Precast concrete sound walls, whether reflective or absorptive, are the best choice for noise abatement.

By Evan Gurley

In 1972, the United States passed the Noise Control Act authorizing the Environmental Protection Agency (EPA) to regulate major sources of noise to protect public health and the environment. In addition, the EPA issues noise emission standards for motor vehicles used in interstate commerce. The Federal Motor Carrier Safety Administration enforces these standards.

EPA Maximum Noise Emission Levels: Newly Manufactured Trucks*

<table>
<thead>
<tr>
<th>Effective date</th>
<th>Maximum noise level 50 ft (15 m) from centerline of travel**</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 1988</td>
<td>80 dB(A)***</td>
</tr>
</tbody>
</table>

*Trucks with Gross Vehicle Weight Rating (GVWR) over 10,000 lb (4,540 kg)
** Society of Automotive Engineers Inc. (SAE) test procedure for acceleration under 35 mph (56 km/h).
***dB: noise intensity is measured in decibel units (dB); “dB” is the most common type of scale for measuring sound.

High Traffic Creates Unwanted Noise

Numerous studies indicate that the most pervasive sources of noise today are those associated with transportation. Major sources of unwanted and destructive noise emissions originate from:

1. Transportation equipment and facilities;
2. Electrical machinery;
3. Construction equipment; and

Sound-sensitive receivers (typically places with people and/or animals who may be adversely impacted by loud noise) include residential homes or apartments, hospitals, schools, office buildings and nature areas.

When transmitted noise adversely affects the receivers, precast concrete sound barriers may be an ideal solution for noise abatement.
Sound walls are the most effective method of mitigating noise from major sources other than sound cessation or volume control at the source. In North America, concrete sound walls account for nearly half of all noise-abatement walls – and with good reason.

Besides being considered one of the strongest, most durable and versatile materials used in construction, precast concrete sound walls also:

1. Provide the highest noise transmission-loss value compared with other common sound wall materials (concrete's greater mass reduces sound penetrating through a wall by more than 80% compared with wood or steel frame construction)
2. Require a considerably smaller footprint compared with earth berms or other noise-reduction methods
3. Can be designed to blend with urban architecture and natural topography (see "Plants and Precast are a Natural Solution" in Summer 2010 Precast Solutions)
4. Can provide absorptive or reflective qualities on both sides of the wall panel system
5. Provide a lower life-cycle cost and high durability compared with other materials

**Sound Wall Geometry Determines Noise Reduction**

Noise intensity is measured in decibel units (dB), and the scale in which decibel units are measured is logarithmic. To the human ear, this means that each increase of 10 dB will essentially result in a doubling of the noise intensity. For example, 50 dB is 10 times more intense than 40 dB, and 60 dB is 100 times more intense than 40 dB and sounds four times as loud to the human ear.

<table>
<thead>
<tr>
<th>Typical Sound Levels (in decibels, dB)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Threshold of audibility</td>
<td>0</td>
</tr>
<tr>
<td>Rustle of leaves in gentle breeze</td>
<td>10</td>
</tr>
<tr>
<td>Average whisper 4 ft. (1.2 m) away</td>
<td>20</td>
</tr>
<tr>
<td>Restaurant</td>
<td>50</td>
</tr>
<tr>
<td>Busy street</td>
<td>60</td>
</tr>
<tr>
<td>Automobile horn 23 ft. (7 m) away</td>
<td>100</td>
</tr>
<tr>
<td>High-speed express train</td>
<td>105</td>
</tr>
<tr>
<td>Threshold of painful sounds, limit of ear's endurance</td>
<td>130</td>
</tr>
<tr>
<td>Jet engine</td>
<td>160</td>
</tr>
</tbody>
</table>

Precast concrete sound walls are designed to drastically reduce noise emissions generated by major sources from affecting sound-sensitive receivers in one of two ways: absorbing the sound energy or reflecting the sound energy back across the source (away from the receiver) and into the atmosphere.

1. FHWA

In order for a sound wall to be an effective barrier to noise sources, the wall must have:

- Minimum density of 37 lb/yd³ (20 kg/m³)
- Sufficient height to block the line-of-site of the noise source
- At least eight times the length of the distance from the receiver to the barrier (to effectively reduce noise coming around the ends of the wall).

Breaking the line-of-site from the noise source to the receiver can account for a 5 dB noise-level reduction. After this reduction, sound barriers can achieve approximately 1.5 dB of noise reduction for each additional 3 ft. (1 m) of barrier height. Because sound levels are measured logarithmically, a reduction of 9 dB is equivalent to eliminating about 80% of unwanted sound. A properly designed sound wall can effectively eliminate the majority of unwanted noise emitted from the noise source.
How sound walls work

Both types of sound walls (absorptive and reflective) help to force sound waves take a longer path (over and around the barriers) thereby reducing the amount of sound reaching the receiver; this is called diffraction. Diffraction occurs when sound waves pass an edge, such as wall edges and at the apex of the wall. Sound walls are more efficient at eliminating higher frequencies (shorter wavelengths) from reaching the receiver, since higher frequencies are diffracted at a smaller degree (angle) as compared with diffraction of lower frequencies (longer wavelengths).
Absorptive Walls
Act as Sound Sponges

Absorptive sound walls allow for sound waves generated by the source to enter the wall structure. As the sound waves travel through the acoustical material or textured surface, they are forced to follow a longer path to the end source (forcing directional changes in the sound waves). Every directional change in the sound waves will decrease the waves’ energy. After passing through a sound-absorbing wall, very low amounts of sound energy remain to re-enter the environment; in this way, less noise reaches the receiver’s ears.

In general, a rule of thumb for sound barriers is that noise reduction falls into one of the following categories:

<table>
<thead>
<tr>
<th>Noise reduction due to barrier</th>
<th>Design feasibility</th>
<th>Reduction in sound energy</th>
<th>Relative reduction in loudness</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 dB(A)</td>
<td>Simple</td>
<td>68%</td>
<td>Readily perceptible</td>
</tr>
<tr>
<td>10 dB(A)</td>
<td>Attainable</td>
<td>90%</td>
<td>Half as loud</td>
</tr>
<tr>
<td>15 dB(A)</td>
<td>Very difficult</td>
<td>97%</td>
<td>One-third as loud</td>
</tr>
<tr>
<td>20 dB(A)</td>
<td>Nearly impossible</td>
<td>99%</td>
<td>One-fourth as loud</td>
</tr>
</tbody>
</table>

Source: FHWA

Materials and finishes that are commonly used for manufacturing precast concrete absorptive sound wall panels and posts include:

- Textured/stamped concrete surface (double raked, popcorn or fuzzy finish); porous finish; or stamped brick
- Sound-absorptive aggregates (perlite or vermiculite)
- Lightweight cellular material
- Acoustic facing tile
- Composite materials
- Fibrous materials (fiberglass; mineral wool; recycled tire rubber; or recycled wood fibers or shavings)

Big players in sound absorption are the size and the shape of the path of the voids between the aggregate particles or admixtures added to the concrete mix. Fibrous materials produce some of the best results for sound absorption, as they are densely packed and randomly arranged in such a manner that makes a difficult path for the pressure wave in the air to be dissipated.

The precast concrete absorptive wall manufacturer essentially strives to design an absorptive wall with...
HIGHWAY SOUND WALLS: FLORIDA DOT

Reflective sound wall systems can be used to help redirect noise emitted from highway transport to areas that will not negatively affect the welfare of the public. The Florida DOT has identified 21 communities that would benefit from the construction of sound walls along the I-959 and the Florida Turnpike corridors. As part of the I-955 Express Corridor Improvements Projects, a total of 13 sound walls will be built. Two types of precast concrete sound barrier walls will be constructed: nine ground-mounted and four shoulder-mounted walls.

A porous surface so that sound waves will enter the absorptive airtight surface and not be reflected by the wall's surface. Sound traveling through a porous, absorptive material travels more slowly – about 70% of the speed that sound travels in open, non-obstructed air. In this way, porous materials increase low-end sound absorption.

HOW SOUND-ABSORBING EFFECTIVENESS IS MEASURED

Sound absorptive walls have been tested and proven to be effective sound-reduction barriers, although there may be an increased cost associated with some absorptive finishes. A challenge for sound wall manufacturers is developing a highly sound absorptive, porous material that will be durable in harsh environments alongside highways in cold climates.

The Noise Reduction Coefficient (NRC) determines the amount of energy reflected back toward the noise source and the amount of energy absorbed by the wall material. NRC ratings will have a range between 0 (100% reflective) to 1 (100% absorptive). A precast concrete sound wall with a rating of 0.7 means that the wall absorbs 70% of the noise and deflects 30% of the noise back toward the source. A typical NRC for an absorptive sound wall ranges from 0.6 to 0.9.

The Sound Transmission Class (STC) determines the amount of noise energy that is ultimately transmitted through the wall material and the noise energy that reaches the receiver. Sound walls that have a STC rating of 30 or more represent walls in which less than 0.1% of the noise energy is transmitted through the barrier material. Many state DOT specifications require a minimum STC rating of 24.

Absorptive sound wall surfaces avoid the negative effects that may occur with reflective sound wall surfaces. Reflected sound waves may pose a problem, as it is difficult to precisely predict the path of the reflected sound waves. Once a sound wave is reflected...
from a flat surface, numerous variables can affect the
direction of the diffracted sound wave. Therefore, sound
absorptive walls are less likely to produce uncontrollable
and unexpected results.

**Reflective Sound Walls Repel Sound Waves**

Reflective noise walls are not designed with an
absorptive material or surface finish. Consequently,
sound reflects off the surface and back toward the noise
source or into the atmosphere. The decreased noise
level reflected back to the source or into the atmosphere
is less than the original noise emission, because some
of the noise is absorbed into the wall (natural materials
in concrete will absorb some sound) and because noise
dissipates over distance. Flat, hard concrete surfaces
with no surface textures will reflect noise back to the
source or into the atmosphere.

Noise emissions that are reflected back to the source
or into the atmosphere may not reflect in a straight-
line fashion due to various conditions that affect noise
wave diffraction, including: atmospheric variations
(temperature, wind gradients); divergence; shielding;
the ground effect; and higher and lower frequencies.

Therefore, when designing reflective noise walls, these
various conditions must be considered or the reflected
sound may actually increase and create more unwanted
noise.

Although reflective noise walls do, by definition,
redirect noise emissions from a source back at the
source or into the atmosphere, if a reflective precast
concrete sound wall is properly designed only limited
or inaudible (< 3 dB) noise will be experienced at the
receiving location.

**Field Studies on Sound Walls**

According to the Retaining Wall Noise Reflection
Analysis on I-70/I-71 South in Ohio, potential traffic noise
reflections associated with large retaining walls were
tested to see if absorptive treatments on segments of
the highway would be needed if elevated levels of noise
were experienced.

The testing showed that while there was a minimal
detectable increase in noise due to deflections, the
application of sound-absorptive materials would provide
only marginal improvement; that is, the reduction in noise
would not be perceptible to the human ear. So in this
case, a reflective barrier was sufficient for the project.

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\(^2\)NRC: Noise Reduction Coefficient; http://acoustical.com/acoustical_soundproofing_education/what_is_nrc_stc_sea.html

\(^3\)Sound Transmission Class (STC) is the most common sound reduction measurement in the U.S.; STC is a measure of
how well a material attenuates airborne sound.
Research has been conducted on precast concrete sound walls on both sides of a noise source as well as on only one side. The results were interesting: For properly designed and constructed precast concrete sound walls located on one side of the noise source, residents located on the opposite side of the noise wall perceived that the noise levels had actually increased due to the reflective sound-barrier construction. Field studies have debunked this perception.

Research states that even if all the noise striking the barrier on one side of the road were reflected back to the other side of the highway, the increase in sound would be only about 3 dB. In reality, not all of the acoustical energy is reflected back to the other side; rather, some sound is absorbed by the barrier itself, some sound travels through the barrier and some sound is redirected to other locations.

For properly designed and constructed precast concrete sound walls located on both sides of a highway or noise source, studies show that problems associated with this type of reflective noise are similar to results from studies of one wall. If elevated noise levels are perceived by resident receivers, sound absorptive treatments can be used to eliminate the additional perceived noise.

Attractive precast concrete sound walls are becoming more popular in applications from highways to hospitals. Depending on the particular challenges of the site and the sound source, absorptive or reflective precast concrete wall systems are the most effective engineering solutions for reducing adverse sound impacts on humans and animals. 

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