Can You Hear Me Now?

How do structural choices affect sound transmission in finished buildings? Read on for a primer on the basics of architectural acoustics.

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WEBSTER'S DICTIONARY DEFINES ACOUSTICS AS THE SCIENTIFIC STUDY DEALING WITH THE PRODUCTION, CONTROL, TRANSMISSION, RECEPTION, AND EFFECTS OF SOUND. Obviously, acoustics is a complex subject; this article will focus on sound transmission and control, how is sound measured, how structural assemblies are rated, and how different structural systems compare.

How loud is loud?

Sound is a form of mechanical radiant energy (pressure) transmitted through a medium, such as air. The intensity of sound (loudness) is measured by the decibel (dB) scale, which has to cover a very large range from the quietest whisper to the loudest explosion. The ratings are based on a logarithmic scale measuring watts per square meter. For example: 0 dB translates to 1×10^{-12} w/m^2; 10 dB (10 times more intense) translates to 1×10^{-11} w/m^2; and 20 dB (100 times more intense) results in 1×10^{-10} w/m^2. Below is a chart outlining a wide range of sounds and their corresponding sound levels:

Source	Level (dB)
Threshold of Hearing (TOH)	0
Pin Dropping	10
Whisper	20
Quiet Conversation	40
Normal Conversation	60
Street Traffic	70
Vacuum Cleaner	80
Fire Cracker	100
Front Rows of Rock Concert	110
Threshold of Pain	130
Air Raid Siren	140
Instant Perforation of Eardrum	160

While the intensity of sound can be objectively measured using the Decibel scale, the perception of sound by humans is usually described as subjective. These levels of perception are made up of three main items:

1. **Loudness** (based on physical response to pressure and intensity)
2. **Pitch** (based on frequency)
3. **Discrimination** of the human senses

How do you rate?

Now that you know how sound is measured, how does that translate into construction? When you are measuring an assembly, whether it is a floor or ceiling, there are two main testing procedures in the country: Sound Transmission Class (STC) and Impact Insulation Class (IIC).

STC measures an assembly's ability to block airborne sound transmission and is reported by a single number rating. Higher ratings indicate better ability to block airborne sound. This "single number" can be produced two ways: in a laboratory (ASTM E90) and in the field (ASTM E413). The two standards are necessary due to the variations that occur between lab models and actual assemblies. A field assembly cannot be expected to perform as well as the same assembly constructed in a lab. Because of this, design professionals should take precautions to ensure that the actual field assembly meets the requirements of their client.

An assembly will typically be weakest at the points where two materials meet, such as at the joints between gypsum panels or at mechanical penetrations. Care should be taken with these details because these "sound leaks" are the easiest way for airborne sound to transfer from one side of the partition to the other.

In addition, STC numbers focus on sounds in the range of human speech frequencies; they do not evaluate lower frequencies such as musical bass and mechanical equipment noise. Even if the partition has a high STC, an occupant on the other side may still be able to hear music and become irritated.

The STC test is carried out by placing a noise source on one side of the assembly and a microphone on the other side connected together by a spectrum analyzer. The transmission loss or decibel drop is recorded and compared against the standard STC definitions as defined by ASTM. Code requirements for sound transmission are covered in International Building Code in section 1207, which states that the minimum requirement between dwellings and/or public service areas is not less than STC 50 (45 if field tested). Another suggestion is that this level of STC 50 be raised when working with high-end residential construction, and a level of STC 60 is recommended for a high degree of sound attenuation.

IIC measures how an assembly can block impact sound, such as a footfall. It also uses a single number, and, as with STC numbers, a higher number indicates better assemblies. The IIC does not separate lab from field values, but most experts and codes do break out a lower value for field tested assemblies, which is the same as the STC value of 45.

The procedure and sound measurement for this test are defined in ASTM E492 and E989. The test uses a machine with five steel hammers, which are driven by a motor and strike the floor ten times per second. The machine is moved around the assembly and the impact sound pressure is measured from below. The same IBC requirements as for STC apply to this testing procedure, and the same higher recommendations for luxury units also apply.

One of the weaknesses of this test is that the impact machine does not resemble a human footfall and doesn't take into account the load transfers created by a moving person. Another issue is that carpet can have a greater damping effect with this test than it has with human footfalls, which would result in the resident below still being able to hear a footfall.

Putting it all Together

So, how do real-world typical assemblies perform? Good question! Acoustic performance is notoriously difficult to simplify, and "minor" details affected by construction practice, field fit-up and the like will greatly affect performance. A nail in the wrong place, or a mere 1⁄32 in. open joint can seriously degrade acoustic isolation. Nevertheless, as a broad generalization, you could reasonably expect that a 3 inch metal deck system with 3 in. of concrete cover would exhibit a STC rating in the range of 51 and an IIC rating of 21. Eight inch hollow core deck that is commonly used in steel framed multi-story residential structures typically exhibits a STC rating of 53 and an IIC rating of 21.

To improve on these figures you should first consider which type of sound rating you're trying to affect. STC ratings can be increased by blocking airborne transmission paths so consider sealing all utility penetrations with gaskets or the like. IIC ratings are enhanced by adding sound-absorbing materials at the interfaces between surfaces so that sound vibrations aren't transmitted from one to the other. With careful attention you can address both ratings with the same fix. For example, sealing a pipe penetration with a gasket will improve STC performance, but if you make sure that gasket is suitably flexible and isolates the pipe from the surrounding floor you can reduce pipe-to-floor transmission and thereby increase your IIC rating at the same time.

As you might expect, there are innumerable products that aim to fix acoustic problems. Many of these are intended to reduce noise within a space, rather than between spaces, so pay careful attention to the manufacturer claims and don't buy the wrong product for the job. A few common solutions are:

- ✔ **Sound-absorbing panels.** Typically made of porous expanded polypropylene or an equivalent and applied to a surface, one inch of this material can improve STC by 9. Two inches may improve STC by around 13 overall. These are most commonly used to control sound reflection within a space, but some versions are useful for controlling sound transmission between spaces.
- ✔ **Floor underlayments.** Although carpeting and floor underlayments are relatively ineffective at blocking airborne noise and won't contribute much to your STC ratings, they can be very effective at increasing your IIC rating. Carpet and a suitable pad will add up to 40 points to IIC; hard-surfaced floors can be installed with specialized underlayments (both roll and poured) that improve their IIC by around 20 points and generally require about an inch of depth.
- ✔ **Unfaced fiberglass acoustic insulation.** Depending on the specifics of a project and the installation details, putting acoustic fiberglass in a ceiling assembly will raise the STC rating of that assembly by 4 to 10 points. You must take care not to compress the batt.
- ✔ **Acoustic sheet rock.** Used in place of normal sheetrock, this can yield an STC that's 4 to 12 points better.
- ✔ **Isolation hangers.** These are often used to suspend ceiling finishes, decoupling them from the structure and minimizing vibration. Depending on type and installation, these can increase the STC rating of an appropriate ceiling by 12 to 16 points. Care must be taken to ensure that each hanger is carrying a suitable load; excessive loads can impair their effectiveness.
- ✔ **Resilient channel.** Generally used to mount gypsum board, these raise STC by 3 to 5 points, with higher-end types increasing STC by up to 7. You must not nail through the channel except in approved places or the channel will be rendered useless.

In many cases, products can be combined for further benefits—using acoustic batt above sheetrock that's suspended with isolation hangers will yield better results than any one of those products used alone. Remember, however, that every one of these solutions depends on proper application and correct installation.

Resources

Other useful resources for additional acoustics' information include:

- ➜ Canadian National Research Council
- ➜ ASTM Standards
- ➜ *Sound, Noise, and Vibration Control* by Lyle F. Yerges
- ➜ **www.acoustics.org**

And, as always, AISC's Steel Solutions Center is available to answer questions concerning structural steel within one business day. Contact the Steel Solutions Center at 866.ASK.AISC or at solutions@aisc.org. MSC

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