Quieter Pavement Performance in Washington State

University of Washington and the Washington State Department of Transportation

Rocky Mountain Asphalt Conference
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Topics

- Noise basics
- What are quieter pavements?
- State experience
  - Arizona pavements in Phoenix
  - Washington State experience
    - Interstate 5
    - SR 520
- Bottom Line
Noise Basics
Sound Pressure Scales

<table>
<thead>
<tr>
<th>Source</th>
<th>dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold of hearing for normal young people</td>
<td>0</td>
</tr>
<tr>
<td>Rustling leaves</td>
<td>20</td>
</tr>
<tr>
<td>Quiet whisper at 3 ft.</td>
<td>30</td>
</tr>
<tr>
<td>Quiet street</td>
<td>50</td>
</tr>
<tr>
<td>Inside car</td>
<td>70</td>
</tr>
<tr>
<td>Diesel truck</td>
<td>100</td>
</tr>
<tr>
<td>Jet at 100 ft.</td>
<td>130</td>
</tr>
</tbody>
</table>
Noise Basics

- Sound level change of 1 dB can barely be detected by humans.
- Change of 2 to 3 dB, barely noticeable.
- Change of 5 dB, readily noticeable.
- Change of 10 dB perceived as a doubling in loudness.
- Change of 20 dB represents a dramatic change.
- Change of 40 dB represents the difference between a faintly audible sound and a very loud sound.

## Noise Basics

The minimum change in sound level that a human ear can detect is about 3 dB.

The average person perceives a change in sound level of about 10 dB as a doubling or halving of the sound’s loudness.

The table to the left shows a relationship between dBA and “noise loudness” levels.

- 70 to 80 dB: 2x as loud
- 70 to 90 dB: 4x as loud
- 70 to 100 dB: 8x as loud etc.


### Noise Basics Table

<table>
<thead>
<tr>
<th>Noise Source (at Given Distance)</th>
<th>Noise Environment</th>
<th>A-Weighted Sound Level</th>
<th>Human Judgment of Noise Loudness (Relative to Reference Loudness of 70 Decibels)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Military Jet Takeoff with Afterburner (50 ft)</td>
<td>Carrier Flight Deck</td>
<td>140 Decibels</td>
<td>128 times as loud</td>
</tr>
<tr>
<td>Civil Defense Siren (100 ft)</td>
<td></td>
<td>130</td>
<td>64 times as loud</td>
</tr>
<tr>
<td>Commercial Jet Take-off (200 ft)</td>
<td></td>
<td>120</td>
<td>32 times as loud</td>
</tr>
<tr>
<td>Pile Driver (50 ft)</td>
<td>Rock Music Concert</td>
<td>110</td>
<td>16 times as loud</td>
</tr>
<tr>
<td>Ambulance Siren (100 ft)</td>
<td>Inside Subway Station (New York)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newspaper Press (5 ft)</td>
<td></td>
<td>100</td>
<td>8 times as loud</td>
</tr>
<tr>
<td>Gas Lawn Mower (3 ft)</td>
<td></td>
<td></td>
<td>Very Loud</td>
</tr>
<tr>
<td>Food Blender (3 ft)</td>
<td>Boiler Room</td>
<td>90</td>
<td>4 times as loud</td>
</tr>
<tr>
<td>Propeller Plane Flyover (1,000 ft)</td>
<td>Printing Press Plant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diesel Truck (150 ft)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garbage Disposal (3 ft)</td>
<td>Higher Limit of Urban Ambient Sound</td>
<td>80</td>
<td>2 times as loud</td>
</tr>
<tr>
<td>Passenger Car, 65 mph (25 ft)</td>
<td></td>
<td>70</td>
<td>Reference Loudness</td>
</tr>
<tr>
<td>Living Room Stereo (15 ft)</td>
<td></td>
<td></td>
<td>Moderately Loud</td>
</tr>
<tr>
<td>Vacuum Cleaner (10 ft)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal Conversation (5 ft)</td>
<td>Data Processing Center</td>
<td>60</td>
<td>1/2 as loud</td>
</tr>
<tr>
<td>Air Conditioning Unit (100 ft)</td>
<td>Department Store</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Traffic (100 ft)</td>
<td>Large Business Office</td>
<td>50</td>
<td>1/4 as loud</td>
</tr>
<tr>
<td>Quiet Urban Daytime</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bird Calls (distant)</td>
<td>Quiet Urban Nighttime</td>
<td>40</td>
<td>1/8 as loud</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Quiet</td>
</tr>
<tr>
<td>Soft Whisper (5 ft)</td>
<td>Library and Bedroom at Night</td>
<td>30</td>
<td>1/16 as loud</td>
</tr>
<tr>
<td>Quiet Rural Nighttime</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadcast and Recording Studio</td>
<td>20</td>
<td>1/32 as loud</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Just Audible</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td>1/64 as loud</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>1/128 as loud</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Threshold of Hearing</td>
</tr>
</tbody>
</table>

Source: Compiled by Kimley-Horn and Associates, Inc.
What are quieter pavements?
What are Quieter HMA Pavements

- Quieter pavements initially reduce the noise created as a tire rolls along the pavement surface
- Noise reduction results from surface texture
  - Finer gradation → quieter the pavement
    - Aggregate size < 3/8 inch
    - Need 15-20 percent air voids
    - Europeans find a two layer concept with ¾ inches of fine graded OGFC over 1-½ inches of coarse graded OGFC provides best noise reduction
Asphalt Pavement - Surface Texture

Open-graded friction course

Dense-graded Hot Mix Asphalt
Performance of WSDOT Class D Mixes is strongly affected by studded tire wear.
Asphalt Binder Types

- **Asphalt rubber**
  - Incorporates recycled tires (tread only)
  - Improves durability (aging) properties of the asphalt binder
  - Contributes ~1 dB(A) noise reduction

- **Polymer modified**
  - Rubber (not recycled tire) product
    - Styrene-butadiene-styrene (SBS)
  - Improves durability (aging) properties of the asphalt binder
  - Contribution to noise reduction, if any, is unknown
What are Typical Sound Levels?

On-Board Sound Intensity (dBA)

Dense-graded Asphalt

Open-graded Asphalt

OBSI Device
State Experiences
Experience of other states

- Southern states (AZ, CA, FL, GA, NC, SC and TX) indicate average life of 10 to 12 years
  - Placement temperature
    - AZDOT requires 85°F surface temperature
    - CALTRANS allows 60°F air temperature
    - Contractor (Granite Construction) prefers 70°F air temperature
    - Challenge was placement during night time construction in western WA (contract allowed 55°F air temperature)
Arizona
Arizona Performance

I-17
118,000 ADT
8 to 9 years old

Photo courtesy of Joe Mahoney
Arizona Performance
Asphalt Rubber Friction Course (ARFC)

- Arizona first used asphalt rubber products in 1964 (City of Phoenix). Early ADOT use was for a chip seal in 1968,
- Placed first non-experimental section of ARFC in 1985 on I-17.
- Current ARFC consists of:
  - 3/8” minus open graded aggregate
  - Asphalt rubber binder with a content ranging between 9.0 to 9.6% by weight of total mix.
  - Used to overlay PCC since 1988.
I-17 ARFC 1” surfacing, MP 199, age ~ 4 years

(original PCC slabs constructed in 1960 9” thick and overlayed in 1990 with ARFC—at that time slabs were faulting and needed joint patching—this is the second ARFC overlay at this location)

Northbound view—ARFC in good condition.
US 60 Eastbound, ARFC 1” surfacing, approximately MP 175-178, age ~ 5 to 6 years
US 60 Eastbound, ARFC 1” surfacing, approximately MP 175-178, age ~ 5 to 6 years

PCC approximately 11 to 13 inches thick. Note ARFC and transverse tined PCC.
Noise Level for Asphalt Pavements (Arizona DOT)
Washington State
Washington State Experience

- Studded tires
  - No to minimal use in southern states
  - Is a major issue in Washington State
  - Prior Class D experience (earlier open graded)
Test Project Details and Results (Lynnwood, WA)

- South bound only
- OGFC-AR
- OGFC-SBS
- ½” Dense-graded HMA
Interstate 5
Open graded—rubber asphalt binder

Wear or Rut Depth (mm)

Smoothness (IRI)

Sound Intensity (dBA)

Sept 2006

Jan 2009
Interstate 5
Open graded—SBS binder

Wear or Rut Depth (mm)

Smoothness (IRI)

Sound Intensity Level (dBA)

Sept 2006

Jan 2009
Test Project Details and Results (SR-520 near Bellevue)

- Both directions
- OGFC-AR
- OGFC-SBS
- ½” dense-graded HMA
Late breaking news…

- The open graded sections on I-5 and SR 520 were damaged by tire chains and studs during the heavy snows of December 2008.
SR 520 open graded mix damage

HMA section—Jan 2009

OGFC-AR—Jan 2009
Sound Levels January 20, 2009
(Lane 1 or the outside lane)

<table>
<thead>
<tr>
<th>Pavement Type</th>
<th>I-5 (2.5 years old)</th>
<th>SR 520 (1.5 years old)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>dBA</td>
<td>Wear (mm)</td>
</tr>
<tr>
<td>OGFC-AR</td>
<td>104.9</td>
<td>8</td>
</tr>
<tr>
<td>OGFC-SBS</td>
<td>103.1</td>
<td>5</td>
</tr>
<tr>
<td>0.5” dense-graded HMA</td>
<td>105.0</td>
<td>4</td>
</tr>
<tr>
<td>Aged adjacent HMA</td>
<td>106.0</td>
<td>--</td>
</tr>
</tbody>
</table>
Open graded surfacings have converged on dense graded HMA with respect to measured sound levels. Snow during December 2008 accelerated the convergence.

Improved binders have not solved the studded/chained tire problem.

Reduced noise levels were destroyed by buses with tire chains.

**Personal conclusion:** The current family of open graded surfacings do not work in a studded/chained tire environment.
Questions?