Superpave5
Designing and Constructing Superpave Asphalt to Five Percent Air Voids

Bill Pine
Heritage Construction & Materials
Superpave5

Concept

- Design at 5% air voids
- Compact to 5% (95% Gmm)
- Increase air voids by 1%
  - 5% instead of 4%
- Increase VMA by 1%
- Aggregate specifications stay the same
  - *Lift thickness stays the same*
Superpave5

Design Changes

Concept

- Design at 5% air voids
- Compact to 5% (95% Gmm)
- Increase air voids by 1%
- Increase VMA by 1%
- Aggregate specifications stay same
- Lift thickness stays same
Mix Designs (4% Air Voids)

<table>
<thead>
<tr>
<th></th>
<th>125 gyrations</th>
<th>100 gyrations</th>
<th>75 gyrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>125 gyrations</td>
<td>15.2 VMA</td>
<td></td>
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</tr>
<tr>
<td>100 gyrations</td>
<td>15.4 VMA</td>
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<tr>
<td>75 gyrations</td>
<td></td>
<td>15.3 VMA</td>
<td></td>
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<tr>
<td></td>
<td>125 gyrations</td>
<td>100 gyrations</td>
<td>75 gyrations</td>
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<td>------------</td>
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<td>---------------</td>
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<tr>
<td>125 gyrations</td>
<td>5.8%</td>
<td>5.7%</td>
<td>5.7%</td>
</tr>
<tr>
<td>100 gyrations</td>
<td>5.7%</td>
<td>5.7%</td>
<td>5.7%</td>
</tr>
<tr>
<td>75 gyrations</td>
<td>5.7%</td>
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Asphalt Content @ 4% Air Voids

<table>
<thead>
<tr>
<th></th>
<th>125 gyrations</th>
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<th>75 gyrations</th>
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<tr>
<td>125 gyrations</td>
<td>5.8%</td>
<td>5.7%</td>
<td></td>
</tr>
<tr>
<td>100 gyrations</td>
<td>5.7%</td>
<td>5.7%</td>
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<tr>
<td>75 gyrations</td>
<td>5.7%</td>
<td>5.7%</td>
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</tr>
</tbody>
</table>

Gradation IS Different!
Superpave5 Concept

- Requires change in N-design

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

- If N-design too low
  - More likely to rut
Superpave5

Benefits

- 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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<tbody>
<tr>
<td>9.5</td>
<td>15.0</td>
<td>4.0</td>
<td>11.0</td>
<td>16.0</td>
<td>5.0</td>
<td>11.0</td>
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<tr>
<td>12.5</td>
<td>14.0</td>
<td>4.0</td>
<td>10.0</td>
<td>15.0</td>
<td>5.0</td>
<td>10.0</td>
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<tr>
<td>19.0</td>
<td>13.0</td>
<td>4.0</td>
<td>9.0</td>
<td>14.0</td>
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<td>25.0</td>
<td>12.0</td>
<td>4.0</td>
<td>8.0</td>
<td>13.0</td>
<td>5.0</td>
<td>8.0</td>
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Purdue Study to Set N-design

<table>
<thead>
<tr>
<th>ESAL</th>
<th>Gyrations</th>
<th>9.5-mm</th>
<th>19.0-mm</th>
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<tbody>
<tr>
<td>3-10 million</td>
<td>70</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>10-30 million</td>
<td>70</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>x</td>
<td>x</td>
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## 9.5-mm Mixtures

<table>
<thead>
<tr>
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<th>Trial Number</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>N100/4</td>
<td>N70/5</td>
<td>N50/5</td>
<td>N30/5</td>
</tr>
<tr>
<td>(P_{b}, %)</td>
<td>5.9</td>
<td>5.9</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>(P_{be}, %)</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
<td>4.7</td>
</tr>
<tr>
<td>(V_{a}, %)</td>
<td>4.1</td>
<td>5.1</td>
<td>4.9</td>
<td>5.3</td>
</tr>
<tr>
<td>VMA, %</td>
<td>15.0</td>
<td>16.0</td>
<td>15.8</td>
<td>16.3</td>
</tr>
<tr>
<td>VFA, %</td>
<td>72.3</td>
<td>67.9</td>
<td>68.9</td>
<td>67.7</td>
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</tbody>
</table>
9.5-mm Mixture Gradations

Sieve Size raised to 0.45 power, mm

Percent Passing

N100

Max Density Line
9.5-mm Mixture Gradations

![Graph showing percent passing vs. sieve size raised to 0.45 power for N100 and N70 mixtures, with the Max Density Line.](image-url)
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

30 gyration mix approx. equal to 100 gyration mix

E* @ 50C

E* @ 25 Hz

E* @ 10 Hz
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
N-Design Recommendations

- < 3 million ESALs: 30 gyrations (75)
- 3 – 30 million ESALs: 50 gyrations (100)
- > 30 million ESALs: 70 gyrations (125)

Ndesign difference (Spave4 – Spave5) ~ 50 gyrs
Superpave5 Field Trial
Georgetown Road
Georgetown Road

- Reconstruction and widening
- Superpave5 Trial Mix
  - 19.0-mm NMAS
  - 330 lb/yd² (3 inches)
  - Ndesign = 30 gyrations
- Superpave4 Control Mix
  - Same NMAS and lift thickness
  - Ndesign = 100 gyrations
Superpave5 Trial Conditions

- December 12 & 13, 2014
  - Loose mix samples (Plant and Mat)
  - Cores
- Outside Temperature
  - 34°F to 46°F (~1°C to 8°C)
  - Light wind
Paving Train
N30 (Superpave5) Mix
Field Density Quality Control
Research Cores
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>
</tr>
</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>
</tr>
<tr>
<td>% Asphalt</td>
<td>4.8</td>
<td>4.44</td>
<td>4.76</td>
<td>4.6</td>
<td>4.68</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>
<td>2.356</td>
<td>2.362</td>
<td>2.367</td>
<td>2.394</td>
<td>2.411</td>
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<tr>
<td>Air Voids</td>
<td>5.0</td>
<td>5.8</td>
<td>5.2</td>
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<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>
</tr>
</tbody>
</table>
### QA Core Density

<table>
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<tr>
<th></th>
<th>Superpave5</th>
<th>Superpave4</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>DMF</td>
<td>Sublot 1</td>
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<tr>
<td>Gmm</td>
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<tr>
<td>Core Gmb 1</td>
<td>2.505</td>
<td>2.494</td>
</tr>
<tr>
<td>Core Gmb 2</td>
<td>2.412</td>
<td>2.345</td>
</tr>
<tr>
<td>%Gmm 1</td>
<td>96.3</td>
<td>94.0</td>
</tr>
<tr>
<td>%Gmm 2</td>
<td>96.5</td>
<td>96.2</td>
</tr>
<tr>
<td>Air Voids 1</td>
<td>3.7</td>
<td>6.0</td>
</tr>
<tr>
<td>Air Voids 2</td>
<td>3.5</td>
<td>3.8</td>
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</table>
Where Have We Been?  
Where Are We Headed?

- Promising Concept  
  - Constructible  
  - Performs in the field  
  - Research & trials show benefits
- Lab Study Complete  
  - N-design recommendations  
    - 30, 50 and 70
- Three trials constructed  
  - N-design set at 30 gyrs (one)  
  - N-design set at 50 gyrs (two)  
  - Trial spec used in project Fall 2016

- Let Additional Trial Project(s)  
  - Let as Superpave5  
    - Spave5 specs in contract(s)  
  - Various ESAL categories  
  - Broader Industry representation
- Determine PWL tolerances  
  - Air voids  
  - VMA  
  - Density
Questions?

Thank You!

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