HMA Quiet Pavement Overview: Causes and Cures

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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
- Surface radiation
- Air-cleaner box
- Hose connections
- Cardan shaft
Intake system
- Surface radiation
- Transmission
- Drive train
- Intake manifold
- Oil pan
- Accessories
- Cylinder head
- Valve cover
- Engine block
Engine
- Powertrain
- 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
- Blocks ‘Snap-Out’
Texture-Noise Relationship

Texture Wavelength

<table>
<thead>
<tr>
<th>Texture</th>
<th>Microtexture</th>
<th>Macrotexture</th>
<th>Megatexture</th>
<th>Roughness</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 μm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 μm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 μm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 mm</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>100 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 m</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PIARC Category

Pavement Surface Characteristic (PSC)

Influence

- Rolling Resistance
- Ride Quality
- Wet Weather Friction
- Dry Weather Friction
- Splash and Spray
- Tire Wear
- Vehicle Wear
- In-Vehicle Noise
- Tire-Pavement Noise

Key:
- Good
- Bad

Source: Iowa State University
<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

![Graph showing noise level vs. frequency for 3/4 inch and 1/2 inch Superpave aggregate sizes.]

Courtesy of Doug Hanson
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

COLORADO DATA

3/4 inch SMA

1/2 inch SMA

3/8 inch SMA

Noise Level (dB)

400 800 1200 1600 2000 2400 2800 3200 3600 4000

Frequency (Hz)

Courtesy of Doug Hanson
Porous Friction Course
Porous Friction Course

- Small aggregate size
- Open-graded aggregate
  - High volume of voids
    \[ \geq 20\% \text{ air voids, in place} \]
- 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
## 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>(\frac{3}{4}) inch</td>
<td>-</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>(\frac{1}{2}) 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>

Courtesy of Doug Hanson
Alabama \{98.6 \text{ dB(A)}\}

Nevada - \{93.8 \text{ dB(A)}\}

Arizona - \{91.5 \text{ dB(A)}\}

Courtesy of Doug Hanson
Porous Friction Course

Seen from the edge of the pavement:

2-4 mm aggregate
25 mm thick

8-11 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
Ongoing Research

- National Center for Asphalt Technology: Evaluation of Low Noise Pavements
- Poroelastic Road Surface (PERS)
NCAT Quiet Pavement Development

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

## North Tangent

<table>
<thead>
<tr>
<th>Layer 1 (1 ¼ inches)</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>AZ OGFC</td>
<td>AZ OGFC</td>
<td>AZ OGFC</td>
<td>PEM</td>
<td>PEM</td>
<td></td>
</tr>
</tbody>
</table>

| Layer 2 (1 ¼ inches) | Track     | AZ OGFC   | PEM       | PEM       | Track     |

## South Tangent

<table>
<thead>
<tr>
<th>Layer 1 (1½ inches)</th>
<th>S 4</th>
<th>S 5</th>
<th>S 6</th>
<th>S 7</th>
<th>S 8</th>
</tr>
</thead>
<tbody>
<tr>
<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>
<td></td>
</tr>
</tbody>
</table>

| Layer 2             | Track     |           |           |           |           |

Courtesy of Doug Hanson
AU 4-C2 Sections

Noise Level (dB(A))

- OGFC/PEM (N 7)
- Thick OGFC (N 6)
- Thin OGFC (N 5)
- PEM (Original)
- Thick PEM (N 8)
- DGA (Original)
- Thin PEM (N 9)
- SMA (Original)
Poroelastic Road Surface (PERS)

Mounting a rubber sheet

Material:
Recycled tire rubber
Poroelastic Road Surface (PERS)

Source: Ulf Sandberg

![Graph showing noise levels for different road surfaces at 70 km/h.]

- CPX(4)
- 70 km/h
- Noise level [dB(A)]
- 12 dB(A)
- Spentab, Rosehill, Tokai, Asphalt

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