Optimizing Laboratory Design for Five Percent Superpave (Superpave5)

Matt Beeson
Indiana Department of Transportation
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- Gerry Huber
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- Bill Pine
  - Heritage Construction and Materials
- John Haddock
  - Purdue University
- Ali Hekmatfar
  - Purdue University
History of Design Air Voids

- Marshall Mix Design
  - Set up in late 1940s
  - Design voids set at 3 to 5%
- Marshall Mix Compaction
  - “Standard” rolling train
    - Static Steel Wheel
    - Pneumatic tired
  - 8% will densify under traffic to 4%
    - “Density at end of life = Design Density”
Superpave Mix Design

- “Marshall” concept carried forward
  - Design air voids fixed at 4%
- Recommended compaction
  - Set at 92% Gmm
Superpave5

Concept
- Design at 5% air voids
- Compact to 5% (95% Gmm)
- Increase VMA by 1%
- Increase air voids by 1%
  - 5% instead of 4%
- Aggregate specifications stay same
- Lift thickness stays same

Benefit
- Asphalt content stays same
- Higher in-place density
- Lower permeability
- Reduced aging (?)
- No(?) increase in cost
Asphalt Content Remains Same

<table>
<thead>
<tr>
<th>NMAS</th>
<th>VMA</th>
<th>Air Voids</th>
<th>Vbe</th>
<th>VMA</th>
<th>Air Voids</th>
<th>Vbe</th>
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</thead>
<tbody>
<tr>
<td>9.5</td>
<td>16.0</td>
<td>5.0</td>
<td>11.0</td>
<td>15.0</td>
<td>4.0</td>
<td>11.0</td>
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<tr>
<td>12.5</td>
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<td>5.0</td>
<td>10.0</td>
<td>14.0</td>
<td>4.0</td>
<td>10.0</td>
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<tr>
<td>19.0</td>
<td>14.0</td>
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<td>9.0</td>
<td>13.0</td>
<td>4.0</td>
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<td>25.0</td>
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<td>8.0</td>
<td>12.0</td>
<td>4.0</td>
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</tr>
</tbody>
</table>
Superpave5 Concept

- Requires change in N-design

- N-design too high
  - Difficult to design
  - Difficult to get compaction

- N-design too low
  - More likely to rut
<table>
<thead>
<tr>
<th>ESAL</th>
<th>Gyrations</th>
<th>9.5-mm</th>
<th>19.0-mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-10 million</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>x</td>
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<tr>
<td>50</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10-30 million</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>x</td>
<td>x</td>
<td></td>
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</table>
### 9.5-mm Mixture (Example)

<table>
<thead>
<tr>
<th>Trial Number</th>
<th>N100/4</th>
<th>N70/5</th>
<th>N50/5</th>
<th>N30/5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P_b, %</strong></td>
<td>5.9</td>
<td>5.9</td>
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</tr>
<tr>
<td><strong>P_be, %</strong></td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
</tr>
<tr>
<td><strong>V_a, %</strong></td>
<td>4.1</td>
<td>5.1</td>
<td>4.9</td>
<td>5.3</td>
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<tr>
<td><strong>VMA, %</strong></td>
<td>15.0</td>
<td>16.0</td>
<td>15.8</td>
<td>16.3</td>
</tr>
<tr>
<td><strong>VFA, %</strong></td>
<td>72.3</td>
<td>67.9</td>
<td>68.9</td>
<td>67.7</td>
</tr>
</tbody>
</table>
9.5-mm Mixture Gradations

Percent Passing

Sieve Size raised to 0.45 power, mm

N100
Max Density Line
9.5-mm Mixture Gradations

Sieve Size raised to 0.45 power, mm

Percent Passing

N100

N70

Max Density Line
9.5-mm Mixture Gradations

Percent Passing

Sieve Size raised to 0.45 power, mm

N100
N70
N50
Max Density Line
9.5-mm Mixture Gradations

Percent Passing

Sieve Size raised to 0.45 power, mm

- N100
- N70
- N50
- N30
- Max Density Line
Rut Resistance Comparison

Higher Flow Number = Higher Rut Resistance
Stiffness Comparison

Number of Gyrations

E* @ 50°C

E* @ 25 Hz

E* @ 10 Hz

30 gyration mix approx. equal to 100 gyration mix
Laboratory Study Conclusions

- Designs at 5% Air Voids and 95% Gmm Compaction
  - Equal or Greater
    - Stiffness
    - Flow Number

- THAN designs at 4% Air Voids and 93% Gmm Compaction

30 gyrations

100 gyrations
Superpave5 Field Trial
Georgetown Road
Georgetown Road

- Reconstruction and widening
- Trial Mix
  - 19-mm NMAS
  - 330 lb/yd² (3 inches)
Trial Conditions

- December 12 & 13, 2014
  - Loose samples
  - Cores
- Temperature
  - 34°F to 46°F
  - Light wind
Paving Train
Paving Train
N30 (Superpave5) Mix
N30 (Superpave5) Mix
Field Density Quality Control
N30 (5% Air Void) Mix
Plate Sample from Road for QA
Loose Research Samples
Research Samples (N30 and N100)
# QA Volumetric Properties

<table>
<thead>
<tr>
<th></th>
<th>Superpave5</th>
<th></th>
<th></th>
<th>Superpave4</th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>DMF</td>
<td>Sub-lot 1</td>
<td>Sub-lot 2</td>
<td>DMF</td>
<td>Sub-lot 1</td>
<td></td>
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<tr>
<td>% Asphalt</td>
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<td>4.44</td>
<td>4.76</td>
<td>4.6</td>
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<tr>
<td>Gmm</td>
<td>2.480</td>
<td>2.505</td>
<td>2.494</td>
<td>2.494</td>
<td>2.523</td>
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<tr>
<td>Gmb</td>
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<td>2.362</td>
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<td>5.2</td>
<td>4.0</td>
<td>4.4</td>
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<tr>
<td>VMA</td>
<td>15.1</td>
<td>14.5</td>
<td>14.7</td>
<td>13.4</td>
<td>12.9</td>
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</table>
# QA Core Density

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<td><strong>Gmm</strong></td>
<td>2.505</td>
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<td>2.521</td>
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<tr>
<td><strong>Core Gmb 1</strong></td>
<td>2.412</td>
<td>2.345</td>
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<td><strong>Core Gmb 2</strong></td>
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<td><strong>%Gmm 1</strong></td>
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<tr>
<td><strong>%Gmm 2</strong></td>
<td>96.5</td>
<td>96.2</td>
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<td>91.2</td>
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<tr>
<td><strong>Air Voids 1</strong></td>
<td><strong>3.7</strong></td>
<td><strong>6.0</strong></td>
<td>6.8</td>
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<td><strong>Air Voids 2</strong></td>
<td>3.5</td>
<td><strong>3.8</strong></td>
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</table>
Superpave5 Field Trial

- Fatigue Testing
  - No aging
  - Long term oven aging
  - Will determine if fatigue properties are improved after aging

- Hamburg
  - New to Indiana
Where Are We?

- Laboratory Study Complete
  - N-design selected at 30 gyrations
- Two trial projects constructed
  - N-design set at 50 gyrations
- Let Trial Project(s)
  - Set up trial specification
  - Let project(s) as Superpave5
- Determine PWL tolerances
  - Air voids
  - VMA
  - Density
Thank You

Greetings from Billy Bob