High Friction Surfaces and Other Innovative Pavement Surface Treatments for Reduced Highway Noise

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What are High Friction Surfaces?

- High Friction Surfaces (HFS) are surface systems with exceptional skid-resistant properties that are not typically acquired by conventional materials.

- Guidelines Document from the British Board Agreement (BBA)
  
  - “...defined as having a minimum skid resistance value (SRV) of 65 measured using the portable Skid-Resistance Tester as defined in TRL Report 176: Appendix E.”
HFS Materials

• Aggregates – generally calcined bauxite or some slags with high PSV materials
  – Generally 3-4 mm size

• Binder system
  – Bitumen-extended epoxy resins
  – Epoxy-resin
  – Rosin-ester
  – Polyurethane-resin
  – Acrylic-resin
HFS

- Surfaces may be colored
- Placed at locations that require high anti-skidding properties
  - Horizontal curves
  - Pedestrian walkways
  - Bus stop areas
HAPAS

• The Highway Authorities Product Approval Scheme (HAPAS) in the UK approves new products for use in highway maintenance and construction

• Set up by the Highways Agency, the CSS, and the British Board of Agrément
HAPAS

- HFS products in the UK must be approved or certified by HAPAS for use
- Installer must also be approved by the BBA
HAPAS Approval

- To be certified, vendors must test per:
  - Guidelines Document for the Assessment and Certification of High-Friction Surfacing for Highways

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Type 1</th>
<th>Type 2</th>
<th>Type 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>SRV (newly laid)</td>
<td>≥ 65</td>
<td>≥ 65</td>
<td>≥ 65</td>
</tr>
<tr>
<td>Texture depth (mm) (initial)</td>
<td>≥ 1.4</td>
<td>≥ 1.2</td>
<td>≥ 1.0</td>
</tr>
<tr>
<td>SRV (trafficked systems)*</td>
<td>≥ 65</td>
<td>≥ 65</td>
<td>≥ 65</td>
</tr>
<tr>
<td>Texture depth (mm)(trafficked systems*)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean value</td>
<td>≥ 1.0</td>
<td>≥ 1.0</td>
<td>≥ 1.0</td>
</tr>
<tr>
<td>Minimum individual value</td>
<td>≥ 0.8</td>
<td>≥ 0.8</td>
<td>≥ 0.8</td>
</tr>
<tr>
<td>Cracking (mm) (trafficked systems)*</td>
<td>≤ 0.5</td>
<td>≤ 0.5</td>
<td>≤ 0.5</td>
</tr>
</tbody>
</table>

* During and at the end of the two-year performance trial
Type 1 material is for the heaviest applications; Types 2 and 3 material is intended for lighter applications

- [http://www.bbacerts.co.uk/hapas.html](http://www.bbacerts.co.uk/hapas.html)
What about HFS and Noise?

- Literature shows relationship between HFS and skid resistance
- What about noise?
- HFS used in the UK since the late 60’s/early 70’s
- Not much noise testing performed
Texture and Tire-Pavement Noise

Texture and Tire-Pavement Noise Diagram

- Microtexture
- Megatexture
- Roughness

Texture Wavelength:
- 1 μm
- 10 μm
- 100 μm
- 1 mm
- 10 mm
- 100 mm
- 1 m
- 10 m
- 100 m

PIARC Category:
- Microtexture
- Megatexture
- Roughness

Pavement Surface Characteristic (PSC):
- 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, PIARC
**NCAT Trial**

- NCAT test track originally built in 2000
- 46 different sections, trafficked with 10 million ESALs
- In 2003, two sections overlaid with calcined bauxite friction surface (E2 and E3)

```
<table>
<thead>
<tr>
<th></th>
<th>Year</th>
<th>Section</th>
<th>Surface Type</th>
<th>Aggregate Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>S7</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>LMS / RAP</td>
</tr>
<tr>
<td>S8</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>Marble Schist</td>
</tr>
<tr>
<td>S9</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>Granite</td>
</tr>
<tr>
<td>S10</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>Granite</td>
</tr>
<tr>
<td>S11</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>Marble Schist</td>
</tr>
<tr>
<td>S12</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>Limestone</td>
</tr>
<tr>
<td>S13</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>Granite</td>
</tr>
<tr>
<td>E1</td>
<td>2003</td>
<td>10</td>
<td>SMA</td>
<td>Limestone</td>
</tr>
<tr>
<td>E2</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>Granite</td>
</tr>
<tr>
<td>E3</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>Granite</td>
</tr>
<tr>
<td>E4</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>Granite</td>
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<tr>
<td>E5</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>Granite</td>
</tr>
<tr>
<td>E6</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>Granite</td>
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<tr>
<td>E7</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>Granite</td>
</tr>
<tr>
<td>E8</td>
<td>2000</td>
<td>20</td>
<td>Superpave</td>
<td>Granite</td>
</tr>
</tbody>
</table>

These sections were overlaid with a calcined bauxite friction surface.
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NCAT Data

- Sand patch macrotexture

Source: Smit and Waller
NCAT Noise Data

- CPX Trailer with OBSI mics 45mph
- SRTT tire used
- Converted to 60 mph to readily compare to industry norm
Belgium Study

• Noise study on existing road surfaces in Belgium (1979)
• 40 to 120 km/h (25 to 75 mph)
• Noise tests inside and outside of vehicle
• Outside measurements were recorded at 7.5m from the centerline and 1.2m above pavement level (ISO SPB location)
• Inside measurements recorded with microphone placed at the level of the head of passenger
Belgium Study

Reference = 75 dBA

- Emery 1/3mm: -3.5
- Bauxite 4/6mm: -1.5
- “Dense-graded HMA”
- Conventional chip seal: +3
- “Grooved concrete”: +4

Exterior Noise Levels (SPB)
Netherlands Study

• Noise level measurements on five types of surfaces
  – “Old” concrete surface
  – “Steel broom” textured concrete
  – “Horsehair broom” textured concrete
  – “Jute”/burlap textured concrete
  – “Coating of the concrete surface with a rough layer”

• Noise collected via single-wheel trailer, 100 km/h (62 mph)
Netherlands Study

Exterior Noise Levels (Trailer)

Reference = 103.5 dBA

- HFS -0.3
- "Dense-graded" HMA
- Burlap 0.6
- "Heavily Worn" Concrete 4.8
Italgrip in Wisconsin

- Italgrip section on STH 16 in Wisconsin
  - Eastbound lane – 3mm aggregate
  - Westbound lane – 4mm aggregate
- French-German controlled passby method used
Italgrip in Wisconsin

- At 60 and 65 mph
  - 1 dB reduction in noise level when compared to ground PCC pavement
- Between 1,600 and 2,000 Hz
  - 2 to 3 dB reduction in noise level when compared to the ground pavement
- At 70 mph
  - No significant noise level change
- Comparing 3mm and 4mm aggregate
  - No significant noise level difference
Westbound at 60 mph

Source: WisDOT
Westbound at 65 mph
Comparison of Italgrip Aggregate Size at 60 mph

Source: WisDOT
Comparison of Italgrip Aggregate Size at 65 mph

Source: WisDOT
Nanosoft

• Innovative asphalt material developed by COLAS S.A.
• Exceptional acoustic performance

Source: Gautier and Ballie
Nanosoft Properties

- Maximum particle size = 4 mm
- Grading curve optimized during absorption studies = SMA/gap graded
- Optimum sound absorption for thicknesses = 25-40 mm
- Polymer modified bitumen
  - SBS content dependent on site characteristics
Application of Nanosoft

- Applied as a wearing course
- Efficient for <30 mph conditions, as well as higher speeds
- Paving process same as traditional asphalt pavement
# Mechanical/Physical Properties

<table>
<thead>
<tr>
<th>Tests</th>
<th>Nanosoft</th>
<th>BBTM 0/6*</th>
<th>BBM 0/10**</th>
</tr>
</thead>
<tbody>
<tr>
<td>P.C.G. (Void Content)</td>
<td>$25 \leq V \leq 30$</td>
<td>$20 \leq V \leq 25$</td>
<td>n/a</td>
</tr>
<tr>
<td>Duriez (immersion/compression ratio)***</td>
<td>$\geq 0.80$</td>
<td>$\geq 0.80$</td>
<td>$\geq 0.80$</td>
</tr>
<tr>
<td>Rutting test (mm)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10,000 cycles</td>
<td>$\leq 15$</td>
<td>$\leq 20$</td>
<td>n/a</td>
</tr>
<tr>
<td>30,000 cycles</td>
<td>$\leq 10$</td>
<td>n/a</td>
<td>$\leq 10$</td>
</tr>
</tbody>
</table>

* very thin surfacing with aggregate size down to 6 mm  
** thin surfacing  
*** unconfined compression test, where “good quality aggregate” >30 kN dry and >20 kN wet

Source: Gautier and Ballie
Field Demonstrations

• 2006: Departmental Road 974, near Dijon
• 300 m section alongside BBTM 0/10 pavement (thin layer asphalt pavement)

Source: Gautier and Ballie
# Testing on Dijon Section

<table>
<thead>
<tr>
<th>Longitudinal Friction Coefficient</th>
<th>Nanosoft</th>
<th>BBTM 0/10 Reference</th>
<th>French specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Adhera” trailer, PIARC 98 tyre</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Measures after 6 months</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>traffic T 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 km/h</td>
<td>0.68</td>
<td>0.65</td>
<td>0.36</td>
</tr>
<tr>
<td>60 km/h</td>
<td>0.62</td>
<td>0.50</td>
<td>0.25</td>
</tr>
<tr>
<td>90 km/h</td>
<td>0.57</td>
<td>0.39</td>
<td>0.14</td>
</tr>
<tr>
<td>Texture Mean Depth (mm)</td>
<td>0.6 to 0.8</td>
<td>0.95</td>
<td></td>
</tr>
<tr>
<td>(NF EN 13 036-1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Gautier and Ballie
Testing on Dijon Section

- SPB measurement
  - After 6 months T1 traffic
  - 90 km/h (56 mph)

<table>
<thead>
<tr>
<th>Nanosoft</th>
<th>BBTM 0/10 Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>69.4 dB(A)</td>
<td>78.6 dB(A)</td>
</tr>
</tbody>
</table>

Source: Gautier and Ballie
Field Demonstrations

• October 2006
  – “Madeleine Boulevard” in Lille
    • 6,000 m² laid
    • 3 cm thickness
  – Subjective noise reduction by neighbors and Lille Urban Community authorities

Source: Gautier and Ballie
## Dijon Testing

- **CPX testing**
  - After 2 months

<table>
<thead>
<tr>
<th>Speed</th>
<th>Nanosoft</th>
<th>BBTM 0/10 Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 mph</td>
<td>82 dB(A)</td>
<td>90 dB(A)</td>
</tr>
<tr>
<td>55 mph</td>
<td>91 dB(A)</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Source: Gautier and Ballie
Comparison to Nanosoft

- Comparison to Strasbourn LRPC SPB database

Source: Gautier and Ballie
Summary

- HFS are another viable solution
- High friction proven
- Low noise still to be confirmed, but so far it appears to be quiet!
- Cost, durability key factors too
- FHWA Study will look at these per U.S. conditions!
- Nanosoft and similar materials may also prove a better balance of low noise, good friction, durable, and cost effective
Thank you for your time!

Any Questions?