Quieter (?) Pavements in Washington State
Past, Present, and Future

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Conclusions

• Initially, OGFC pavements showed audible benefits compared to standard DGFC pavements in Washington State. However, these benefits generally disappeared in about 6 – 12 months.

• Currently, OGFC pavements are equivalent to, or louder than, standard DGFC pavements installed at the same time.

Rutted section of pavement installed in the 1990’s.
Outline

• Why is WSDOT looking at quieter pavements?
• What pavements are being evaluated?
• How is WSDOT evaluating performance?
• What was done in the past?
• How have the pavements performed so far?
• Conclusions to date
• What’s next?
Why is WSDOT testing quieter pavements?

- Potential for mitigation, impact avoidance, lower noise walls
- Public interest: citizens, legislator, media
- Noise walls are expensive and don’t always work
- Future capacity increases

Design visualization of noise wall in Seattle, WA, USA
What does WSDOT consider as “quieter pavements?”

- Pavements that create an audible, **3 dB(A)**, reduction in tire-pavement noise compared to a standard WSDOT pavement.

- “A low noise road surface is a road surface which, when interacting with a rolling tire, influences vehicle noise in such a way as to cause at least 3db(A) lower vehicle noise than that obtained on conventional and most common road surfaces.”

  - The Little Book of Quieter Pavements

*Signage indicating OGFC-AR test section on SR 520*
What pavements has WSDOT evaluated?

- Test sections compare pavements installed at the same time

- Open-graded friction course (OGFC) asphalt overlay
  - Rubber-modified binder (**OGFC-AR**)
  - Polymer-modified binder (**OGFC-SBS**)
  - Slightly different mixes and construction conditions
  - ~20% air voids

- Standard HMA overlay
  - Installed at the same time
  - “Control” variable

*Newly installed OGFC-AR on I-5 (2006)*
How does WSDOT evaluate quieter pavement?

Acoustic Performance

- **Monthly** OBSI measurements
- Surface and air temperatures
- Consistent with provisional AASHTO standard for OBSI
How does WSDOT evaluate quieter pavement?

Wear Performance/Durability

- Friction, smoothness, rut depth – 2x’s per/year

Pavement distress van

Friction testing
What happened in the past?

OGFC pavements in WA during the 1980s/1990s

Need for QP??

Performance??

OGFC pavements in WA during the 1980s/1990s
Spokane
Yakima
Seattle
PCC test locations
OGFC test locations
## Differences between Sections

<table>
<thead>
<tr>
<th></th>
<th>I-5</th>
<th>SR 520</th>
<th>I-405</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>Aug 2006 (59 months)</td>
<td>July 2007 (48 months)</td>
<td>August 2009 (11 months)</td>
</tr>
<tr>
<td><strong>Straight</strong></td>
<td>Straight flat</td>
<td>Hills, curves</td>
<td>Slight grade, curves</td>
</tr>
<tr>
<td><strong>Traffic</strong></td>
<td>160,000 AADT</td>
<td>95,000 AADT</td>
<td>160,000 AADT</td>
</tr>
<tr>
<td><strong>Trucks</strong></td>
<td>7%</td>
<td>3%</td>
<td>7%</td>
</tr>
<tr>
<td><strong>Base</strong></td>
<td>HMA</td>
<td>HMA</td>
<td>PCC</td>
</tr>
<tr>
<td><strong>Thickness</strong></td>
<td>1.83 cm</td>
<td>1.83 cm</td>
<td>2.44 cm</td>
</tr>
<tr>
<td><strong>Ambient</strong></td>
<td>Night, 70 °F</td>
<td>Day, 72 °F</td>
<td>Day, 75 °F</td>
</tr>
<tr>
<td><strong>Asphalt</strong></td>
<td>314 °F</td>
<td>282 °C</td>
<td>345 °C</td>
</tr>
<tr>
<td><strong>Anti-Strip</strong></td>
<td>liquid, 0.5%</td>
<td>liquid, 0.25%</td>
<td>, hydrated lime 0.5%</td>
</tr>
</tbody>
</table>
OGFC Test Section: I-5

OGFC-Test Section on I-5 near Lynnwood, WA
Initial & Current OBSI Levels
I-5 Lynnwood Test Section

- New HMA
- Rubberized Asphalt
- Polymer-Modified Asphalt

Sound Intensity (dBA)

Initial/ Sept 2006
- New HMA: 98.8
- Rubberized Asphalt: 95.0
- Polymer-Modified Asphalt: 96.0

Current/July 2010
- New HMA: 104.3
- Rubberized Asphalt: 104.4
- Polymer-Modified Asphalt: 103.6

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Tire/Pavement Noise: Sound Intensity Over Time
I-5 Lynnwood, WA, through March 2010

New HMA
Low - 98.8
High - 105.4
Max Variation - 6.6

OGFC-AR
Low - 95.0
High - 106.6
Max Variation - 11.6

OGFC-SBS
Low - 96.0
High - 105.7
Max Variation - 9.7
Relative Performance
I-5 Lynnwood through July 2010

- HMA - OGFC-AR
- HMA - OGFC-SBS

Months Since Construction

Relative Avg. Sound Intensity Level (dBA)
Frequency Comparison Over Time
I-5 OGFC Pavement Test Section

- new HMA (2010)
- OGFC-AR (2010)
- OGFC-SBS (2010)
- new HMA (2006)
- OGFC-SBS (2006)
OGFC Test Section: SR 520

OGFC-Test Section on SR 520 near Medina, WA
Initial and Current OBSI Levels
SR520 Medina Test Section

Sound Intensity (dBA)

Initial/ July 2007
- New HMA: 99.8
- Rubberized Asphalt: 96.1
- Polymer-Modified Asphalt: 97.8

Current/ July 2010
- New HMA: 102.8
- Rubberized Asphalt: 102.7
- Polymer-Modified Asphalt: 102.2
Tire/Pavement Noise: Sound Intensity
SR 520 Medina, WA, through April 2010

Average Sound Intensity Level (dB(A))

Months Since Construction

Pre-Paving HMA
HMA
OGFC-SBS
OGFC-AR

New HMA
Low – 99.8
High – 104.5
Max Variation – 4.7

OGFC-AR
Low – 96.1
High – 105.4
Max Variation – 9.3

OGFC-SBS
Low – 97.8
High – 104.2
Max Variation – 6.4

y = 0.1327x + 100.53
R² = 0.5531

y = 0.2221x + 98.254
R² = 0.7015

y = 0.3464x + 96.141
R² = 0.8116
OGFC Test Section: I-405
Tire/Pavement Noise: Sound Intensity
I-405 Bellevue, WA, through March 2010

Average Sound Intensity Level (dB(A)) vs. Months Since Construction

- **Pre-Paving Concrete**
  - \( y = 0.3568x + 100.15 \)
  - \( R^2 = 0.3709 \)

- **Avg. Diamond Grind w/Dowel**
  - \( y = 0.5725x + 100.64 \)
  - \( R^2 = 0.3348 \)

- **HMA**
  - \( y = 0.7219x + 96.61 \)
  - \( R^2 = 0.5496 \)

- **OGFC**
  - \( y = 0.6287x + 96.278 \)
  - \( R^2 = 0.7524 \)

- **OGFC-AR Average**

Legend:
- Pre-Paving Concrete
- Avg. Diamond Grind w/Dowel
- HMA
- OGFC-AR Average
- OGFC-SBS Average
Frequency Analysis: I-5 OGFC Test

Sound Intensity (dBA) vs Frequency (Hz)

- new HMA (2010)
- OGFC-AR (2010)
- OGFC-SBS (2010)
- new HMA (2006)
- OGFC-SBS (2006)
Pavement raveling on I-5 OGFC-AR test section two years after install.

Raveled pavement and visible rutting on SR 520 OGFC-AR test section
Challenges to QP in Washington

- High traffic volumes
- Winter conditions
  - Studded Tires
  - Snow Chains
  - Snow Plows
- Frequent Precipitation
- Cooler summer temps
  - Rarely exceed 70°F at night
  - Daytime temps >80°F hard to predict
- Freeze-Thaw Cycling
  - Temperate climate: temps hover above/below 0°C
Rut Depth Measurements
I-5 Lynnwood, Fall 2009 (39 months since construction)

Program for replacement around 10.5 mm.
Rut Depth Measurements
SR 520 Medina, Fall 2009 (28 months since construction)

Program for replacement around 10.5 mm.

Percent of total trucks, incl. bus

<table>
<thead>
<tr>
<th>Lane</th>
<th>Rut Depth (mm)</th>
<th>Percent of total trucks, incl. bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB Lane 1</td>
<td>84%</td>
<td>10%</td>
</tr>
<tr>
<td>WB Lane 2</td>
<td>10%</td>
<td>6%</td>
</tr>
<tr>
<td>WB HOV</td>
<td>6%</td>
<td>80%</td>
</tr>
<tr>
<td>EB Lane 2</td>
<td>80%</td>
<td>20%</td>
</tr>
<tr>
<td>EB Lane 3</td>
<td>20%</td>
<td>6%</td>
</tr>
</tbody>
</table>
Rut Depth Measurements
I-405 Bellevue, Fall 2009 (4 months after construction)

Max Rut Depth (mm)

<table>
<thead>
<tr>
<th>Lane</th>
<th>new HMA</th>
<th>OGFC-AR</th>
<th>OGFC-SBS</th>
<th>Percent of total trucks, incl. bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane 1</td>
<td>53%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lane 2</td>
<td></td>
<td>21%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lane 3</td>
<td>26%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HOV</td>
<td></td>
<td>???</td>
<td></td>
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</tr>
</tbody>
</table>

Program for replacement around 10.5 mm.
Largest Measured OBSI Difference between Lanes within OGFC Test Sections: I-5 and SR520 Test Sections

- I-5: OGFC-AR
- SR520: OGFC-AR
- I-5: OGFC-SBS
- SR520: OGFC-SBS

Months Since Construction

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Conclusions

• Initially: noise reductions from OGFC pavements compared to standard HMA. However, the reductions were lost within in about 6 months for most pavements.

• Primary cause for deterioration remains unclear.
  – Traffic appears to play a major role
  – Temperature and precipitation effects harder to quantify, but likely contributors

• WSDOT will continue monitoring pavements until end of useful life before making conclusions.
Other testing

• Two sections of NGCS
• One section of diamond ground pavement
Preliminary Results

Before and After Grinding: NGCS
Avondale Road between NE 144th Place and NE 151st Street at 40, 50, & 60 mph

Avg. Sound Intensity (dBA)

Pre-Grind @ 40 mph
Post-Grind @ 40 mph
Pre-grind @ 50 mph
Post-grind @ 50 mph
Pre-grind @ 60 mph
Post-grind @ 60 mph

<table>
<thead>
<tr>
<th>MPH</th>
<th>Pre-Grind</th>
<th>Post-Grind</th>
<th>Pre-grind</th>
<th>Post-grind</th>
<th>Pre-grind</th>
<th>Post-grind</th>
</tr>
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<tbody>
<tr>
<td>40</td>
<td>100.2</td>
<td>94.6</td>
<td>103.5</td>
<td>96.2</td>
<td>101.0</td>
<td>97.7</td>
</tr>
<tr>
<td>50</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
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</tbody>
</table>
Before and After Grinding
Diamond Grind on I-5, Seattle vic. between 60th Street North and NE 163rd Street
Average OBSI at 60 mph

- Lowest post grind value = 102.4 dBA
Questions?

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Excellence in Quieter Pavements Research

Washington Department of Transportation

For the asphalt-rubber friction course placed on I-5, I-405, in 2006 and 2007