The Influence of Quieter Pavement & Absorptive Barriers on US 101 in Marin County

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TAM US 101 Widening Project in Marin County (2007)

• Addition of HOV lane in each direction, all lanes re-paved with new OGAC
• Added multi-use path
• Re-located barrier in southbound direction
• Added absorption to barriers on both sides
Noise Measurements

- Long term overall sound pressure levels above sound wall along northbound lanes
- Short term $\frac{1}{3}$ octave band sound pressure levels above and 50 ft behind the wall
- On-board sound intensity (OBSI) tire/pavement noise source levels
- Purpose was to document overall change in noise level
Measurements above the Sound Wall

- Long & short term microphone locations
- View from top of wall (July 2009)
Measurements
50 ft behind Sound Wall
On-Board Sound Intensity

• Quantify tire/pavement noise source levels
• AASHTO TP 76 except use of Goodyear Aquatred 3 test tire
Overall OBSI Levels Pre & Post Project

Overall Sound Intensity Level, dBA

- **Northbound**
- **Southbound**

Lane 5: Pre-Project
Lane 4: Post-Project
Lane 3: Pre-Project
Lane 2: Post-Project
Lane 1: Pre-Project
Outside Lane: Post-Project
Pre & Post Long Term Measurements: Above Northbound Wall

Average Difference = 6.9 dB
Pre & Post OBSI and Short-Term Wayside Noise Levels

Overall Sound Level, dBA

<table>
<thead>
<tr>
<th>Location</th>
<th>Pre-Project 12/1/2007</th>
<th>Post-Project 8/7/2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above Wall</td>
<td>84.6</td>
<td>77.7</td>
</tr>
<tr>
<td>Behind Wall</td>
<td>66.6</td>
<td>59.5</td>
</tr>
<tr>
<td>Average Pavement OBSI Level</td>
<td>105.6</td>
<td>99.4</td>
</tr>
<tr>
<td>Northbound OBSI Level</td>
<td>106.0</td>
<td>99.1</td>
</tr>
</tbody>
</table>

6.9 dB 6.2 dB 6.9 dB
Comparison of Wayside & OBSI Spectra

Sound Level, dBA

Tire Noise Sound Intensity

Pre-Project Dec 07

Post-Project Aug 10

1/3 Octave Band Center Frequency, Hz
Effect of Added Barrier Absorption

- Concern by residents of reflected noise from opposite side barrier
- Led to added sound absorptive facing
- How necessary was it?
Interim Measurement Conditions

- Mixed pavement (old & new)
- 4 lanes southbound
- 5 lanes northbound
- Southbound wall reconstructed
- **Condition 1** – July 2009, northbound wall not absorptive
- **Condition 2** – September 2009, northbound absorptive
Mid & Post Project OBSI Levels

Overall Sound Intensity Level, dBA

Northbound
Lane 5 | Lane 4 | Lane 3 | Lane 2 | Lane 1

Southbound
Lane 4 | Lane 3 | Lane 2 | Lane 1

Jul/Sep 2009
Aug 2010
Interim Long Term Measurements:
Above Northbound Wall

Average Difference w/ & w/o Absorptive Treatment – 0.0 dB
Long Term Measurements: Above Northbound Wall

Noise Level (dBA)

Hour Beginning

Monday  Tuesday  Wednesday  Thursday

Pre-Project Dec 07  Mid-Project Jul 09  Mid-Project Sep 09  Post-Project Aug 10
Comparison of Wayside & OBSI Spectra

Tire Noise Sound Intensity

Sound Level, dBA

1/3 Octave Band Center Frequency, Hz

Top of Barrier

50ft behind Barrier

Dec-07
Jul-09
Aug-10
Assessing the Effect of Added Absorption

- Wayside measurements were inconclusive
  - Geometry changes
  - Varying pavement during project phases

- Analysis approach
  - TNM not directly suitable
  - Applied SoundPLAN 7.0 &1978 FHWA algorithm
  - Confirmed with image sources and standard barrier calculations
Typical Cases of Concern

- Clear view to opposite sound wall
- Partially shielded view opposite sound wall
- Partial view to road & opposite sound wall
- Fully shielded view to opposite sound wall

- Modeled without a opposite barrier & with a totally reflective barrier
- Calculated differences with & without opposite barrier using US 101 road geometry
Study Area along Northbound Lanes
Increase Due to Reflection

Results utilize the 1978 FHWA algorithm in SoundPLAN 7.
Traditional Barrier Analysis

- Replace wall reflections with image sources
- Calculate sum of diffracted, direct, & direct/reflected (images)
Spreadsheet Example Results

- 650 ft from 14 ft barrier & 146 wide freeway
- Receptor height variable
- Cases:
  - Image sources become direct
  - All actual & image sources are diffracted
  - No line of sight to opposite wall
- Increases of 5 dB may be possible
- Given distance & close barrier, levels will be low
Attenuation of Absolute Levels

Reference Location - no influence of reflected sound

- Shows combined effect of distance from highway & reflections from far wall
- Reference point is attenuated by 14 dB due to near barrier
- New quieter pavement reduces all points further by about 6 to 7 dB
Observations & Conclusions

• Quieter pavement greatest contributor to lower wayside noise levels
  ➢ Direct line-of-sight
  ➢ Behind sound walls

• Effect of added absorption could not be directly measured (in this case)

• Effect of added absorption modeled to provide additional reductions of 3 to 5 dB for
  ➢ Distant receptors (greater than 500 ft)
  ➢ Elevated receptors

• Less effect closer in (1 to 2½ dB)