The Effect of Porous Pavement on Wayside Traffic Noise Levels:
Highway US 101 Rehabilitation

By
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Project Description

- Marin-Sonoma Gap Closure Project
  - Creates continuous HOV lanes north of Golden Gate Bridge to Santa Rosa, California
  - HOV lanes already existing in some portions – not Type 1 projects
Residents clamor for a noise wall

But do not qualify
Project Description

• Marin-Sonoma Gap Closure Project
  ➢ Creates continuous HOV lanes north of Golden Gate Bridge to Santa Rosa, California
  ➢ HOV lanes already existing in some portions – not Type 1 projects

• Study area receives only pavement rehabilitation, no configuration change

• Noise project goals
  ➢ Estimate expected reduction due to pavement
  ➢ Document reduction after rehabilitation
A/B Noise Comparison

• Site A
  – To receive new OGAC pavement
  – No configuration changes
  – In vicinity of complaints

• Site B
  – New pavement in 2010
  – Previous documented improvement nearby of about 7 dB
Wayside Noise Measurements

- CTIM-like
- 60 ft from near lane center

- Microphone heights of 5 and 10 ft
- Back-to-back same day measurements
- Temperatures 67 to 71°F
- No traffic corrections
Tire/Pavement Source Levels at A&B

- OBSI (AASHTO TP 10-76)
- Measurements directly after CTIM data completed
Site A & B Comparison & Previous Gap Closure Project Results

<table>
<thead>
<tr>
<th>Location</th>
<th>Old Pavement</th>
<th>New OGAC Pavement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site A &amp; B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wayside 5 ft</td>
<td>79.9</td>
<td>72.1</td>
</tr>
<tr>
<td>Wayside 10 ft</td>
<td>82.1</td>
<td>73.7</td>
</tr>
<tr>
<td>OBSI</td>
<td>107.0</td>
<td>99.2</td>
</tr>
<tr>
<td>Gap Closure Project</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wayside Above Wall</td>
<td>84.6</td>
<td>77.7</td>
</tr>
<tr>
<td>OBSI</td>
<td>106.0</td>
<td>99.1</td>
</tr>
</tbody>
</table>

Difference:
- 7.8 dB
- 8.4 dB
- 6.9 dB
Pre & Post Rehabilitation CTIM

- **Pre** – June 10, 2011, 67 to 70°F, mostly calm w/wind gusts to 5 mph
- **Post** – August 10, 2012, 74 to 78°F, clam to 3 mph

- Traffic counts & vehicle speed measured
- From TNM, +0.4 dB added to Pre levels
- Mid-morning
CTIM Results in 5 Minute Intervals

- Pre at 5ft
- Post at 5ft
- Pre at 10ft
- Post at 10ft

11.2 dB Reduction at 10 ft High Mic
10.5 dB Reduction at 5 ft High Mic
Overall Pre & Post OBSI Levels

<table>
<thead>
<tr>
<th>Lane</th>
<th>Pre Rehab</th>
<th>Post Rehab</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lane 4</td>
<td>106.9</td>
<td>106.7</td>
<td>0.2 dB</td>
</tr>
<tr>
<td>Lane 3</td>
<td>107.5</td>
<td>106.6</td>
<td>0.9 dB</td>
</tr>
<tr>
<td>Lane 2</td>
<td>107.0</td>
<td>107.1</td>
<td>0.1 dB</td>
</tr>
<tr>
<td>Average</td>
<td>107.1</td>
<td>107.1</td>
<td>0.0 dB</td>
</tr>
</tbody>
</table>

Southbound Lanes: 7.1 dB

Northbound Lanes: 6.4 dB
Pre & Post Long-Term Measurements
Long-Term Noise Measurements

- 4+ days of 24-hour noise monitoring Pre & Post
- Week days and weekends

- Overall A-weighted levels in 10-minute intervals
- Combined into 1-hour time blocks ($L_{eq}$ & $L_n$’s)
- 173 ft from center of near lane
Pre & Post Long-Term Hourly Noise Levels

Pre

Post

9.1  8.8  7.2  7.3
Comparison of Noise Reductions

<table>
<thead>
<tr>
<th>Sound Level, dBA</th>
<th>Pre Rehab</th>
<th>Post Rehab</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTIM 5 ft</td>
<td>80.3</td>
<td>69.8</td>
</tr>
<tr>
<td>CTIM 10 ft</td>
<td>82.6</td>
<td>71.4</td>
</tr>
<tr>
<td>Long Term Weekend</td>
<td>72.5</td>
<td>63.5</td>
</tr>
<tr>
<td>Long Term Weekday</td>
<td>72.1</td>
<td>64.8</td>
</tr>
<tr>
<td>OBSI</td>
<td>107.1</td>
<td>7.1</td>
</tr>
</tbody>
</table>
Wayside CTIM & OBSI Comparison

Sound Level, dBA

1/3 Octave Band Center Frequency, Hz

OBSI Levels

New OGAC Aug 2012
Old DGAC Jun 2011

Wayside Noise Levels (10 ft)

Wayside Noise Levels (5 ft)
Noise Reductions for CTIM & OBSI

~6 to 7 dB
New Site A & Site B Comparison

- New OGAC at Site A
- 2010 OGAC at Site B

OBSI Levels

Wayside Noise

Sound Level, dBA

1/3 Octave Band Center Frequency, Hz
Porous vs. Non-Porous Pavement

NCAT Test Pavements

- Average of Non-Porous Pavements
- Average of Porous Pavements

Sound Intensity Level, dBA

1/3 Octave Band Center Frequency, Hz

- 5 to 6% Air Voids
- 16 to 22% Air Voids
Sound Propagation Tests

- Measure average sound intensity over the face of the loudspeaker.
- Measure sound pressure at 25 & 50 ft.
- Subtract sound pressure level from average sound intensity level to calculate difference.
Added Attenuation for Propagation over Porous Pavement Relative to Non-Porous
25 ft Pass-Bys vs. OBSI for Porous & Non-Porous Pavements
Variation in OBSI Level along US 101

OBSI Sound Intensity Level, dBA

1/3 Octave Band Center Frequency, Hz

Pre-Rehab Levels

Post-Rehab Levels
Identification of Porous Pavements

1/3 Octave Band OBSI Level, dBA

- 800 Hz
- 1600 Hz

Overall OBSI Level, dBA

- Non-Porous
- Porous
Conclusions

• 10 to 11 dB noise reduction in wayside level with new OGAC

• Porosity produced an additional 3½ to 4 dB reduction over tire/pavement source levels

• Potential to relate 1600 Hz $\frac{1}{3}$ octave band to occurrence of porosity
Recommendations

- Compare CTIM & OBSI at more sites with & without porous pavements
- Develop means of rapidly & accurately identifying & quantifying porous pavements
- Incorporate absorptive effects into prediction methods/models
- Develop controls to reduce variability
Thank You