

Understanding and Improving Sound Transmission Loss

Introduction

Any wall or floor, which separates one dwelling or unit from another, must provide adequate resistance to the passage of sound.

There are two types of sound which need to be resisted. These are from airborne sources such as speech, musical instruments and loudspeakers and the other being impact sources, such as footsteps and the moving of furniture.

This Information Bulletin describes methods that can assist in achieving adequate sound insulation (sound transmission loss).

Sound Transmission Loss

The difference between the sound energy on one side of the wall or floor and that radiated from the second side (both expressed in decibels) is called the sound transmission loss. The larger the sound transmission loss (in decibels), the smaller the amount of sound energy passing through and consequently, less noise heard.

Transmission loss depends on frequency. Low frequencies pass through walls/floors much more easily than high frequencies. That is why bass guitar and drum sounds from adjacent units are easily heard.

Perception of loudness does not decrease at the same rate as the decrease in sound energy. For example, a 10 decibels decrease in sound energy would be perceived as a halving of the loudness. In practical situations, the smallest difference that people can detect easily is about three decibels. Where various systems are compared, a variation of one or two decibels will have little detectable difference. Refer to Table 1 for subjective perceptions of sound energy in decibels.

Table 1. Subjective Perception of Sound Energy

CHANGE IN DECIBELS (dB)	SUBJECTIVE PERCEPTION	SOUND ENERGY CHANGE %
0 – 3	Barely perceivable	50
4 – 5	Perceivable and significant	69
6	Resultant sound level is ¼ less than the original sound	75
7 – 9	Major reduction in sound level	87
10	Resultant sound is ½ less than the original sound	90

Sound Transmission Class

The Sound Transmission Class (STC) is a method of rating the airborne sound transmission loss of a wall or floor/ceiling assembly at different frequencies by means of a single number. The STC is determined from the sound transmission loss values of an assembly and is obtained from laboratory tested systems.

Sound Regulations – Building Code of Australia (BCA)

The Building Code of Australia, nominates minimum STC requirements for walls and floors between adjoining dwellings or units and around service ducts. Refer Table 2.

Table 2. BCA Minimum STC Requirements

Wall/Floor Location	Minimum STC Rating
Floors between units -	STC 45
Walls between units -	
habitable against habitable	STC 45
habitable against wet area	STC 50 + impact requirements
wet area against wet area	STC 45
Walls between service pipes and units -	STC 30

NOTE:

1. All Sound Transmission Classes are determined in accordance with AS1276.
2. Habitable areas include bedrooms, lounge rooms, dining rooms, etc.
3. Wet areas are bathrooms, WC, laundries and kitchens.

How to Improve Sound Transmission Loss or STC Values

Increase in Mass

An increase in transmission loss is expected with increasing mass of the wall or ceiling system because the heavier the element the less it vibrates in response to sound waves, hence, less sound energy will be radiated on the other side.

Cavity Construction

One of the most effective ways of increasing sound transmission loss is to use double layer construction, that is, two layers of material separated by an air space. (Refer Figure 1). This ideal cavity system would have no structural connection between the layers. The cavity provides increased noise reduction because only a fraction of the sound energy is transmitted through the surface, then the cavity and again another surface.

However, the transmission loss may be reduced if there is structural coupling between the layers, allowing sound vibrations to transfer through the structure. This is the acoustical equivalent of an electrical short circuit.

For lightweight wall construction, there are several practical ways of reducing mechanical connections between partition layers. These include – double stud (dual or twin walls) which are two independent frame walls (Fig 1a); staggered studs which are separate rows of studs that share common wall plates (Fig 1b); or a single row of studs with resilient metal channels or mounts to support the wall linings on one side (Fig 1c).

With equivalent lining configurations, double stud wall systems perform the best as they have truly independent leaves.

The next best sound transmission loss performance is generally obtained with staggered stud walls, as they eliminate the direct sound transmission through studs but share top and bottom plates, therefore allowing some ‘short circuiting’ of sound energy.

Single stud walls with a resilient mounted lining system generally do not perform as well as double stud or staggered stud systems.

For floor/ceiling systems, separation between floor and ceiling is best achieved by supporting the linings on resilient channels or mounts. (Refer Fig 2).

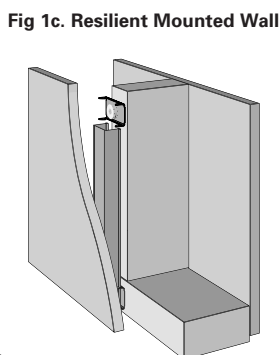
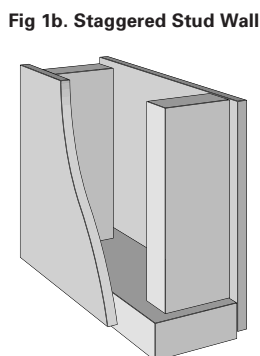
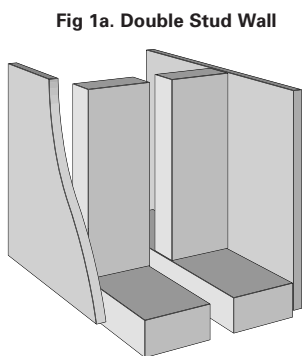
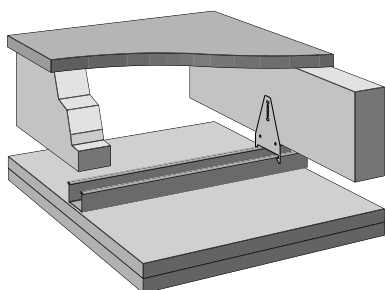


Fig 2. Typical Floor/Ceiling System



Absorptive Material

Filling the cavity with absorptive insulation material (cellulose fibre, glass fibre or mineral wool) can increase the transmission loss substantially, especially when the cavity is large.

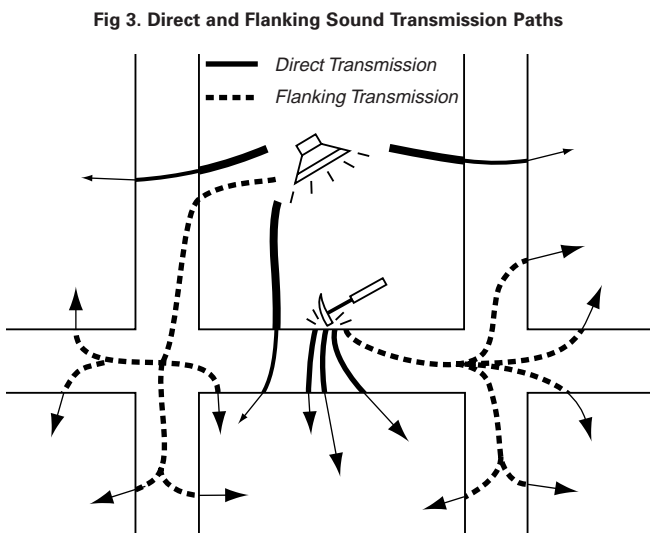
The sound-absorbing material should be a minimum of 50mm thick and a minimum density of 12kg/m³. Batts thicker than two-thirds of the wall or floor/ceiling cavity width or depth provide little additional increase in STC.

Adding absorptive material to the cavity is beneficial only if structural connections between the surfaces do not transmit the vibrational energy. For example, adding insulation between the studs of a single stud wall (a timber stud wall with linings attached directly to both faces of the studs) has little effect because it does not alter the dominant direct vibration transmission path through the studs.

Flanking Paths

In a building where all the components are rigidly connected, sound energy can be transmitted through the ceiling, wall and the floor structures to adjacent rooms. Vibrations within the structure cause sound to be radiated from all surfaces as shown in Figure 3. This occurs for all materials used in construction (brick, concrete, timber, steel, etc.).

Those paths that are not directly through the floor or walls are termed flanking paths.



When partitions or floors are tested in acoustical laboratories, great care is taken to ensure that the only significant sound transmission path is through the test specimen itself. Solid connections between the specimen and the surrounding structure are eliminated or made sufficiently resilient.

To approach the same sound performance in buildings that is attained in laboratory tests, energy transmission along flanking paths must be minimised. This is achieved by introducing breaks in the construction such as resilient connections.

Noise Control by Good Building Design

There are many aspects of the building layout that could assist to improve noise transmission loss without the need for any additional construction. The following principles should be considered during the design of a building.

Dwelling Layout

One of the simplest means of controlling noise is to isolate noise sources from sensitive receiving areas. An important example of this is that laundries, service shafts, stairs and other noisy areas in buildings should be located as far as possible from sensitive living or sleeping areas. Placing relatively quiet areas such as bedrooms or lounge rooms next to each other also helps to minimise the noise transmitted.

Figure 4, details many GOOD and BAD design practices that should be considered when laying out a residential building plan.

Windows

Two forms of noise problems can be associated with windows. The first is the noise travelling from one unit to the next, the other is the noise from outside the building.

Windows normally have a lower transmission loss value than the surrounding wall, even when closed. Many high performing sound rated wall systems have become ineffective due to the windows being the dominant noise path. Care is required in locating the windows to ensure they do not face noisy areas, and that there is adequate separation between windows in adjoining units.

Where exposure to noise is unavoidable, one or a combination of the following suggestions can enhance the performance of the window:-

- thicker or laminated glass;
- reducing the window area;
- double glazing;
- weather stripping of windows;
- use fixed glazing in lieu of opening windows.

Door Openings

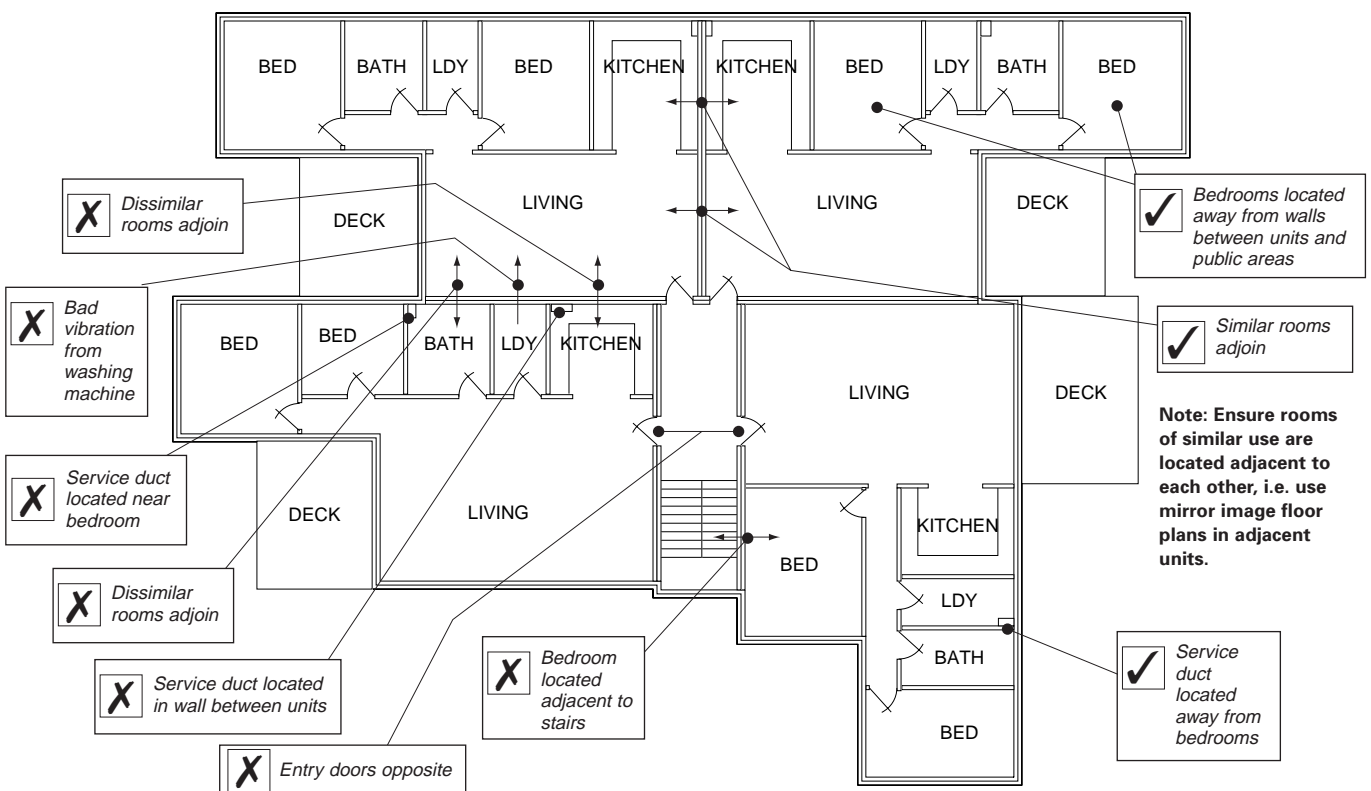
Public corridors serve as buffer zones between units, but the doors into them often permit noise to intrude. Sound rated walls may become ineffective by the inclusion of a door within the wall. Generally, doors do not have the same transmission loss as the wall and may become the dominant path for noise.

A way to deal with this problem is to offset doors along the corridor and to add sound-absorbing materials to the surfaces in the corridor to reduce noise reflection along it.

Where improvement in the performance of the door is required, solid core doors as a minimum should be used. Door tops and sides should have gaskets with soft weather stripping. Use of threshold closures at the bottom of the door or air seals will also reduce sound transmission.

Sliding doors should be avoided where optimum noise control is expected. Entry doors could include air locks to reduce airborne noise travelling to adjacent units.

Fig. 4 Good and Bad Design Practice in Building Layout



Wall and Floor/Ceiling System Selection

There is a large variety of wall and floor systems available which utilise modern construction techniques. Each system has a different fire resistance level (FRL) and sound transmission class (STC). These ratings are generally dependent on the thickness and combination of lining material, cavity insulation and stud arrangement selected. Refer to MRTFC Information Bulletin N°5.

Once the required FRL is established, wall or floor system selection is normally controlled by the level of sound performance required. STC ratings specified for wall systems are generally based upon a laboratory test.

These laboratory tests are accurate values determined by careful measurements in highly controlled conditions. Comparisons between laboratory and field test have shown that STC values of installed system may be reduced due to flanking paths, air leaks, services penetrations, etc.

Typically, the installed performance of a wall or floor/ceiling system may be 2 to 5 STC points less than the laboratory test.

To overcome the difference between field and laboratory performance, it is recommended to select a wall or floor/ceiling system rated at 5 STC points above the level of sound attenuation required.

Wall Systems

Sound Leaks

Sound leaks can easily occur at the perimeter of walls and floors where caulking is absent or improperly installed, or where a penetration is made to add some service such as electricity or plumbing. To reduce sound leaks, all penetrations and fissures in a wall or floor must be thoroughly caulked, all windows and doors must be tightly weather stripped and holes for services properly sealed.

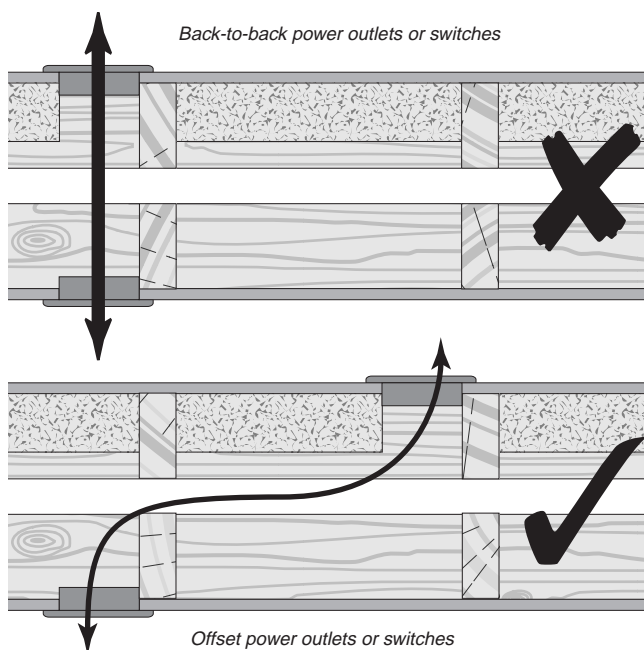
Sound leaks can significantly reduce the effectiveness of a system. A wall with a potential STC of 60, which has a hole of only 0.001% of the total wall area (10 x 10mm hole in a 2.4 x 4.2 m wall), can be reduced to an effective STC of 50. As the hole area increases, eventually the rating is determined entirely by the hole area. The higher the acoustical isolation that is sought, the more important it is to eliminate all sound leaks.

If the system is not airtight, then there is a good chance it is not 'sound-tight' because if air can pass from one room to the other, then sound will also be transmitted.

Electrical and Other Wiring Outlets

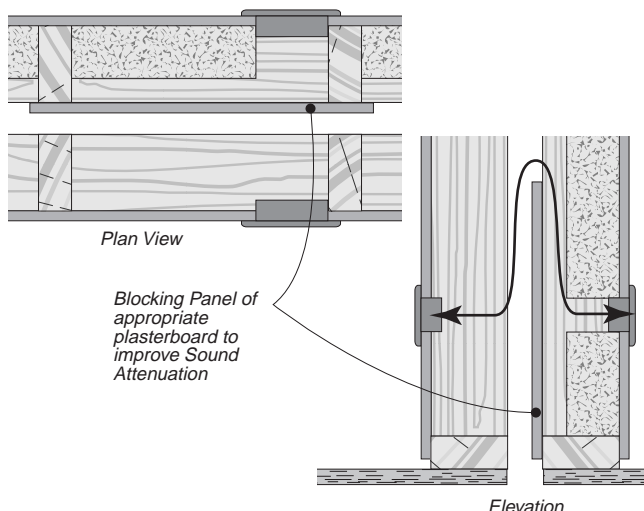
It is always preferable to avoid placing services in sound rated walls, but where this cannot be avoided, leaks around electrical and other wiring outlets are a common problem, especially when the outlets are back-to-back. Offsetting the switches as shown in Figure 5 will improve the sound transmission loss.

Fig. 5 Offset Switches to Improve Acoustic Attenuation



This is especially effective when the wall is filled with sound absorbing material. Leaks usually permit only high-frequency sound to pass through. Sound absorbing material is most effective at high frequencies. Where back-to-back power points cannot be avoided, blocking panels, as shown in Figure 6, provide some sound insulation but are generally less effective and more expensive to construct.

Fig. 6 Blocking Panels in wall cavity to Improve Acoustic Attenuation



If electrical power points must be installed in a party wall, they should be offset from each other along the wall and be correctly sealed.

Plumbing Noise

Water turbulence in plumbing systems is a source of hydrodynamic noise. This can be reduced by minimising fittings, sharp bends and constrictions in the system.

Plumbing noise is almost always transmitted as structure-borne vibration, and eventually radiates from lightweight surfaces. The most common error made is to connect the water supply and waste pipes and other fixtures rigidly to the neighbouring unit's structure.

To reduce the amount of noise entering the structure, pipes should be isolated from the frame using resilient sleeves and hangers, and flexible connections. Where pipes penetrate sound barriers, the holes should be carefully sealed. Contact of piping with lightweight surfaces (which radiate sound easily) must be avoided.

As with other noise sources, the layout in the building is important for control of plumbing noise. Where possible, pipes should not be installed in walls or in floor/ceiling systems adjoining areas where noise is likely to be of concern. In critical situations pipes should be enclosed in service shafts incorporating sound-absorbing materials on the inside.

Pipe Materials

Different pipe materials transmit sound energy differently. For supply systems, plastic pipes are significantly quieter than copper pipes but where they both are resilient mounted there is little difference. The opposite occurs for waste systems, where metal pipes provide better sound performance than plastic pipes.

Where pipe noise is a problem, adding extra linings or insulation will reduce the noise, but the addition of resilient metal channels is more effective and provides some margin if construction errors result in accidental solid contact between pipes and the structure.

Floor/Ceiling Systems

In the design of floor/ceiling systems, both impact and airborne noise must be controlled. From an acoustical point of view, the material used for the joists, whether solid, I-beam or truss construction is not important.

For many floors, the main cause of noise transmission is sound energy transmitted through the structural connections between the surfaces of the floor and the ceiling below. Ideally, the floor and ceiling surfaces should be isolated from each other.

Providing independent joists to support the ceiling is the best solution, where this is cost effective. This could be used in bathrooms or laundries where drop ceilings are used to allow falls for plumbing.

Where this is not possible, the use of resilient channels or mounts to attach the ceiling linings to the bottom of the floor joists is the next best alternative.

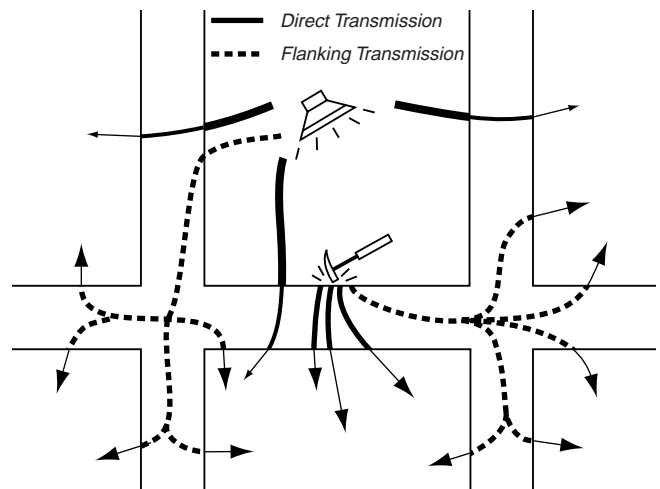
If rigid structural connections between the surfaces are avoided, adding absorptive material to the spaces between the floor joists can further improve sound transmission loss.

Control of Impact Noise

Impact sound (eg. footstep noise), is one of the most difficult forms of sound energy to control. The transfer of sound energy through the structure when a solid object strikes a floor is a much more efficient process than airborne sound transmission, refer to Figure 7a.

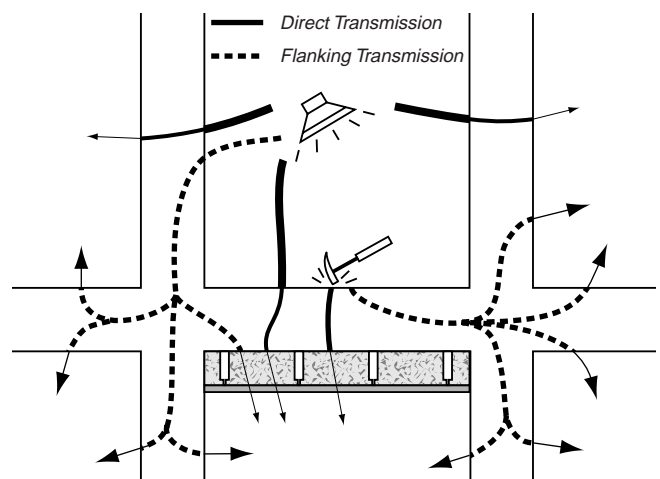
Dividing a floor and ceiling into two isolated or resiliently connected layers (Figure 9), decreases the transmission of vibration between them and thus reduces both the impact and airborne sound radiation through the surfaces. Sound-absorbing material inside the cavity of properly isolated floor/ceiling systems has the same beneficial effect in reducing impact noise as was detailed previously for airborne sound reduction.

Fig. 7a Airborne and Impact Sound Transmission Paths



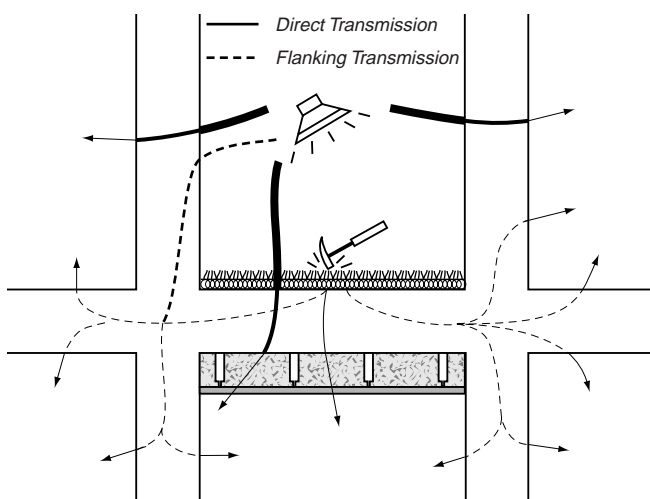
The use of a resiliently suspended ceiling or the use of cavity absorption will reduce the amount of direct sound transmission, but cannot control the noise transmission through the floor framing to adjacent rooms on the same level, or the transmission down the supporting walls. Refer Fig 7b. For these situations, control of impact sound at the source is required.

Fig. 7b Reduced Direct Sound Transmission through Resilient Mounted Ceiling System



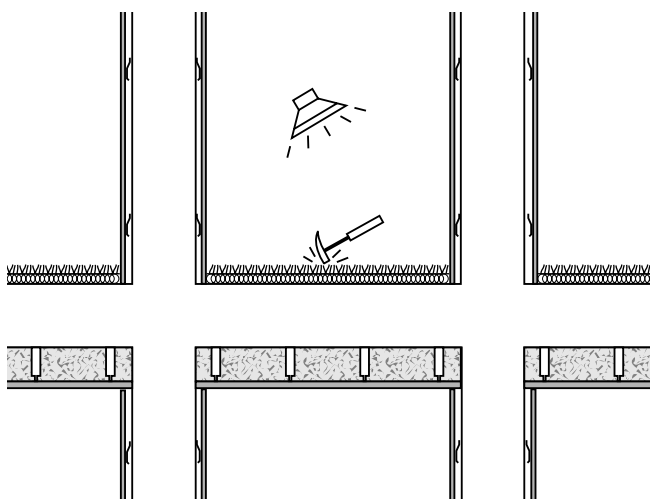
The best way of controlling impact noise is to lay a soft resilient layer, such as a carpet and underlay, on top of the floor (Figure 7c). The impact force is cushioned by the resilient layer, reducing the sound energy that is transferred to the floor structure. For example, the addition of carpet and underlay to a timber floor system that incorporates a resilient channel mounted ceiling and includes cavity insulation, can increase the impact insulation class (IIC) from about 50 to 70 or more, depending on the type of carpet. However, the addition of carpet and underlay will have little effect on the STC of the floor.

Fig. 7c Carpet and Underlay Reduce the Generation of Impact Sound at its Source



Ultimate performance is achieved where all surfaces are resiliently supported (Figure 7d). Generally, this may be too expensive or impractical to achieve.

Fig. 7d All Surfaces Resiliently Mounted

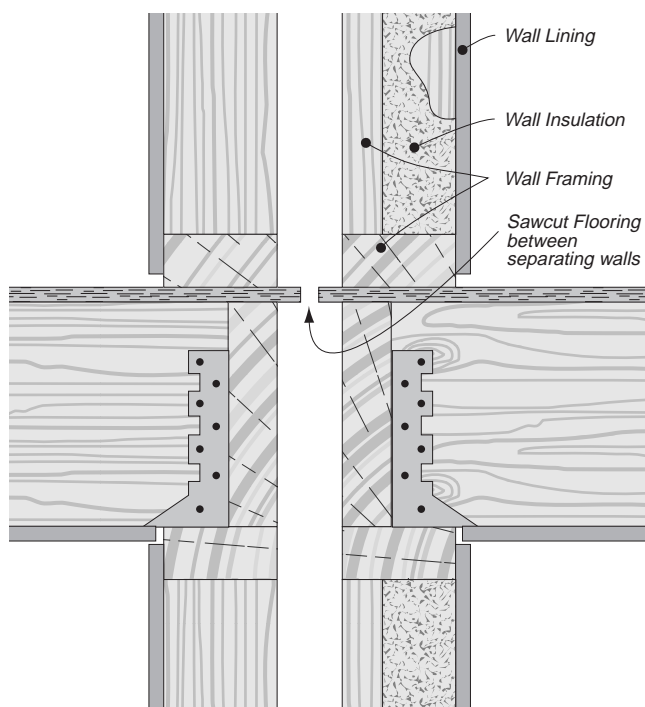


Flanking Sound in Floors

To create a successful acoustical design for a building, not only must the performance of the components selected be considered, but also the details of the interconnections.

For structural reasons a floor is normally rigidly connected to the adjoining and supporting walls. Impact and airborne sound transmission along flanking paths can be a serious problem (Figure 9). Research has shown that up to 6 STC points can be lost due to the continuation of the flooring, because the wall is 'short-circuited' by the top layer of the floor. To remedy this, a structural discontinuity is needed to reduce the passage of vibration along the lightweight layer without compromising the structural integrity of the system. Such a break can be a saw-cut in the flooring as shown in Figure 8.

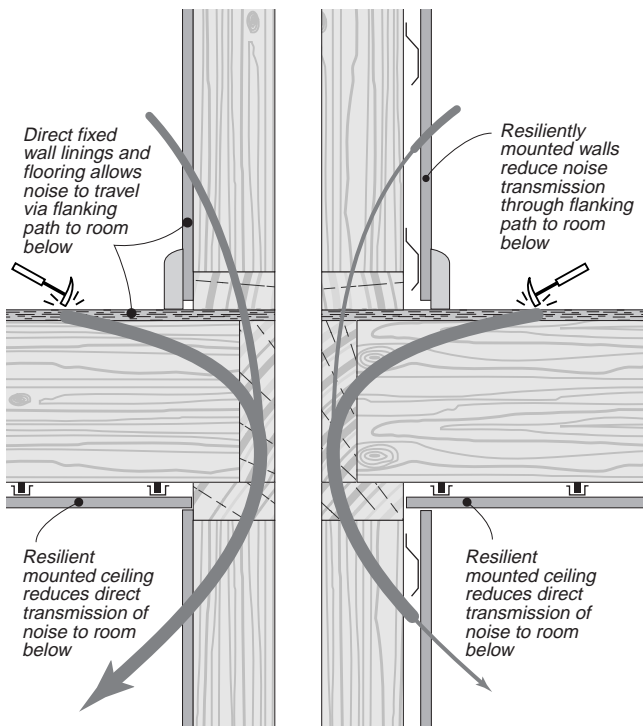
Fig. 8 Stop Flooring or Saw-cut Flooring to reduce Flanking Noise Transmission



Sound, especially impact noise, can travel down the walls to the space below (Figure 9). Resiliently suspending the ceiling below the floor, as in Figure 9, does not reduce in any way the transmission paths to adjacent rooms on the level below.

One method to reduce transmission along this path is to resiliently support both the ceiling and the wall linings.

Fig. 9 Resilient Mounted Walls reduce noise transmission via flanking paths to room below



Where resilient supported linings are not practical or affordable, impact sound transmission can be reduced by the use of carpets. Alternatively, where hard surface floors are required, tiles, decorative timber, etc., impact noise can be reduced by the use of a 'floating floor', refer to Figure 10.

Sound energy will be dissipated within the carpet or floating floor, or will be substantially reduced as it propagates from the carpet or floating floor through the supports to the rest of the structure.

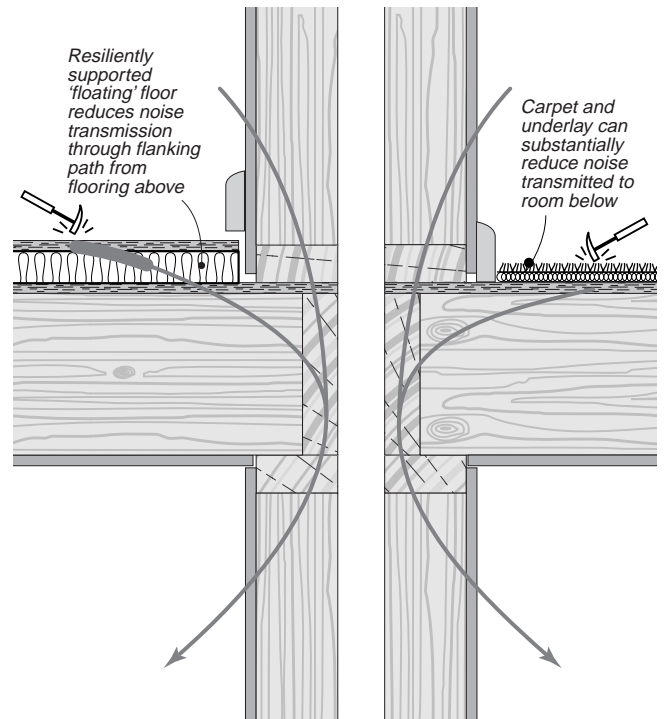
Washing Machines, Cloths Dryers, Dish Washers, Air-conditioners, Etc.

Washing machines, cloths dryers, dish washers, air-conditioners, etc. produce vibration noise that is readily transferred to the building's structure.

Care is required to ensure these items are not installed on walls separating dwellings, or above sound sensitive areas.

Vibrational noise can be reduced by supporting the appliance on resilient mounts or pads designed to support the loads.

Fig. 10 Carpeting or Resilient Mounted Flooring reduces noise generation and transmission to room below



Reference Material

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Technical Advice

Further technical information and assistance is available from the following Timber Advisory Services.

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Timber Research and Development Advisory Council of Queensland.
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