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Sound Walls: Absorptive versus reflective design and effectiveness

ABSTRACT

The overlap of commercial development and urban residential sprawl has created an intense awareness of noise in America, and a demand for better noise abatement practices. The primary noise sources which elicit the most fervent public resistance are road & traffic noise, and commercial developments including the explosive trend in Big Box stores. Sound barrier walls have been one of the most common and effective abatement treatments for such applications. Due to the availability and relatively low cost, reflective materials like concrete, brick or block have been the traditional manufacturing components of sound walls. As the public's knowledge of noise and noise treatments has evolved, however, so has its demand for more efficient sound wall performance. As a result, sound walls comprised of absorptive materials have grown in popularity amongst architects, developers, contractors and the general public. Thus there is an ongoing, vigorous discussion on the differences between absorptive and reflective sound walls, and which type is best suited for specific applications.

1 INTRODUCTION

Sound barriers are an effective means to reduce the noise impact from sound sources affecting sound-sensitive receivers. Common sound sources include roads & highways, retail and big-box developments, mechanical & hvac equipment, construction sites, etc. Receivers may include homes or apartments, schools, hospitals, office buildings or even public parks. When noise becomes an issue between such sources and receivers, the use of sound barriers may be an ideal solution.

Sound walls are use in many applications around the world, including DOT projects and "big-box" stores.

2 SOUND BARRIERS – REALISTIC EXPECTATIONS

Although often overlooked, sound barriers can be an effective sound attenuation and noise reduction option. Sound barriers are most effective at mid- and high-frequencies, while low frequency sounds may require the use of longer and taller sound walls for mitigation.

While the sound insertion loss of a sound barrier can be limited, it can be often optimized to provide sufficient reduction of the offensive sounds. The height and length relationship of sound barriers is well documented. At a minimum, the sound barrier should at least block the line-of-sight between the sound source and the receiver. Additionally, the sound waves that travel around the ends and over the top of the sound barrier can be significant, as well as the sound waves reflecting off of other nearby buildings and structures as shown in Figure 1.

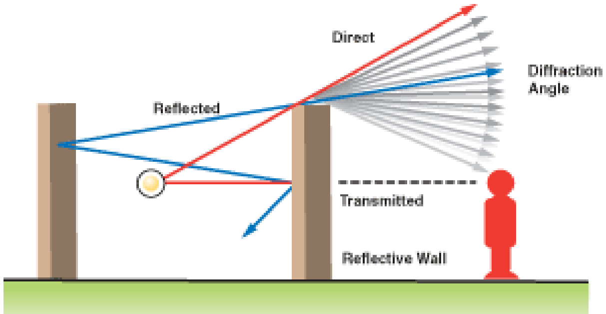

Figure 1: Sound waves not directly blocked by sound wall can travel around and over to the Receiver.

The key noise mitigation factor of a sound wall is the mass of the wall structure. It must be sufficiently dense to eliminate sound waves from traveling through it. Since design factors such as wind-loading inherently contribute to the mass of the wall's design, most of today's top-performing sound walls meet this minimum-mass level. This leaves only the noise that travels over or around the wall to contend with. As long as the sound transmitted through the barrier is at least 10 decibels (dB) below what is diffracted and transmitted over the top, the sound barrier has sufficient mass.

In general, the rules of thumb for sound barriers are easy to remember and fairly accurate: Up to 10 dB of sound reduction is fairly straightforward to obtain. A range of 15-17 dB is practical to obtain. But more than 20 dB of reduction is difficult to obtain, and more than 25 dB is impossible to obtain.

3 BENEFITS OF SOUND ABSORPTION ON SOUND BARRIERS

A key factor that is often overlooked on sound barrier selection is the effect of the surface design on overall performance. Most common building materials such as wood, metal and masonry have hard surfaces and thus reflect sound. i.e. they are considered "Reflective" barriers. Thus when sound strikes the surface of a reflective barrier, some energy is transmitted through the wall but the bulk is reflected back in the general direction of the noise source. Depending upon the roughness and shape of the surface, (and the wavelength of the sound), the sound may be fractured in different directions.

As with interior building materials, the use of sound absorptive materials in a sound wall can be beneficial in eliminating unwanted noise. Additionally, the physical geometry and location of the barriers can impact sound mitigation. For example, having two reflective sound walls – one on each side of a roadway – forms a "sound canyon" resonating with reflective sound from and between each wall, see Figure 2. The same configuration using absorptive sound walls eliminates such reflected noise. This is an obvious example of an application where the use of an absorptive sound wall should be considered.

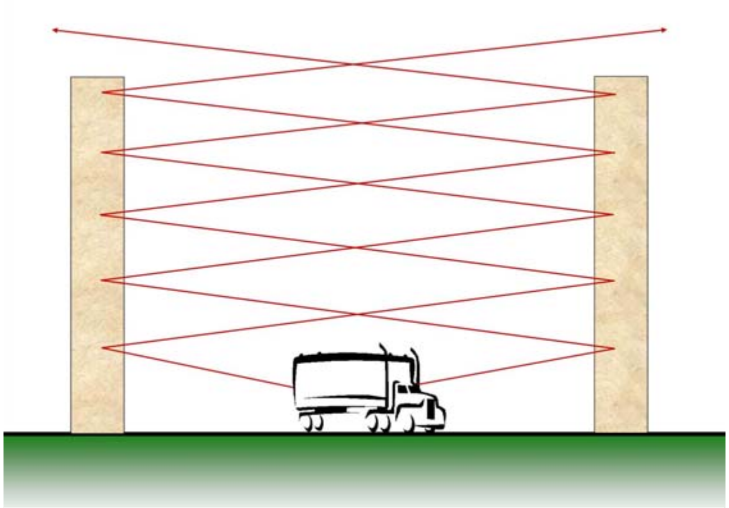

Figure 2: Reflective parallel barriers cause sound to reverberate between them; a process which is eliminated with the use of absorptive barriers.

And there are other situations favoring the use of absorptive barriers that are not quite as obvious. Here are two such examples:

3.1 Service Drive and Roadway Sound Barriers

Consider the placement of a sound barrier between some houses and the back of a shopping center, see Figure 3. The drives behind the stores are often used for deliveries by medium "bob tail" trucks and heavy delivery or even over the road "semi" trucks with tall side trailers. The truck engine and running gear are perhaps at a nominal 6' tall but the trailers are 10 to 12' tall. Thus as truck moves through one of the drives the sound reflects between the side of the truck and trailer and the sound barrier wall. Sound travels at over 1,000 fps so there will be multiple reflections of sound between the two that produces a reverberant sound buildup. Thus the sound levels are increased and also the height of the sound source is effectively increased.

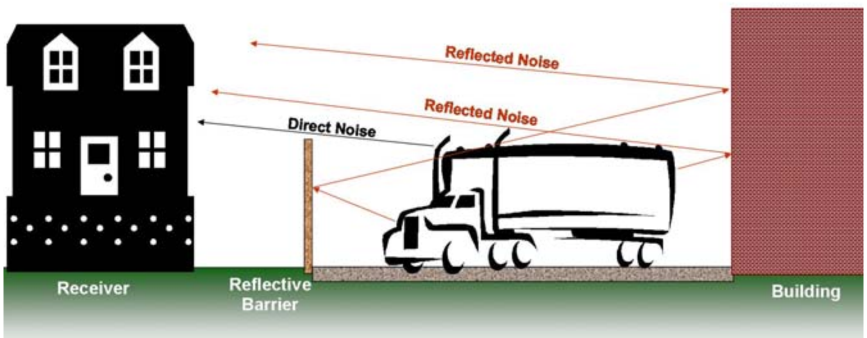

Figure 3: The combination of *reflective* barriers and commercial buildings often increase noise to the Receiver via unintended reflective sound waves.

Reflection is a critical factor when the vehicle is almost as tall as the wall or, in many cases, taller than the wall. The sound levels at the receiver can be easily increased perhaps 3 to 5 dB, and some times up to 7 dB via reflective noise. Therefore the designed sound barrier provided only 3 to 5 dB of sound attenuation in the field, where more than 10 dB was expected. Use of acoustical absorption on the source side of the sound barrier wall would have provided the desired level of performance, see Figure 4. The same type of condition would apply to a roadway barrier with semi truck traffic on the street or highway and houses on the receiver side of the wall.

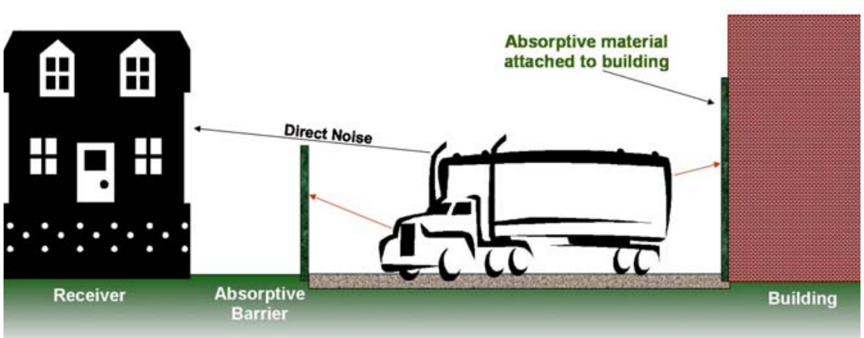

Figure 4: When *absorptive* materials are used at the barrier and on the building, reflected sound is minimized, significantly reducing noise at the Receiver.

3.2 Mechanical Equipment Noise

Consider the placement of mechanical and hvac equipment such as air cooled outdoor chillers, cooling towers, and emergency engine/generators. Often the pieces of equipment are placed behind or beside an industrial, hospital, educational or commercial building. This equipment is usually close to a property line. When residential homes and apartments are adjacent to such commercial property, specific (low) sound levels are mandated due to zoning regulations. Sound level limits in the 45 to 50 dBA range at night are not unusual. Many times simply meeting zoning requirement is not enough to eliminate nuisance complaints from neighbors, so sound levels approaching the general background sounds are desired.

In many cases, screen walls are typically used to hide the equipment, see Figure 5. Since there is a significant amount of sound reduction needed, these walls also need to serve double-duty as a sound barrier. Screen walls comprised of reflective materials like concrete, metal, wood or brick will often create sound buildup in the receiver's area due to sound reflecting off of the screen walls and the sides of the building, which are typically reflective and much taller than the screen wall.

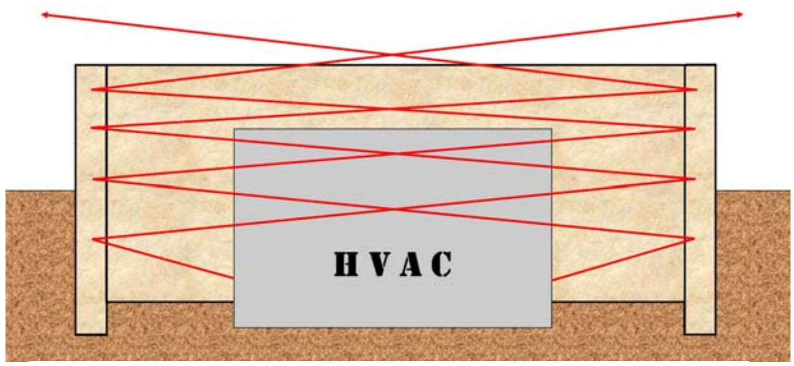

Figure 5: Reflective sound enclosures and architectural screens simply redirect unwanted sound waves, and can actually *increase* noise via unintentional redirected sound

It is imperative to use acoustical absorption on the source side of such enclosures, see Figure 6. In addition, supplemental use of acoustical absorption on the side of the building may also be required. Reflection of 3 to 5 dB or higher is often generated off the building. If that reflection is removed, that is sound that the sound barrier itself does not have to overcome.

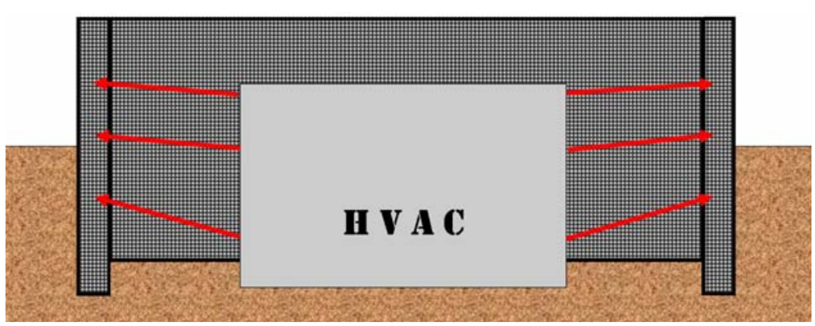

Figure 6: *Absorptive* sound enclosures and architectural screens actually absorb sound waves, minimizing the affect of unintentional, unwanted noise.

4 ABSORPTIVE SOUND BARRIERS

There are several varieties of sound absorptive barriers. Most consist of a hard material such as HDPE, wood, sheet metal and masonry for the basic construction to provide the sound transmission loss. The acoustical absorptive materials are also varied. The majority make use of fibrous material such as fiberglass and mineral wool. These products will not “wick or wet” and retain moisture. Thus even when rained upon the surface will dry. Provisions must be made in the panel design not to trap water in formed channels or elsewhere in the wall. The acoustical absorptive material can be selected to provide a significant amount of sound absorption on a wide frequency range, with 2” to 4” being perhaps typical thicknesses, see Figure 7. The amount of lower frequency sound absorption increases with increased thicknesses. Use of un-faced materials are probably best so as not to reduce the higher frequency absorption.

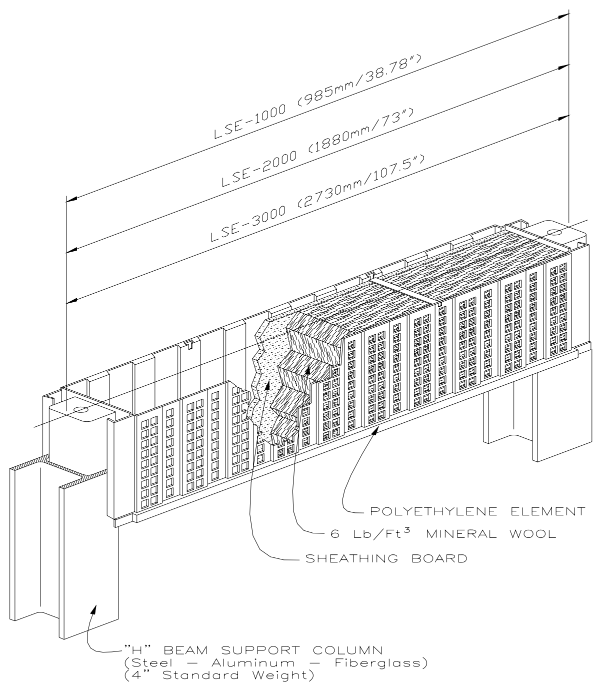

Figure 7: The design of an absorptive sound wall includes multiple elements engineered to dampen incoming sound waves..

5 SUMMARY

There are many designs and variances of sound barrier wall design, material and construction. As with any other building material, the cost and benefits must be considered. The use of acoustical absorptive sound barriers is a cost effective solution where reverberant and reflective sound reduction is needed to maximize overall noise mitigation.

6 ACKNOWLEDGMENTS

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