Second generation thin layer surfacings for urban roads

Hans Bendtsen,
Senior Researcher
Danish Road Institute/Road Directorate

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Guest researcher at UC Davis in California
Part of large EU SILENCE project:
  Cooperation between Danish, Swedish and German National Road Institutes

Background:
- 13 urban test sections with noise reducing thin layers/ In EU project SILVIA
- 6 highway test sections with noise reducing thin layers / Danish Road Directorate and Dutch DVS IPG programme

Goal:
- Optimize noise reduction of thin Stone Mastics Asphalt (SMA) layers for urban roads
- Based upon laboratory samples (Marshall)
Full scale experiment on Kastrupvej in Copenhagen - 7 promising thin layers + a dense reference were constructed 2007
Speed limit 50 km/h
Traffic 7000 (7% heavies)

Cooperation between:
• Danish Road Institute
• Municipality of Copenhagen
• Colas Contractors
Design guidelines

Reduce **vibration** generated noise
500-1500 Hz
   - even and smooth surface
   • using small max. aggregate (4 – 6 mm)
   • cubic aggregates + good compaction

Reduce **aero-acoustic** noise sources
Over 1000Hz
   - open (but dense) surface structure
   • high built-in air void
   • adding 5 - 15 % oversize grains
## Selected mixes

<table>
<thead>
<tr>
<th>Pavement</th>
<th>Max. aggr. mm</th>
<th>Binder %</th>
<th>Air-void, % geo.</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAC 0/11 (ref.)</td>
<td>11</td>
<td>-</td>
<td>5.4</td>
</tr>
<tr>
<td>SMA 0/6</td>
<td>6</td>
<td>6.9</td>
<td>15.3</td>
</tr>
<tr>
<td>SMA 6+ 5/8</td>
<td>6 + 5/8</td>
<td>7.1</td>
<td>3.4</td>
</tr>
<tr>
<td>SMA 6+ 5/8 (1)</td>
<td>6 + 5/8</td>
<td>7.0</td>
<td>5.7</td>
</tr>
<tr>
<td>SMA 6+ 5/8 opt.</td>
<td>6 + 5/8</td>
<td>6.5</td>
<td>13.9</td>
</tr>
<tr>
<td>OGAC 0/6</td>
<td>6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SMA 0/4</td>
<td>4</td>
<td>7.0</td>
<td>8.8</td>
</tr>
<tr>
<td>SMA 4+ 5/8</td>
<td>4 + 5/8</td>
<td>6.7</td>
<td>10.2</td>
</tr>
</tbody>
</table>

Road Directorate
## SMA variants

<table>
<thead>
<tr>
<th>SMA 0/6</th>
<th>SMA6+ 5/8 (1)</th>
<th>SMA 0/4</th>
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<td>SMA6+ 5/8</td>
<td>SMA6+ 5/8(opt.)</td>
<td>SMA4+ 5/8</td>
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</table>
Measurement method

Statistical pass-by (SPB) measurements
ISO 11819-1 at 8 test sections

- cars only (few or atypical trucks (busses))
- reference speed 50 km/h
- temperature normalized (20°C)
- speed corrected due to angle error
- age of test sections ≈ 3 months
SPB-results, cars at 50 km/h

DAC 0/11, ref., (new surf.!

Nord2000 ref. = 71.8 dB
8 years old

OGAC 0/6
Noise reduction relative to the reference DAC 0/11, year 0

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<th>SMA 6+ /5/8 (1)</th>
<th>SMA 6+ /5/8</th>
<th>SMA 0/4</th>
<th>SMA 4+ / 5/8</th>
</tr>
</thead>
<tbody>
<tr>
<td>SMA 0/6</td>
<td>SMA 6+ /5/8 (Opt.)</td>
<td>OGAC 0/6</td>
<td></td>
</tr>
</tbody>
</table>

Noise reduction [dB]

- SMA 6+ /5/8 (1) 0.9 dB
- SMA 6+ /5/8 1.3 dB
- SMA 0/4 1.6 dB
- SMA 4+ / 5/8 3.0 dB
- SMA 0/6 3.2 dB
- SMA 6+ /5/8 (Opt.) 3.7 dB
- OGAC 0/6 4.3 dB
Noise spectra cars at 50 km/h SMA 6 variants

- DAC 0/11, ref.
- SMA 0/6
- SMA 6+ 5/8
- SMA 6+ 5/8 (1)
- SMA 6+ 5/8 (Opt.)

L_pAF_{max}, [dB]

Centre frequency, [Hz]
Noise spectra cars at 50 km/h SMA 4 variants

Graph showing centre frequency vs. $L_{PAF_{max}}$ for different variants:
- DAC 0/11, ref.
- OGAC 0/6
- SMA 0/4
- SMA 4+ 5/8

Legend:
- Vibration
- Aero-acoustic
ISO/CD 11819-2 draft
A and D tyre
Data recorded:
• The average A-weighted noise level at each wheel per 20 m
• 1/3-octave band frequency spectra
• The vehicle speed
• Gps coordinates
• Air temperatures
• Tyre temperatures
CPX index and SPB

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<th>SMA 4+ 5/8</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPXL</td>
<td>92,4</td>
<td>88,6</td>
<td>90,3</td>
<td>89,3</td>
<td>89,1</td>
<td>88,1</td>
<td>88,5</td>
</tr>
<tr>
<td>L_pAFmax</td>
<td>69,9</td>
<td>66,7</td>
<td>68,6</td>
<td>66,2</td>
<td>65,6</td>
<td>68,3</td>
<td>67</td>
</tr>
</tbody>
</table>
Variation along the road - homogeneity

Most surfaces are homogene along the road – typical variation < ±0.4 dB

Typical: SMA 0/6

Atypical: OGAC 0/6
SPB levels in relation to air void content

\[ y = -0.2576x + 70.23 \]

\[ R^2 = 0.7382 \]
Summary and conclusion

Statistical pass-by levels for cars at 7 optimized thin layer test sections showed at 50 km/h:

- noise reduction up to 4.3 dB rel. DAC11 same age, when new
- oversize aggregate reduce noise
- high built in air void reduce noise
- 4 mm aggregate did not reduce noise
- Measurements will continue
Thank you for your attention!

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