Toll Plaza Rumble Strip Noise

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Project Location

I-80 Toll Plaza at I-480/I-80 Interchange, Lorain County, Ohio
Rumble Strips for Safety at the Toll Plaza
Problem Statement Questions

- Can rumble strip noise be mitigated with a noise wall of any type or size?
- Can anything can be constructed to mitigate rumble strip noise (i.e., specialized noise wall design features, such as a T-top, etc.)?
- Is a noise wall feasible and reasonable from a traffic noise standpoint?
- What is the most acoustically effective noise wall that can be constructed regardless of cost reasonableness, although probable construction costs should be included?
Challenges

- Residents were annoyed, yet preliminary ODOT measurements showed minor increase in $L_{eq}(h)$
- While TNM was used on this project originally, the problem statement asks questions that cannot be answered solely in TNM
- Modeling was to be done in CadnaA, but some additional data was needed
- Needed to consider existing 16-ft high safety wall
Safety Barrier
Vehicle Pass-by Measurement Plan
Vehicle Pass-by Measurement Sites
# Vehicle Pass-by Results

<table>
<thead>
<tr>
<th>Site</th>
<th>Rumble Strips</th>
<th>Vehicle Type</th>
<th>$L_{max}$, dBA</th>
<th>Difference, dB</th>
<th># Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB Ramp</td>
<td>No</td>
<td>Auto</td>
<td>78.5</td>
<td></td>
<td>27</td>
</tr>
<tr>
<td>WB Ramp</td>
<td>Yes, RS 1</td>
<td>Auto</td>
<td>87.5</td>
<td>9.0</td>
<td>106</td>
</tr>
<tr>
<td>WB Ramp</td>
<td>No</td>
<td>HT</td>
<td>83.8</td>
<td></td>
<td>51</td>
</tr>
<tr>
<td>WB Ramp</td>
<td>Yes</td>
<td>HT</td>
<td>91.0</td>
<td>7.2</td>
<td>53</td>
</tr>
<tr>
<td>EB Ramp</td>
<td>No</td>
<td>Auto</td>
<td>78.4</td>
<td></td>
<td>15</td>
</tr>
<tr>
<td>EB Ramp</td>
<td>Yes, RS 1</td>
<td>Auto</td>
<td>90.8</td>
<td>12.3</td>
<td>127</td>
</tr>
<tr>
<td>EB Ramp</td>
<td>No</td>
<td>HT</td>
<td>84.8</td>
<td></td>
<td>34</td>
</tr>
<tr>
<td>EB Ramp</td>
<td>Yes, RS 1</td>
<td>HT</td>
<td>92.3</td>
<td>7.4</td>
<td>39</td>
</tr>
</tbody>
</table>
WB Automobile Pass-by Spectra

Sound Pressure Level (dB)

Frequency (Hz)

Non Rumble Strip WB Ramp
Rumble Strip WB Ramp
WB Heavy Truck Pass-by Spectra

- **Frequency (Hz)**: 25.0, 31.5, 40.0, 50.0, 63.0, 80.0, 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000, 1250, 1600, 2000, 2500, 3150, 4000, 5000, 6300, 8000, 10000
- **Sound Pressure Level (dB)**: 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95

- **Graph Legend**:
  - **Non Rumble Strip WB Ramp**
  - **Rumble Strip WB Ramp**
EB Automobile Pass-by Spectra

![Graph showing sound pressure level (dB) versus frequency (Hz) for Non Rumble Strip EB Ramp and Rumble Strip EB Ramp.](image)
EB Heavy Truck Pass-by Spectra

Frequency (Hz)

Sound Pressure Level (dB)

Non Rumble Strip EB Ramp

Rumble Strip EB Ramp

Bowlby & Associates, Inc.
Community Measurements

[Map of a community with various measurements marked on it.]

Bowlby & Associates, Inc.
Noise Measurement Summary –

- Reference sound level measurements at 25 feet from center of travel lane: levels increased by 9 and 7 dB, respectively, for autos and HTs for WB approach ramp rumble strips, and 12 and 7 dB, respectively, for autos and HTs for EB approach ramp rumble strips.

- WB ramp rumble strip sound pressure level peaks were in 200, 800 and 1,000 Hz bands for autos and, for HTs, in 1,000, 200 and 80 Hz bands, in that order.

- EB ramp rumble strip peaks are in 1,000, 200 and 80 Hz bands, in that order, for autos, and 200 Hz and 500-630 Hz for HTs.

- The community noise level measurements showed 15-20 minute $L_{eq}$ values to be in 48-62 dBA range. Rumble strip noise was clearly audible, but did not raise A-weighted levels appreciably.
Traditional TNM Modeling

- 71 single-family residences modeled
- Each rumble strip modeled as a short roadway segment in TNM with and without Adjustment Factors
- Three abatement options considered:
  - 16 ft tall wall
  - 24 ft tall wall
  - Refined height wall
TNM Modeling Results

- In model validation, 13 of the 16 noise measurement points were within +/- 3 dB
- Using adjustment factors for the rumble strips only increased the modeled $L_{eq}(h)$ by an average of $0.5 \, \text{dB}$ – dominance of rest of highway
- Six of the 71 modeled locations had noise levels that approached or exceeded the NAC
- None of the analyzed barrier options met ODOT’s traffic noise policy criteria
CadnaA Modeling

- Rumble strips were the only sources included
- Spectral data from pass-by measurements used to create the source spectra
- Modeled as both “no rumble strip” and “with rumble strip”
- Maximum sound levels from the rumble strips predicted at the receivers
## Cases Modeled

<table>
<thead>
<tr>
<th>EB</th>
<th>RS 1</th>
<th>Auto &quot;no rumble strip&quot;</th>
<th>Auto &quot;with rumble strip&quot;</th>
<th>HT &quot;no rumble strip&quot;</th>
<th>HT &quot;with rumble strip&quot;</th>
</tr>
</thead>
<tbody>
<tr>
<td>WB</td>
<td>RS 1</td>
<td>Auto &quot;no rumble strip&quot;</td>
<td>Auto &quot;with rumble strip&quot;</td>
<td>HT &quot;no rumble strip&quot;</td>
<td>HT &quot;with rumble strip&quot;</td>
</tr>
</tbody>
</table>
WB Auto: with rumble strip

WB Auto: no rumble strip
WB HT: with rumble strip

WB HT: no rumble strip
EB Auto: with rumble strip

EB Auto: no rumble strip
EB HT no rumble strip

EB HT with rumble strip
Abatement Design in CadnaA

- Abatement design goal: reduce rumble strip noise down to “no rumble strip” level
- No barrier and with barrier sound levels calculated on an $L_{\text{max}}$ basis
- No attempt to determine effect on overall $L_{\text{eq}}(h)$
- Both standard and T-Top walls were considered
Example T-Top Walls from Berea, OH on the Ohio Turnpike
Noise Barrier Design Options

- Reflective barrier unit cost of $25 per sq ft, provide by ODOT
- Extra cost for sound-absorption on the roadway side of $4 per sq ft, based on discussions with the manufacturers
- Extra cost for a sound-reflecting T-top of $30 per linear ft, based on discussions with the City engineer and design consultant
- A cantilever barrier was modeled in CadnaA to represent a T-Top barrier
Recommended Barriers

LOR-480/TURNPIKE NOISE STUDY
EXHIBIT
Recommended Barriers
### Summary of Barrier Design Recommendations

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
<th>Height (feet)</th>
<th>Length (feet)</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northside Westbound Approach</td>
<td>T-top</td>
<td>12-14</td>
<td>430</td>
<td>$175,300</td>
</tr>
<tr>
<td>Northside Eastbound Approach</td>
<td>T-top</td>
<td>10</td>
<td>600</td>
<td>$192,000</td>
</tr>
<tr>
<td>Southside Westbound Approach</td>
<td>Vertical top</td>
<td>10</td>
<td>340</td>
<td>$98,600</td>
</tr>
<tr>
<td>Southside Eastbound Approach</td>
<td>Vertical top</td>
<td>14</td>
<td>340</td>
<td>$138,040</td>
</tr>
</tbody>
</table>

- The T-Top offers similar or slightly improved performance on the Northside at a lower cost.
Answers to Problem Statement

- Can rumble strip noise be mitigated with a noise wall of any type or size? **It can be.**
- Can *anything* can be constructed to mitigate rumble strip noise (i.e., specialized noise wall design features, such as a T-top, etc.)? **Yes.**
- Is a noise wall feasible and reasonable from a traffic noise standpoint? **No.**
- Determine what is the most acoustically effective noise wall that can be constructed in this area regardless of cost reasonableness, although probable construction costs should be included **Done.**
Questions?

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