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
As-Constructed Air Voids

- NCHRP Report 573
Typical Final Density

91.8% 94.6%

NCHRP Report 573
Figure 4.8
LCPC Developed Mix Design Method
Design to 5%
Construct to 5%
Performance Good
Superpave5

- Inspired by LCPC
- Designed in America
Superpave 5 Concept

- Mix Design
  5% air voids

- Field Compaction
  95% Gmm

- No change in asphalt content
<table>
<thead>
<tr>
<th>NMAS</th>
<th>VMA</th>
<th>Voids</th>
<th>Vbe</th>
<th>VMA</th>
<th>Air</th>
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Study Conclusions

- Designs at 4% Air Voids and 93% Gmm Compaction

≈

- Designs at 5% Air Voids and 95% Gmm Compaction
Design Recommendations

- <3 million ESALs: 30 gyrations
- 3 million to 30 million ESALs: 50 gyrations
- >30 million ESALs: 70 gyrations
SR 13, Middlebury, Indiana

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

<table>
<thead>
<tr>
<th>Material</th>
<th>Superpave4</th>
<th>Superpave5</th>
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<tbody>
<tr>
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<td>40</td>
<td>43</td>
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<tr>
<td>#12 Limestone</td>
<td>20</td>
<td>17</td>
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<tr>
<td>Stone Sand</td>
<td>15</td>
<td>18</td>
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<tr>
<td>Natural Sand</td>
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<tr>
<td>RAS (Shingles)</td>
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Gradation

Sieve Opening (mm) Raised to the 0.45 Power

PERCENT PASSING

Superpave4
Superpave5
# Mix Designs

<table>
<thead>
<tr>
<th></th>
<th>Superpave4</th>
<th>Superpave5</th>
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<tbody>
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<td>Natural Sand</td>
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<td>RAS (Shingles)</td>
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<table>
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<tr>
<td>Gyration</td>
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<tr>
<td>Asphalt Content</td>
<td>5.1%</td>
<td>5.4%</td>
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<tr>
<td>Recycled Binder Ratio</td>
<td>0.206</td>
<td>0.193</td>
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<tr>
<td>Air Voids</td>
<td>4.0</td>
<td>5.0</td>
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<tr>
<td>VMA</td>
<td>15.5</td>
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Counter-Flow Drum Mix Plant
Superpave5 Compaction
# Mix Construction Properties

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<td>Air Voids, %</td>
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<td>Density, %Gmm</td>
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<td>91.6</td>
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<td>94.7</td>
<td>96.9</td>
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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>
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<tr>
<td>2</td>
<td>147+37</td>
<td>180+25</td>
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<td>3</td>
<td>124+74</td>
<td>214+74</td>
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Project built June 2013
Six Cores At Each Location
## Core Properties

<table>
<thead>
<tr>
<th></th>
<th>Superpave4</th>
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<th>Superpave5</th>
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<tbody>
<tr>
<td></td>
<td>Loc 1</td>
<td>Loc 2</td>
<td>Loc 3</td>
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<tr>
<td>Thickness, mm</td>
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<td>Density, %Gmm</td>
<td>91.8</td>
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Average Values
Permeability

![Graph showing permeability versus air voids, with data points for Superpave 4 and Superpave 5.]
Recovered Binder Master Curve
Glover Rowe, SP5, Location 3
## Glover Rowe Results

<table>
<thead>
<tr>
<th>Superpave4</th>
<th>Location 1</th>
<th>Glover Rowe Value</th>
<th>Expected Performance</th>
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<tr>
<td></td>
<td>880</td>
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<tr>
<td></td>
<td>363</td>
<td>Might Crack</td>
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<tr>
<td></td>
<td>858</td>
<td>Should crack</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Superpave5</th>
<th>Location 1</th>
<th>Glover Rowe Value</th>
<th>Expected Performance</th>
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<tbody>
<tr>
<td></td>
<td>170</td>
<td>Should Not Crack</td>
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<tr>
<td></td>
<td>315</td>
<td>Might Crack</td>
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<tr>
<td></td>
<td>69</td>
<td>Should Not Crack</td>
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## Recovered Asphalt Binder Grade

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<thead>
<tr>
<th>Location</th>
<th>High Fail Temp, °C</th>
<th>Low Fail Temp, °C</th>
<th>Low Fail Temp, S, °C</th>
<th>ΔTc, °C</th>
<th>High Temp Grade, °C</th>
<th>Low Temp Grade, °C</th>
<th>Low Fail Temp, S, °C</th>
<th>ΔTc, °C</th>
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<td>-9.2</td>
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<td>-21.0</td>
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</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