HMA Quiet Pavement Overview

Illinois Bituminous Paving Conference
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Office of Pavement Technology
Presentation Outline

• Sources of traffic noise
• Tire-pavement noise mechanisms
• Methods for reducing noise on HMA
• Ongoing research
Sources of Traffic Noise

Noise Source Distribution of a 74dB vehicle in drive-by test

Tyres

- Free rolling noise
- Tail pipe(s)
- Exhaust system
- Intake pipe
- Intake system
- Engine
- Powertrain
- Transmission
- Oil pan
- Drive train
- Exhaust manifold
- Oil pan
- Accessories
- Cylinder head
- Valve cover
- Engine block

Remaining unidentifiable noise:
- Air turbulence noise
- Exhaust system engine, tyres, etc...

Source: Ulf Sandberg
Components of Tire-Pavement Noise

- Block Impact
- Air Pumping
- Contact Length
- Tread Block Slip
- Highest Slip Velocities
- Pavement

Blocks ‘Snap-Out’
Texture-Noise Relationship

Texture-Wavelength

- Microtexture
- Macrotexture
- Megatexture
- Roughness

PLARC Category

- Rolling Resistance
- Ride Quality

Pavement Surface Characteristic (PSC)

- Dry Weather Friction
- Wet Weather Friction
- Splash and Spray
- Tire Wear
- Vehicle Wear
- In-Vehicle Noise
- Tire-Pavement Noise

Key:
- Good
- Bad

Source: Iowa State University
# Pavement Factors

<table>
<thead>
<tr>
<th>No.</th>
<th>Parameter</th>
<th>Degree of influence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Macrotexture</td>
<td>Very high</td>
</tr>
<tr>
<td>2</td>
<td>Megatexture</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Microtexture</td>
<td>Low - moderate</td>
</tr>
<tr>
<td>4</td>
<td>Unevenness</td>
<td>Minor</td>
</tr>
<tr>
<td>5</td>
<td>Porosity</td>
<td>Very high</td>
</tr>
<tr>
<td>6</td>
<td>Thickness of layer</td>
<td>High, for porous surfaces</td>
</tr>
<tr>
<td>7</td>
<td>Adhesion (normal)</td>
<td>Low/moderate</td>
</tr>
<tr>
<td>8</td>
<td>Friction (tangent.)</td>
<td>See microtexture</td>
</tr>
<tr>
<td>9</td>
<td>Stiffness</td>
<td>Uncertain, moderate (?)</td>
</tr>
</tbody>
</table>

Source: Ulf Sandberg
Pavement Factors – Texture

Source: Ulf Sandberg
Pavement Technologies

• Asphalt technologies
  – Fine Superpave mixes
  – Stone Matrix Asphalt (SMA)
  – Porous Friction Course
Fine Superpave Mixes
Fine Superpave Mixes

- Small aggregate size
- Fine gradation
- Dense graded
- Pooled fund
Noise Level vs. Aggregate Size

A-Weighted SPL Superpave

Sound Level (dBA) vs. Frequency (Hz)

- 4.75mm Superpave
- 9.5mm Superpave
- 12.5mm Superpave
Stone Matrix Asphalt
Stone Matrix Asphalt

- Small aggregate size
- Gap-graded aggregate (usually from coarse aggregate)
- Manufactured sands and mineral filler
- Asphalt binder typically modified

Source: Univ. of Washington
Stone Matrix Asphalt

Source: Univ. of Washington, Mark Swanlund
Noise Level vs. Aggregate Size

A-Weighted SPL SMA

9.5mm SMA
12.5mm SMA
19mm SMA

NCAT Report 06-06
Porous Friction Course

Courtesy of Doug Hanson
Porous Friction Course

- Small aggregate size
- Open-graded aggregate
  - High volume of voids
  - ≥ 20% air voids, in place
- Thick asphalt binder coating
- Array of tortuous pores
- Dissipates energy through friction
- Reduce surface area and slip-stick or slap
- Reduces horn effect
- Modified binders may increase elasticity
Porous Friction Course
# OGFC GRADATIONS

<table>
<thead>
<tr>
<th>Gradation</th>
<th>Arizona (^1)</th>
<th>Nevada (^1)</th>
<th>AL 1 – 7 (^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Max Size</td>
<td>4.75 mm</td>
<td>9.5 mm</td>
<td>12.5 mm</td>
</tr>
<tr>
<td>¾ inch</td>
<td>-</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>½ inch</td>
<td>-</td>
<td>100</td>
<td>89</td>
</tr>
<tr>
<td>3/8 inch</td>
<td>100</td>
<td>95</td>
<td>56</td>
</tr>
<tr>
<td>No. 4</td>
<td>38</td>
<td>45</td>
<td>14</td>
</tr>
<tr>
<td>No. 8</td>
<td>6</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td>No. 16</td>
<td>-</td>
<td>11</td>
<td>-</td>
</tr>
<tr>
<td>No. 200</td>
<td>1.2</td>
<td>2</td>
<td>3.2</td>
</tr>
<tr>
<td>Fineness Modulus</td>
<td>5.42</td>
<td>5.00</td>
<td>6.14</td>
</tr>
<tr>
<td>Air Voids</td>
<td>-</td>
<td>-</td>
<td>17 %</td>
</tr>
<tr>
<td>Noise Level</td>
<td>91.5</td>
<td>93.8</td>
<td>98.6</td>
</tr>
</tbody>
</table>

\(^1\) Courtesy of Doug Hanson

\(^2\) Arizona 1 – 7 test results.
Alabama - {98.6 dB(A)}
Nevada - {93.8 dB(A)}
Arizona - {91.5 dB(A)}

Courtesy of Doug Hanson
Porous Friction Course

Seen from the edge of the pavement:

- 2.4 mm aggregate
- 25 mm thick

Close-up view from the top:

- Noise reduction:
- 6 dB when new compared to new HMA with 16 mm aggr

Double-layer porous asphalt
(example of Klooserzande test track)

Source: Ulf Sandberg
Pavement Performance

CPX trailer, 4 ref tires

Source: Ulf Sandberg
Pavement Performance

Typical Sound Intensity (dBA)

96  98  100  102  104  106  108  110

Dense-graded Asphalt

Open-graded Asphalt

Concrete

Source: Transtec CPSC
POP QUIZ

Quiet or Loud?
Calcined Bauxite, 1-3mm
Zebragrip, Calcined Bauxite, 1-3mm
Dense graded HMA, 20M ESALs, 19mm

20 mm
Superpave, 9.5mm, 20M
ESALS, 0.8mm MTD
Milled Asphalt

20 mm
Hot Rolled Asphalt 20mm

20 mm
OGFC, 20M ESALs,

NMS 12.5mm, MTD 1.6mm

20 mm
Ongoing Research

• NCAT and Purdue University
  – development & evaluation of low noise pavements
• Poroelastic Road Surface (PERS)
NCAT and Purdue
Quiet Pavement Development

• Develop and evaluate quiet pavement technology
  – Double layer porous
  – Thin, gap-graded asphalt layers
## AU 4-C2 Sections

### North Tangent

<table>
<thead>
<tr>
<th></th>
<th>N 5</th>
<th>N 6</th>
<th>N 7</th>
<th>N 8</th>
<th>N 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 1 (1 ¼ inches)</td>
<td>AZ OGFC</td>
<td>AZ OGFC</td>
<td>AZ OGFC</td>
<td>PEM</td>
<td>PEM</td>
</tr>
<tr>
<td>Layer 2 (1 ¼ inches)</td>
<td>Track</td>
<td>AZ OGFC</td>
<td>PEM</td>
<td>PEM</td>
<td>Track</td>
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### South Tangent

<table>
<thead>
<tr>
<th></th>
<th>S 4</th>
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<tr>
<td>Layer 1 (1¼ inches)</td>
<td>&lt; 4.75 SMA</td>
<td>4.75 SMA</td>
<td>9.5 SMA</td>
<td>4.75 DGA</td>
<td>9.5 DGA</td>
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<td></td>
<td></td>
<td>Track</td>
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Courtesy of Doug Hanson
AZ OGFC and Georgia PEM

20 mm
# AU 4-C2 Sections

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Courtesy of Doug Hanson
OBSI Spectra @60 MPH, GDYR

A-Weighted OBSI Porous Asphalt

Source: NCAT Report 06-04
Poroelastic Road Surface (PERS)

Mounting a rubber sheet

Material:
Recycled tire rubber

Source: Ulf Sandberg
Poroelastic Road Surface (PERS)

Source: Ulf Sandberg
Poroelastic Road Surface (PERS)

...but .... the underlying asphalt broke

Rubber shaved off, with top asphalt layer sticking to the rubber

Source: Ulf Sandberg
Thank You

Mark Swanlund
Office of Pavement Technology