Thin asphalt layers for highways – optimised for low tyre / road noise

Bent Andersen
Danish Road Directorate / Road Institute
Senior researcher / Traffic Noise
bea@vd.dk
Background and purpose

- First thin layer experiment in Denmark: 6 test pavements in 2004 at M10. Danish Road Directorate
- Second experiment: 11 test pavements in 2006 at M64. Part of DRI-DWW noise abatement program
- Purpose:
  - Develop and optimise thin semi-dense pavements for highway application
  - Monitor performance over time:
    - noise (SPB and CPX), texture, and friction
Measurement program

- **Noise**
  - SPB method (ISO 11819-1)
  - CPX method (ISO/CD 11819-2)

- **Texture (laser profilometer)**

- **Friction (wet, 20% slip, 60 km/h)**
Thin layers at M10 - DK 2004

- 110 km/h
- 84000 veh/24h
- Ref. AC 11d

- SMA 8
- AC 8o
- UTLAC 8
- SMA 6+
- SMA 8+
SPB results for cars at 110 km/h

- Range ≈ 3 dB
- Nord2000 ref. (8 years): 83.8 dB
- Noise reduction: 2 – 5 dB initially, 0 – 2 dB 4 years
- Best surfaces:
  - AC 8
  - SMA 6+

Portorož, Slovenia
SPB results for multi-axle trucks at 85 km/h

- Range ≈ 3 dB
- Nord2000 ref. (8 years, 5 ax): 88.5 dB
- Noise reduction:
  - 1 – 2 dB initially
  - -1– 2 dB 4 years
- Best surfaces:
  - AC 8o
  - UTLAC 8
  - SMA 8

Multi-axle trucks 85 km/h

<table>
<thead>
<tr>
<th>Surface</th>
<th>Lveh [dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC 11d</td>
<td></td>
</tr>
<tr>
<td>SMA 8</td>
<td></td>
</tr>
<tr>
<td>UTLAC 8</td>
<td></td>
</tr>
<tr>
<td>SMA 6+</td>
<td></td>
</tr>
<tr>
<td>AC 8o</td>
<td></td>
</tr>
<tr>
<td>SMA 8+</td>
<td></td>
</tr>
</tbody>
</table>

Age [yrs]

Portorož, Slovenia
SPB results for dual-axle trucks at 85 km/h

- Range $\approx$ 3 dB
- Best surfaces:
  - AC 8o
  - UTLAC 8
  - SMA 8

Dual-axle trucks 85 km/h

<table>
<thead>
<tr>
<th>Age [yrs]</th>
<th>Lveh [dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>80</td>
</tr>
<tr>
<td>1</td>
<td>82</td>
</tr>
<tr>
<td>2</td>
<td>84</td>
</tr>
<tr>
<td>3</td>
<td>86</td>
</tr>
<tr>
<td>4</td>
<td>88</td>
</tr>
<tr>
<td>5</td>
<td>90</td>
</tr>
</tbody>
</table>

Legend:
- AC 11d
- SMA 8
- UTLAC 8
- SMA 6+
- AC 8o
- SMA 8+
New experiment 2006: M64, Herning-1

- 90 km/h
- 7100 veh/24h
- Ref. AC 11d

- Optimize mix ← intl. experience
- Max aggregate size 6+ mm
- Increase built-in air void
- 4 pavement families:
  - SMA
  - UTLAC
  - BBTM
  - AC 0
### Herning-1 test surface data, M64

<table>
<thead>
<tr>
<th>Pavement</th>
<th>Max. aggr. [mm]</th>
<th>Air void [%]</th>
<th>Thickness [mm]</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTLAC 8</td>
<td>8</td>
<td>12</td>
<td>22</td>
</tr>
<tr>
<td>UTLAC 6</td>
<td>6</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>BBTM 6 – cl. 2</td>
<td>6</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>BBTM 8 – cl. 1</td>
<td>8</td>
<td>14</td>
<td>25</td>
</tr>
<tr>
<td>BBTM 8 – cl. 2</td>
<td>8</td>
<td>16</td>
<td>24</td>
</tr>
<tr>
<td>SMA 6</td>
<td>6</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>SMA 6+</td>
<td>6 + 5/8</td>
<td>6</td>
<td>22</td>
</tr>
<tr>
<td>SMA 8</td>
<td>8</td>
<td>8</td>
<td>24</td>
</tr>
<tr>
<td>AC 6o</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC 8o</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAC 11</td>
<td>11</td>
<td>2.3</td>
<td>-</td>
</tr>
</tbody>
</table>

Portorož, Slovenia
Grading curves – SMA

SMA 6, SMA 6+, SMA 8 and AC 11 (ref.)

Percentage passing [%]

0,063 0,125 0,250 0,5 1 2 4 5 6 8 11,2 16 [mm]
Portorož, Slovenia

DAC 11

SMA 6+

SMA 6

SMA 8
Grading curves – UTLAC

UTLAC 6, UTLAC 8 and AC 11 (ref.)

- AC 11 dense
- UTLAC 6
- UTLAC 8

Percentage passing [%]

0 10 20 30 40 50 60 70 80 90 100

0,063 0,125 0,250 0,5 1 2 4 5,6 8 11,2 16 [mm]
Grading curves – BBTM (semi-porous)

BBTM 6 Class 2, BBTM 8 Class 1, BBTM 8 Class 2 and AC 11

- AC 11 dense
- BBTM 6 Class 2
- BBTM 8 Class 1
- BBTM 8 Class 2

Percentage passing [%]

0 10 20 30 40 50 60 70 80 90 100

0,063 0,125 0,250 0,5 1 2 4 5 6 8 11,2 16 [mm]
SPB results for cars at 90 km/h, year 0

- **Range**: 73.8 – 78.6 dB
- **Uncertainty (95% conf.)**: ≈ ± 0.2 dB
SPB results for cars at 90 km/h, year 0 & 1

- Range 5 – 6 dB
- Nord2000 ref. (8 years): 80.5 dB
- Noise reduction 2 – 7 dB initially 1 – 7.4 dB 1 year
- Best surfaces: AC 6o AC 8o SMA 6+

Portorož, Slovenia
SPB results for multi-axle trucks at 80 km/h, year 0

**Range**
84.5 – 87.5 dB

**Uncertainty**
(95% conf.) ≈ ± 0.4 dB
SPB results for multi-axle trucks at 80 km/h

- Range ≈ 3 dB
- Nord2000 ref. (8 years, 5 ax): 87.7 dB
- Noise reduction: 0 – 3 dB initially, .5 – 3.7 dB 1 year
- Best surfaces: AC 6o, SMA 8, AC 8o, BBTM 8 Cl. 2
1/3 octave band SPB spectra, cars, M64 year 0

Vibration noise

No absorption dip

Air pumping noise

Portorož, Slovenia
**CPX\textsubscript{DK} index at M10, year 3, 80 km/h**

- **Range**: 100 – 101.5 dB
- **Best surfaces**: SMA 8, SMA 6+, AC 8o

---

Portorož, Slovenia
CPX$_{DK}$ index at M64, year 1, 80 km/h

- **Range**
  - 95.5 – 98.2 dB

- 3 – 5 dB lower than M10, year 3

- **Best surfaces:**
  - SMA 6+
  - BBTM 6 Cl.2
  - UTLAC 6
  - SMA 6
  - AC 6o
AC 8o (best surface)

Texture spectra almost identical year 0 & 2, noise increased
Texture and SPB noise spectra, M10 year 0 & 2

- SMA 6+
- Texture spectra year 2 lower, noise increased
- Texture levels lower than for AC 80, noise levels similar
- NO simple relationship found

Portorož, Slovenia
MPD for 6 and 8 mm test surfaces

- MPD reduced by traffic during first ½ year (M64)
- MPD increased from year 0 to year 2 (M10, 84000 veh/day)
- MPD for test surfaces > MPD for AC 11d ref. surface

Portorož, Slovenia
Skid resistance for 6 and 8 mm test surfaces

- Friction increased by traffic during first ½ year (M64)
- Friction reduced from year 0 to year 2 (M10, 84000 veh/day)
- Friction for test surfaces > friction for AC 11d ref. surface

Portorož, Slovenia
Summary, thin surface layers, 6 – 8 mm max

Traffic noise reduction, year 0 – 1:

- ore DAC 11 same age:
  - Light 5 dB
  - Heavy 3 dB
  - Traffic 4 dB

- ore Nord2000:
  - Light 7 dB
  - Heavy 4 dB
  - Traffic 5 dB

**MPD**: test surfaces > AC 11d ref. surface

**Friction**: test surfaces > AC 11d ref. surface
Recommendations

Optimize thin layers for noise reduction: AC · o, SMA · , and BBTM · Cl.2

Pavement design:
• Small, cubic aggregate
• Good compaction
• High built-in air void
• Modified bitumen

Lifetime investigations are needed

New: Herning-2
7 thin layers built
Sept. 2008
Thank you for your attention!

For detailed information:
download DRI reports from www.roadinstitute.dk
or contact bea@vd.dk