Superpave5
Superpave Design at Five Percent Air Voids
Marshall Mix Design

- Design Air Voids 3-5%

- Field Compaction
  - 8% after rolling
  - 4% after traffic

Construction (8%) → Decreases to Service Life (4%)
Strategic Highway Research Program

- “Marshall” carried forward
- Design air voids fixed at 4%
- Recommended compaction set at 92% Gmm
Interstate Pavement at End of Life

- 89% Density
- 92% Density
- 95% Density
• Mix Design
  5% air voids
• Superpave 5 Concept
• Gyration
• Design Changes
• Field Compaction

95% Gmm
<table>
<thead>
<tr>
<th>NMAS</th>
<th>VMA</th>
<th>Effective Asphalt (volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.5</td>
<td>15.0</td>
<td>11.0</td>
</tr>
<tr>
<td>12.5</td>
<td>14.0</td>
<td>10.0</td>
</tr>
<tr>
<td>19.0</td>
<td>13.0</td>
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</tr>
<tr>
<td>25.0</td>
<td>12.0</td>
<td>8.0</td>
</tr>
</tbody>
</table>
SR 13, Middlebury, Indiana

- 2013 Trial Project
- 13,400 AADT
- 19% heavy trucks
Gradation

Sieve Opening (mm) Raised to the 0.45 Power

PERCENT PASSING

Superpave4

Superpave5
Counter-Flow Drum Mix Plant
Same Rolling Train
Superpave5 Compaction
## Mix Construction Properties

<table>
<thead>
<tr>
<th></th>
<th>Superpave4</th>
<th></th>
<th></th>
<th>Superpave5</th>
<th></th>
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<tr>
<td></td>
<td>Design</td>
<td>QC</td>
<td>QA</td>
<td>Design</td>
<td>QC</td>
<td>QA</td>
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<tr>
<td>Asphalt, %</td>
<td>5.1</td>
<td>5.1</td>
<td>5.0</td>
<td>5.4</td>
<td>5.5</td>
<td>5.2</td>
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<tr>
<td>Air Voids, %</td>
<td>4.0</td>
<td>3.5</td>
<td>4.1</td>
<td>5.0</td>
<td>4.5</td>
<td>4.0</td>
</tr>
<tr>
<td>Density, %Gmm</td>
<td>-</td>
<td>-</td>
<td>91.6</td>
<td>-</td>
<td>94.7</td>
<td>96.9</td>
</tr>
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</table>
### 2018 Core Locations

<table>
<thead>
<tr>
<th>Location</th>
<th>Superpave4</th>
<th>Superpave5</th>
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<tbody>
<tr>
<td>1</td>
<td>206+66</td>
<td>155+95</td>
</tr>
<tr>
<td>2</td>
<td>147+37</td>
<td>180+25</td>
</tr>
<tr>
<td>3</td>
<td>124+74</td>
<td>214+74</td>
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</table>
Six Cores At Each Location
### Core Properties

<table>
<thead>
<tr>
<th></th>
<th>Superpave4</th>
<th></th>
<th>Superpave5</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Loc 1</td>
<td>Loc 2</td>
<td>Loc 3</td>
<td>Loc 1</td>
</tr>
<tr>
<td>Thickness, mm</td>
<td>37.3</td>
<td>37.7</td>
<td>34.5</td>
<td>35.2</td>
</tr>
<tr>
<td>Asphalt, %</td>
<td>5.34</td>
<td>5.35</td>
<td>5.56</td>
<td>5.67</td>
</tr>
<tr>
<td>Density, %Gmm</td>
<td>91.8</td>
<td>94.0</td>
<td>92.3</td>
<td>95.7</td>
</tr>
</tbody>
</table>

Average Values
Permeability

![Permeability Graph]

- **Permeability, cm/day**
- **Air voids, %**

Legend:
- Superpave4
- Superpave5
## Recovered Asphalt Binder Grade

<table>
<thead>
<tr>
<th>Location</th>
<th>High Fail Temp., °C</th>
<th>Low Fail Temp, m, °C</th>
<th>Low Fail Temp, S, °C</th>
<th>ΔTc, °C</th>
<th>Superpave4</th>
<th>High Temp Grade, °C</th>
<th>Low Temp Grade, m, °C</th>
<th>Low Fail Temp, S, °C</th>
<th>ΔTc, °C</th>
<th>Superpave5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>99.1</td>
<td>-15.6</td>
<td>-24.8</td>
<td>-9.2</td>
<td>95.4</td>
<td>-20.5</td>
<td>-24.9</td>
<td>-4.4</td>
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<td></td>
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<tr>
<td>2</td>
<td>97.0</td>
<td>-20.4</td>
<td>-25.8</td>
<td>-5.4</td>
<td>96.5</td>
<td>-18.5</td>
<td>-23.4</td>
<td>-4.9</td>
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<tr>
<td>3</td>
<td>103.9</td>
<td>-12.7</td>
<td>-23.1</td>
<td>-10.4</td>
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<td>-1.5</td>
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<tr>
<td>Average</td>
<td>100.0</td>
<td>-16.2</td>
<td>-24.6</td>
<td>-8.3</td>
<td>94.0</td>
<td>-21.0</td>
<td>-24.7</td>
<td>-3.6</td>
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</table>
# Asphalt Binder Grade

<table>
<thead>
<tr>
<th>Temperature, °C</th>
<th>Superpave4</th>
<th>Superpave5</th>
</tr>
</thead>
<tbody>
<tr>
<td>HT</td>
<td>100</td>
<td>94</td>
</tr>
<tr>
<td>LT</td>
<td>-16</td>
<td>-21</td>
</tr>
</tbody>
</table>
Correlation PG High Temp to In-Place Air Voids

\[ R^2 = 0.9117 \]
Correlation PG Low Temp to In-Place Air Voids

\[ R^2 = 0.8885 \]
Correlation Delta Tc to In-Place Air Voids

$R^2 = 0.9544$
What Did We Learn?

Aging of Asphalt Binder Directly Related to In-Place Air Voids
Superpave 5

- 2018
  - 12 projects let as Superpave5
  - 9 projects built or partially built
  - 11 mix designs
    - Four 19.0-mm
    - Seven 9.5-mm

- 2019
  - Standard specifications changed January 2019
  - Specification effective September 2019
  - For 2019, option to change Superpave4 projects to Superpave5
How did they turn out?
Good.

- 19.0 mm Intermediate
- Gyratory Voids 5.42%
- Density 93.73% Gmm (6.27% voids)
- 0.85% difference
Good.

- 9.5-mm Surface
- Gyratory Voids 5.64%
- Density 93.82% Gmm (6.18% voids)
- 0.54% difference
Not so good.

- 9.5-mm Surface Shoulder
- Gyratory Voids 5.56%
- Density 92.86% Gmm (7.14% voids)
- 1.58% different
Good.

- **Gyratory Voids**
  - 4.93%
- **Density**
  - 94.34%
  - 5.66% voids
- 0.73% difference
Not so good.

- Gyratory Voids
  4.37%

- Density
  93.93%
  6.07% voids

1.70% difference
OK.

- Gyratory Voids: 4.58%
- Density: 93.82%
  6.18% voids
- 1.50% difference
Good.

- **Gyratory Voids**
  - 5.75%

- **Density**
  - 93.42%
  - 6.58% voids
  - 0.83% difference
OK.

- Gyratory Voids  
  4.79%

- Density  
  93.87%  
  6.13% voids

1.34% difference
Not so good.

- Gyratory Voids 4.16%
- Density 93.45%
- 6.55% voids
- 2.39% difference
Good.

- Gyratory Voids
  5.19%

- Density
  94.24%
  5.76% voids

0.57% difference
Good.

- Gyratory Voids 5.26%
- Density 94.58%
  5.42% voids
  0.16% difference
## Summary

<table>
<thead>
<tr>
<th>Mix</th>
<th>Air Void Difference</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.0- mm</td>
<td>0.16%</td>
<td>Good</td>
</tr>
<tr>
<td>9.5- mm</td>
<td>0.54%</td>
<td>Good</td>
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<td>9.5- mm</td>
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<tr>
<td>19.0- mm</td>
<td>1.34%</td>
<td>OK</td>
</tr>
<tr>
<td>9.5 - mm</td>
<td>1.50%</td>
<td>OK</td>
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<tr>
<td>9.5 - mm</td>
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<td>1.70%</td>
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<tr>
<td>9.5 - mm</td>
<td>2.39%</td>
<td>Not so good</td>
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</tbody>
</table>
HMA Specification Revisions

- **Superpave5**
  - Design a mix at 5% air voids
  - Target 5% AV (95% density) in field

<table>
<thead>
<tr>
<th>SPECIFICATION LIMITS</th>
<th>MIXTURE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LSL*</td>
</tr>
<tr>
<td>Air Voids at $N_{des}$, %</td>
<td>2.60</td>
</tr>
<tr>
<td>Voids In Mineral Aggregate at $N_{des}$, %</td>
<td>Spec</td>
</tr>
</tbody>
</table>

| DENSITY               |
|----------------------|---------|
|                      | LSL*    | USL**  |
| Roadway Core Density (% Gmm), % | 91.00  | n/a |
|                       | 93.00   | n/a    |

* LSL, Lower Specification Limit
** USL, Upper Specification Limit
HMA Specification Revisions

• Superpave5
  • Fully effective for lettings after 9/1/19
  • Is actually in letting documents starting 3/6/19, but.....

• Construction Memo 19-03
Construction Memo 19-03

- Three different options for contracts let before 9/1/19

- Option 1:
  - All of HMA changes, without Superpave 5

- Option 2:
  - All of HMA changes, including Superpave 5
Construction Memo 19-03

- Three different options for contracts let before 9/1/19
  - Option 1:
    - All of HMA changes, without Superpave 5
  - Option 2:
    - All of HMA changes, including Superpave 5
  - Option 3:
    - All of HMA changes, with Contractor option for Superpave 4 or Superpave 5 for any mix
2019 HMA Changes

- Won’t that cause mass confusion?
- Not any more than switching mix designs normally does
- New DMF Entry and HMA Pay Wizard system will help
Superpave 5

THANK YOU