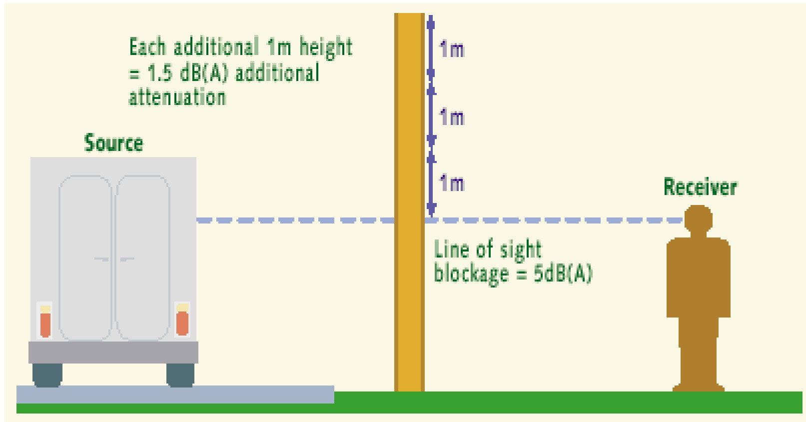
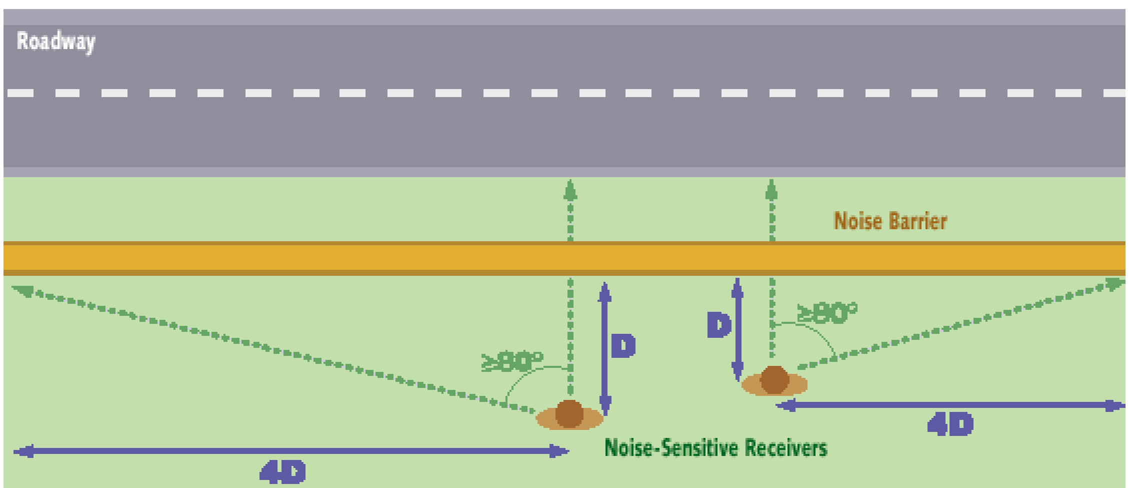
How Does a Noise Barrier Work?

Noise barriers reduce the sound which enters a community from a busy highway by either absorbing the sound, transmitting it, reflecting it back across the highway, or forcing it to take a longer path over and around the barrier. A noise barrier must be tall enough and long enough to block the view of a highway from the area that is to be protected, the "receiver." Noise barriers provide very little benefit for homes on a hillside overlooking a highway or for buildings which rise above the barrier. A noise barrier can achieve a 5 dB noise level reduction, when it is tall enough to break the line-of-sight from the highway to the home or receiver. After it breaks the line-of-sight, it can achieve approximately 1.5dB of additional noise level reduction for each meter of barrier height.



To effectively reduce the noise coming around its ends, a barrier should be at least eight times as long as the distance from the home or receiver to the barrier.



Openings in noise barriers for driveway connections or intersecting streets destroy their effectiveness. In some areas, homes are scattered too far apart to permit noise barriers to be built at a reasonable cost. Noise barriers are normally most effective in reducing noise for areas that are within approximately 61meters (200 feet) of a highway (usually the first row of homes).

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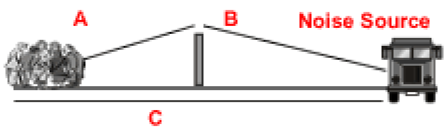
Noise Barrier Geometry Basics



From this sketch, we can derive this equation: Z =A+B-C

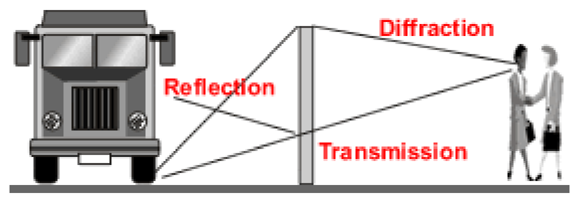
Z (Metres)	Potential Noise Decrease Due to Diffraction
1	15dB(A)
2	18dB(A)

The values above are approximate and do not represent a linear relationship

Reflection & Absorption

The effectiveness of a barrier depends on how well it diffracts and absorbs the noise.

A high performance barrier has negligible noise transmission and reflection. This is controlled by two coefficients: Absorption(NRC) and Sound Transmission (STC)



Quality Noise Barriers

- significantly reduce the noise levels.
- guarantee acoustic performance.
- significantly reduce public complaint levels.
- provide an aesthetic visual barrier that will last.

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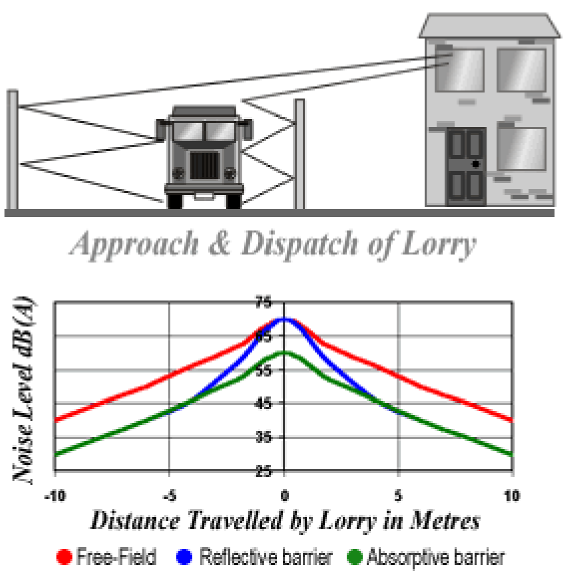
Two Types of Noise Barriers

Absorptive Barriers:	Reflective Barriers:

• Absorb the noise that strikes them
  ○ (Reflections are negligible)
• For High Performance
  ○ Sound Absorption Coefficient > 8dB(A) NRC>0.80 (negligible noise reflected)
  ○ Sound Transmission STC > 35 (negligible noise transmitted)
	• Redirect the noise that strikes them.
	  ○ (They do not "reduce" the noise)
	• For High Performance
	  ○ Sound Transmission Class > 35 (negligible noise transmitted)
	  ○ Reflections must be accounted for. (as shown below)

Reflection Effects: Multiple Reflections & Interactions



As we can see from the example on the left, the lorry acts as a reflecting surface and contains the intensity of the noise (i.e. does not allow it to dissipate) until it has cleared the reflective noise barrier. This results in little, if any reduction of noise.

In some circumstances, if there is a parallel reflective surface this can also reflect the noise on the opposite side of the lorry, doubling the intensity of the noise experienced by the resident.

This is a prime example of where an absorptive noise barrier system would be much more effective and should be incorporated. **Double sided absorptive barriers provide additional benefit by absorbing sounds generated on the receiver side of the barrier, that otherwise may be reflected into adjacent receivers properties.**

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Noise barriers substantially reduce noise levels for people living next to highways, either by absorbing sound energy or by reflecting sound energy. Both methods work, however, sound absorption is more efficient and less likely to produce unexpected results.
Sound absorbing noise barriers allow sound waves to enter the wall, as the sound waves travel through the sound absorbing material the sound waves are forced to change direction and follow a longer path. Every change in direction decreases the sound waves energy. After the sound waves completes its journey through the wall, little, if any sound energy remains to reenter the environment.
In comparison, reflective noise barriers abate noise by redirecting sound waves into the atmosphere. This is risky because reflected sound waves traveling through the atmosphere bend upward or deflect downward depending upon existing meteorological conditions.
Consequently, as atmospheric conditions change , the accuracy to predict how reflected sound waves travel decreases. This explains why some residents living across from a reflective noise barrier may experience new sounds and / or increased noise levels.

UNDERSTANDING SOUND/NOISE

Noise has been an environmental issue throughout the ages. Ancient Romans complained about chariots rattling on cobble stone roadways. Renaissance metal smiths often lost their hearing due to continuous and excessive noise. Noise has been called "the natural by-product of expanding human technology." In other words, disagreeable sounds are mostly the fruits of our own creation. Automotive and truck traffic, airplanes, generators, air conditioning units, dishwashers, car alarms and trains are common sounds often described as noise.

Environmental noise can distract attention, disturb sleep and create anxiety. Prolonged exposure to sound levels above 85dB can impair hearing and can be hazardous to overall health.

Noise might be described as any sound that is annoying. This subjective definition of noise causes serious problems when defining the nature of noise since "one man's music can be another man's misery." In many situations, a noise problem is defined as not being in compliance with a particular specification or regulation. Unfortunately, compliance to specific regulations is not a guarantee that individuals, communities and organizations will not complain about perceived noise levels. Their concerns and complaints need to be addressed.

The first goal when dealing with noise complaints is determining a reasonable solution. Understanding the subjective nature of sound is a step in the right direction for finding a reasonable solution.

SOURCE, PATH & RECIEVER

Three components must be present for noise to exist:

1. **Source**
2. **Path**
3. **Receiver**

Without a source there obviously is no sound. Without a path, the medium through which sound passes to the receiver, there is no sound. Without a receiver, someone who hears the sound, there is no sound problem.

SOURCE

Sound is the result of rapid fluctuations of pressure, which reach a receiver. The frequency of sound is the number of times in a period of one second that the pressure changes from zero to maximum to minimum to zero, thus completing a cycle. In music it is perceived as the pitch or tone of a note.
Frequencies produce sound waves; the length of the sound wave depends on the specific frequency.
Humans tend to be more sensitive to high and mid range frequencies such as sirens, whistles and traffic noise. Lower frequencies tend to be less irritating.
Amplitude refers to the loudness of sound. The loudness of sound is often expressed in decibels (dB).
Human hearing is impacted by the way it perceives sound levels. Higher and lower frequencies of the same magnitude can be perceived as less intense; therefore, to approximate the response of the human ear adjustments are made to account for human sensitivity to certain frequencies. These adjustments are identified as dBA's.
For the majority of people, the threshold of hearing is higher than 0 dBA, probably closer to 10 dBA. A change of 1 dBA in sound is the smallest change most people can recognize when comparing two sounds.
Many State Department of Transportation agencies claim a change of 3 dBA is the smallest change most people can recognize. A change of 10 dBA is generally thought to be "twice as loud."

Common Outdoor Activities	Noise Level dBA	Common Indoor Activities
Jet Fly-over at 300m (1000ft)	--110--	Rock Band
	--100--	
Gas Lawn Mower at 1m (3ft)		
	--90--	
Diesel Truck at 15m (50ft), at 80km/hr (50mph)	--80--	Food Blender at 1m (3ft)
Noisy Urban Area, Daytime		Garbage Disposal at 1m (3ft)
Gas Lawn Mower, 30m (100ft)	--70--	Vacuum Cleaner at 3m (10ft)
Commercial Area		
Heavy Traffic at 90m (300ft)	--60--	
		Large Business Office
Quiet Urban Daytime	--50--	Dishwasher Next Door
Quiet Urban Nighttime	--40--	Theater, Large Conference Room (Background)
Quiet Suburban Nighttime		
	--30--	Library
Quiet Rural Nighttime		Bedroom at Night, Concert Hall (Background)
	--20--	
		Broadcast/Recording Studio
	--10--	
Lowest Threshold of Human Hearing	--0--	Lowest Threshold of Human Hearing

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Decibels are logarithmic units; therefore, multiple dB cannot be added by ordinary arithmetic means. For example, if one automobile generates 70 dB when it passes an individual, two cars passing simultaneously would not produce 140 dB. In fact, they would combine to produce 73 dB. The chart below can be used to reasonably estimate the impact of two or more noise sources together.

When Two Decibel Values Differ By:	Add this Amount to the Higher Value:	Example:
0 or 1 db	3 db	70+69=73
2 or 3 dB	2 dB	74+71=76
4 to 9 dB	1 dB	66+60=67
10 dB or more	0 dB	65+55=65

PATH

Although frequency and amplitude originate at the source, both are significantly altered by the physical variables in the path to the receivers. For example, walls, structures, ground absorption, atmospheric conditions such as temperature, humidity, wind and rain all contribute to changes in source noise levels before it reaches the receiver. A detailed study of the path is a critical step in understanding how to reduce noise levels at specific locations.

RECEIVER

Ultimately, we are concerned with the effect and perception of sound on the receiver. Two elements determine the sound levels upon the receiver: the sound power levels of the source and the characteristics of the path between the source and receiver. A third and critical element is the individual sensitivity of the human receiver. The individual's sensitivity plays a significant role in his perception of noise levels.

REDUCING UNWANTED NOISE

The best place to control noise is close to the source. Enclosing a noise source is an effective method and commonly used in commercial and industrial applications but impractical when addressing traffic noise issues. When the noise source has been minimized or isolated the next step is to interrupt the direct noise path by introducing a sound barrier. The next objective is to remove reflected sound energy as soon as possible. The most practical method is to replace reflective surfaces with absorptive surfaces.

Sound-absorptive walls installed between the noise source and the receivers are effective in reducing reflective noise. The height, location and orientation of the sound wall play a significant role in the wall's effectiveness. Sound walls are most effective when built close to the source or close to the receiver. The height of the wall should interrupt line-of-sight between the source and the receiver.

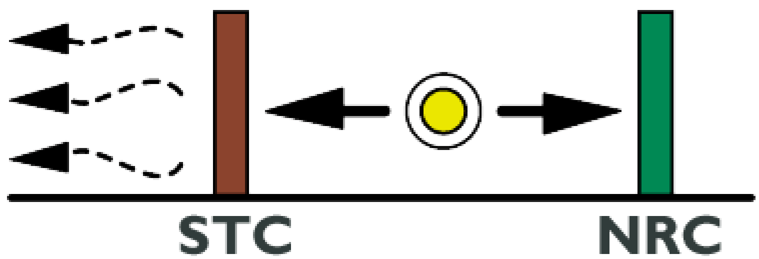
If reflections can be subdued quickly, they cannot develop into reverberations. Reverberations become new sources and add to the original noise source. Minimizing reflections means noise is localized to the extent whereby only direct sound, line-of-sight sound, will be heard.

WHAT MAKES A GOOD SOUND WALL

The most often asked question is are trees, vegetation and landscaping effective noise barriers? Although they help with aesthetics, they, unfortunately, do little to reduce noise.

Sound walls are classified as *reflective* or *absorptive*. Hard surfaces such as masonry or concrete are considered to be perfectly *reflective*. This means most of the noise is reflected back towards the noise source and beyond. A barrier wall with a surface material that is porous with many voids is said to be *absorptive*. This means little or no noise is reflected back towards the source.

Sound walls are performance rated in two categories ***Sound Transmission Class*** (*STC*) and ***Noise Reduction Coefficient*** (*NRC*). The *STC* determines the amount of noise energy transmitted through the wall material. The *NRC* determines the amount of energy absorbed by the wall material and the amount of energy reflected back towards the source.



Walls having STC ratings of 30 or more means that less than 0.1 percent of the noise energy is transmitted through the barrier material. Many State Department of Transportation specifications require minimum STC ratings of 24.
NRC measures the amount of sound energy absorbed and measures the amount of sound energy reflected back towards the source. NRC ratings will range between 0 (100% reflective) to 1 (100% absorptive). A wall with an NRC rating of .85 means the wall absorbs 85% of the noise and reflects 15% of the noise back towards the source. NRC ratings equal to or greater than .85 are considered to be good sound absorbers and are often used as the minimum requirement when considering absorptive walls.

A good sound wall is a sound-absorbing wall with a STC rating of 30 or more and a minimum NRC rating of 0.80to 0.85

WHEN ARE ABSORPTIVE WALLS BENEFICIAL

Absorptive wall applications are numerous. The primary intent is to isolate the noise source and minimize possible reflections. As stated earlier, if reflections are not subdued they become reverberations and become new noise sources.

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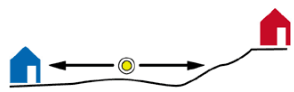
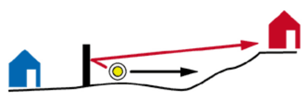
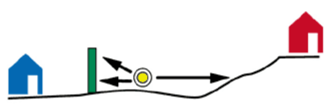
The following illustrations show the impact of having no sound wall, a reflective sound wall and an absorptive sound wall.
The illustration demonstrates the noise source directly impacts the house built at a similar grade as the roadway. The house on the hill is not impacted by the noise source because the ground absorbs the sound.



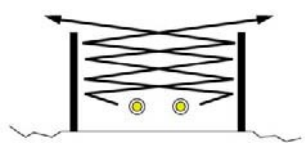
The addition of a reflective sound wall shields the house at the same grade as the roadway. Unfortunately, the reflections from the wall directly impact the house on the hill that was previously not impacted by the roadway noise. This situation depicted usually increases the noise level by 3-5 dBA for the house on the hill.



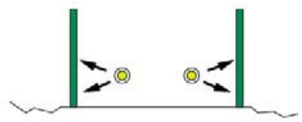
Using an absorptive sound wall shields the house at the same grade as the roadway and does not reflect noise up towards the house on the hill. Both houses are protected from the roadway noise.



It is common to see parallel sound walls on roadways. Reflective parallel sound walls potentially reduce the walls acoustical performance. The net result is less than optimal performance and increased noise levels on and adjacent to the roadway.



Absorptive parallel sound walls reduce reflections and are able to maintain the effectiveness of the barrier. In addition, the noise level on the freeway is reduced.



The above information compiled from several sources including FHWA, DOT, Various Acoustical Consulting Firms, and Trade Publications. Durisol provides the above data for information purposes only.