Sound Transmission in Buildings

Do You Have Noisy Neighbours?

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Over the past 20 years, I've noticed a change in the type of complaint voiced by condominium owners in both new and older buildings. It seems that, lately owners are becoming more aware of and more concerned about the peaceful use of their unit. People don't want to hear their neighbour's music or the sound of trash bouncing down the garbage chute. The elevator, air conditioning, water pipes, fans, and pumps are expected to be silent. Unfortunately, that just isn't happening and people are complaining.

The trouble is twofold; firstly, for new building, the building codes have not kept up with people's expectations and while many new condominium buildings are exceeding building code requirements for sound transmission, that doesn't necessarily mean that you will live in total peace. That brings us to the second reason, which is that noise is insidious and has ways to beat even the most conscientious of attempts to keep things quite.

Understanding why we are not able to stop noise requires a little understanding of noise itself.

Hearing and Measuring Sound

Sound is energy that travels in waves that have both amplitude and frequency. Amplitude relates to pressure and to a large degree affects loudness; frequency relates to pitch and affects how high or low the sound is – whether it is a whine or a rumble. However, sounds of different frequency (pitch) and the same amplitude (loudness) may not be perceived by our ears as being equally loud. People tend to hear higher-pitched sounds better than we do lower pitched sounds of the same amplitude. So, the next time you hear the thumping bass coming from a car stereo or through the wall from next door, just be glad its not the bagpipes they like.

Measuring sound is a complex task. Sound transmission through walls and floors is measured using sensitive instruments and a "standard" noise. A parameter called the A-weighted sound level is measured in decibels [dB(A)]. The measured sound level may need to be corrected for sound reflected off the wall- this is often about 3dB(A) and for the angle at which the sound source is to the wall. This too can be as much as 3 dB(A). In addition, sound several floors above ground is typically greater than that at ground-level due to interference and absorption by the ground and things sitting on the ground. So, if you are in a ground-floor unit in a building you may not be affected by an outdoor sound that is disturbing to someone several floors above you.

Multiple sound sources are not cumulative either. Two trucks parked beside one another with 75 dB(A) diesel engines running don't add to a total 150 dB(A) noise level. Actually, the noise level is increased only to 78 dB(A) and only to 80 dB(A) if there were four engines. So, sound pressure perception does not increase linearly with the number of dB. Each change of 10 dB represents a sound roughly twice as loud. This non-cumulative, non-linear effect means that it would take ten diesel engines running to be twice as loud as just one engine.

Sound transmission loss from one side of a wall to the other is dependent on the materials used and the properties of the sound. In Canada, the rating for insulating against sound is given by the sound transmission class (STC) of the assembly. Notice that we talk about the STC of an "assembly". Unlike thermal resistance values that can be summed up for each layer of a wall assembly (i.e. R12 plus R5 insulation equals R17), one can not sum up the STC values for materials to arrive at a total STC value. Each assembly of materials results in a different STC value for the respective assembly. In fact, adding layers can actually decrease the STC value of a wall or floor. Sound is not simple.

Airborne Sound

Sound energy can be absorbed by materials or lost by reflection off the material. Sound absorbing materials are generally porous and control sound by allowing the sound energy to pass through them and interact with the many surfaces the sound waves intercept. Good sound transmission loss also occurs on non-porous materials that reflect the sound back. These two types of materials work best in tandem – one to reflect the sound back and one to absorb the sound energy.

An "acceptable" indoor sound level is often dependent on the use of the space. For instance, the maximum acceptable sound level in a bedroom may be 40 dB(A); whereas, the maximum sound level acceptable in an office may be as much as 50 dB(A) or about twice as loud.

As well, sound levels near a window are usually greater than near adjacent walls. At our building, the windows are very old, wood-framed, single-glazed with poorly sealed aluminum storms; so, they don't reduce noise transmission very well – hence the street noise. To accommodate the whole wall, the normal practice is to assess the average sound level in a room some distance from the walls and windows. This way, not only is the sound distribution through the various components considered including their relative size, the effect of reduction afforded by sound-absorbing finishes and furnishings in the room is also included. So, if the windows that have poor STC values are small and the room has carpeted floors, the noise level in the room would be less than if the windows were large and the floor was hardwood.

Flanking Sound

So far, we've considered sound energy that is moving more-or-less directly through the wall or floor assemblies. But, sound energy is insidious. It finds what are known as "flanking" paths around the walls through floors materials or through holes. These allow relatively unimpeded transmission of sound energy and substantially reduce the effective STC value of the wall or floor assembly. So, while you may have a partition wall between your units rated at the building code minimum of STC 50; you may hear noise that is coming around the wall through the concrete floor slab or through holes in the partition at improperly fire-stopped pipe penetrations.

So far, as well, we've just considered sound such as speech that travels through the air to a wall or floor materials, travels through the materials and is re-emanated into the air and to our ear on the other side of the wall or floor. Noises created by impact on floors or walls are more problematic. These are created when a solid object comes into abrupt contact with a hard material. Typical of impact noise are; footsteps, tapping, nails on the feet of large dogs, etc. These generate vibrations directly into the floor or wall material, which are then released as airborne sound. The standard measure of the ability of an assembly to deaden that type of sound is the impact isolation class (IIC). Unfortunately, there is no building code requirement in Canada for IIC ratings of assemblies.

Canadian Building Codes

Walls and floors in Canada are required to be designed to have an STC rating. This rating has historically been assessed at roughly the frequency range of normal speech (rather than the full spectrum of sound the human ear can detect). The result is that a wall or floor assembly that is acceptable in terms of STC rating for speech may still allow disturbing lower frequency sounds through. Therefore, while you may not be able to understand the words in the music playing in the unit above you, you can hear the bass line quite clearly.

So, even if the wall or floor between your unit and your neighbour's unit does meet Canadian STC ratings there is no assurance that there will be no disturbing noise transfer between spaces. Many consultants believe that Canadian STC requirements are somewhat lacking when compared to other Countries. The minimum STC 50 rating between living units is often not able to satisfy people who are sensitive to noise. A partition or floor with STC and IIC ratings closer to 60 would be far better and would satisfy more people; but these assemblies tend to reduce ceiling heights and usable floor area, and can add cost to construction.

Hard-Surface Floor Retrofits

Despite the lack of IIC requirements and the low standard for STC rating of wall and floor assemblies in the building codes, until recently there have not been a lot of complaints about noisy neighbours. The main reason is that carpet on floors provides excellent STC and IIC ratings. Hard-surface flooring is another matter. The trend toward hard flooring with a thin-to-non-existent underlay does little to reduce the flanking sound, impact noise, or direct transmission of sound.

To help deal with the trend toward hard-surface flooring and the obligation of all residents to permit peaceful use of their neighbours home, many Condominiums require that a certain percentage of floor area of a unit be covered by carpet or that the owner wanting to install hard surface flooring demonstrate that the proposed floor will meet a certain STC and IIC standards. Enforcement of these requirements is difficult though.

STC and IIC test data supplied with flooring tends to focus on wood-framed assemblies often with suspended ceilings. Published STC and IIC values of 55 to 60 for those assemblies are not applicable to flooring placed on a concrete slab with a stippled ceiling finish. When asked to review hard flooring systems, we require the supplier provide test reports on concrete slabs using the proposed underlay. Only then is the Board protected against claims of noisy neighbours.

Equipment Noise

Another common problem in newer buildings is the noise heard from mechanical equipment or plumbing.

The residents in units adjacent to rooftop HVAC and elevator systems hear droning noises from pumps, motors, and fans. The building code STC requirement for the floors and partitions is slightly better for this condition at STC 55; but still not close to what most people will need to be satisfied. What's more, a large proportion of the noise from the equipment is not airborne (STC-related) but is vibration (IIC-related).

It is necessary to interrupt the path of the vibration through isolation pads and flexible conduit and pipe connections. Old isolation pads on equipment will lose plasticity and old isolation springs such as on air conditioning condensers will flatten allowing vibration through the floors and walls.

It may also be necessary to address flanking transmission paths by improving the fire stop seals through partitions at pipes and conduits; or, to install sound absorbing materials.

Simple Rules to Follow.

As can been inferred from this article, preventing sound transmission and the related complaints is not a simple matter. Moreover, despite all efforts, the noise may still be disturbing even though everything is installed to Code and with good workmanship. However, there are some basics that can be applied in most all cases.

Isolation: By separating the sound source from any hard surface you will reduce transmission of the sound energy into the surface. This means using sound isolation pads under vibrating equipment and noise producers such as stereo speakers. Flexible conduits or pipe should be provided at connections to the equipment. It also means using areas rugs on hard surface flooring, keeping speakers off walls and floors, and keeping hard flooring and underlay separated from partition walls.

Absorption: Provide sound absorbing materials on the sound source side of the partition wall or floor to minimize reverberation of the airborne sound in the source room. This involves acoustic strapping to separate the gypsum board from the solid wall or slab behind. Furnishings that absorb sound, carpets and rugs, etc.

Improve Transmission Losses: Provide heavy walls and floor assemblies to attenuate the sound that passes through the absorbing materials lining the room. Concrete slabs and walls with layers of gypsum board are good for this but will require the absorbing materials and vibration isolation measures as well.

Seal Sound Leakage Paths: Make sure that the holes for mechanical and electrical services are sealed with resilient materials having good acoustic properties. You may also solve some or your odour transmission problems this way.

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