% Gmm
- Type of specification (2)
  - 22 states use minimum lot average
  - 25 states use PWL
    - Impacts contractors’ target and consistency
- Consistency (2)
  - Standard deviations <1.00 were achievable

(#) – Number of States making changes or in the process
Agency Changes (2 of 2)

- Incentives (3)
  - 37 states have incentives: range from 1 to 10%; average 2.9%

- Mixture design changes (5)
  - Many states changing Superpave to get more asphalt
  - Must also look at density specification

- New technologies (2)
  - Did not help improve density, but were a good trouble-shooting tool

(#) – Number of States making changes or in the process
Contractor Changes

- More passes
  - “Roll until you meet density requirements”
- More rollers
  - Some were using 1 roller
- Type of rollers
  - Pneumatic / Oscillation
- Location of rollers
  - Echelon
- General best practices
  - Temperature / spacing / screed

Courtesy Miguel Montoya
State 4:  
Cost / Benefit of Best Practices

- **Benefit of 1% Density Increase**
  10 percent of $60 / ton mix = $$$$$ $$

- **Cost of 1 Percent Density Increase**
  Additional rollers ≤ $
  AVR to 3% W/binder ≤ $$
  WMA Additive ≤ $
  9.5mm vs. 12.5mm ≈ $$
NCAT Report 17-05: “Demonstration Project for Enhanced Durability of Asphalt Pavements through Increased In-place Pavement Density”
July 2017

http://eng.auburn.edu/research/centers/ncat/files/technical-reports/rep17-05.pdf
Next Steps

- Field experiment – Phase 2
  - 8 of 9 states completed construction
  - 2 of 9 states completed reports

- Field experiment – Phase 3
  - 10 of 10 states completed construction
  - 0 of 10 states completed reports

- FHWA’s best practices communication
  - Summary documents: Phases 2 and 3
  - Tech Brief
  - Additional workshops
    - Funding dependent
Thank you

QUESTIONS / COMMENTS:

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