Sound insulation

SECTION 3

General principles and typical constructions are shown in this section. Space does not allow all details for each type of construction to be shown. Many such details are illustrated and discussed in greater detail in Part E of the Building Regulations.[1] Further guidance and illustrations are also available in *Sound Control for Homes*[2] and in manufacturers' literature for proprietary materials and systems.

3.1 Roofs

The sound insulation of a pitched roof depends upon the mass of the ceiling and the roof layers and the presence of a sound absorbing material in the roof space. Mineral wool, used as thermal insulation in the ceiling void, will also provide some acoustic absorption, which will have a small effect on the overall sound insulation of a roof. A denser specification of mineral wool as commonly used for acoustic insulation would have a greater effect on the overall sound insulation of the roof.

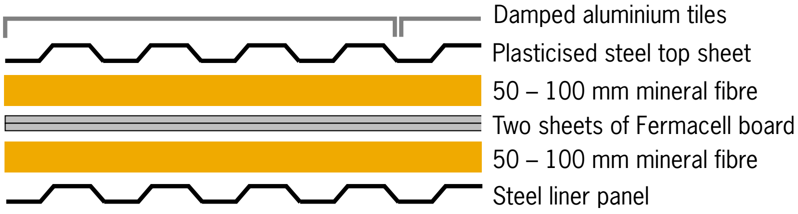
Where it is necessary to ventilate the roof space, it is advisable to make any necessary improvements to the sound insulation by increasing the mass of the ceiling layer, which should be airtight. Recessed light fittings can make this difficult and sometimes it is better to place the sound insulating material below the roof covering and to extend partition walls up to the roof layer (providing adequate ventilation can be maintained).

3.1.1 Rain noise

The impact noise from rain on the roof can significantly increase the indoor noise level; in some cases the noise level inside a school due to rain can be as high as 70 dB(A).

Although rain noise is excluded from the definition of indoor ambient noise in Section 1.1, it is a potentially important noise source which must be considered at an early point in the roof design to minimise disturbance inside the school.

Figure 3.1: Profiled metal clad roof incorporating acoustic damping



Excessive noise from rain on the roof can occur in spaces (eg sports halls, assembly halls) where the roof is made from profiled metal cladding and there is no sealed roof space below the roof to attenuate the noise before it radiates into the space below. With profiled metal cladding, the two main treatments that should be used in combination to provide sufficient resistance to impact sound from rain on the roof are:

- damping of the profiled metal cladding (eg using commercial damping materials)
- independent ceilings (eg two sheets of 10 kg/m^2 board material such as plasterboard, each supported on its own frame and isolated from the profiled metal cladding. Absorptive material, such as mineral fibre, should be included in the cavity.)

Profiled metal cladding used without a damping material and without an independent ceiling is unlikely to provide sufficient resistance to impact sound from rain on the roof. A suitable system that could be used in schools is shown in Figure 3.1. The performance of such a system was measured by McLoughlin et al[3].

Prediction models are available to predict the noise radiated from a single sheet of material; however, a single sheet will not provide sufficient attenuation of impact noise from rain. Suitable lightweight roof constructions that do provide sufficient attenuation will consist of many layers. For these multi-layer roof constructions, laboratory measured data for the entire roof construction is needed.

At the time of writing, a new laboratory measurement standard for impact sound from rain on the roof, ISO 140-18[4], is under development. In the future this will allow comparison of the insulation provided by different roof, window and glazing elements and calculation of the sound pressure level in the space below the roof.

When designing against noise from rain on the roof, consideration should also be given to any glazing (eg roof lights) in the roof. Due to the variety of different roof constructions, advice should be sought from an acoustic consultant who will be able to calculate the sound pressure level in the space due to typical rainfall on the specific roof.

3.2 External Walls

For masonry walls, such as a 225 mm solid brick wall, a brick/block cavity wall or a brick-clad timber frame wall, the sound insulation performance will normally be such that the windows, ventilators and, in some cases, the roof will dictate the overall sound insulation of the building envelope.

Timber frame walls with lightweight cladding and other lightweight systems of construction normally provide a lower standard of sound insulation at low frequencies, where road traffic and aircraft often produce high levels of noise. This can result in a low airborne sound insulation against these noise sources unless the cladding system has sufficient low frequency sound insulation. The airborne sound insulation can be assessed from laboratory measurements carried out according to the method of BS EN ISO 140-3:1995[5].

3.3 Ventilation

The method of ventilation as well as the type and location of ventilation openings will affect the overall sound insulation of the building envelope. When external noise levels are higher than 60 dB $L_{\mathrm{Aeq,30min}}$, simple natural ventilation solutions may not be appropriate as the ventilation openings also let in noise. However, it is possible to use acoustically attenuated natural ventilation rather than full mechanical ventilation when external noise levels are high but do not exceed 70 dB $L_{\mathrm{Aeq,30min}}$.

The School Premises Regulations[6] require that:

> *"All occupied areas in a school building shall have controllable ventilation at a minimum rate of 3 litres of fresh air per second for each of the maximum number of persons the area will accommodate.*
>
> *All teaching accommodation, medical examination or treatment rooms, sick rooms, sleeping and living accommodation shall also be capable of being ventilated at a minimum rate of 8 litres of fresh air per second for each of the usual number of people in those areas when such areas are occupied."*

In the case of the latter densely occupied spaces such as classrooms, 8 litres per second per person is the minimum amount of fresh air that should be provided by a natural or mechanical ventilation system under normal working conditions, in order to maintain good indoor air quality.

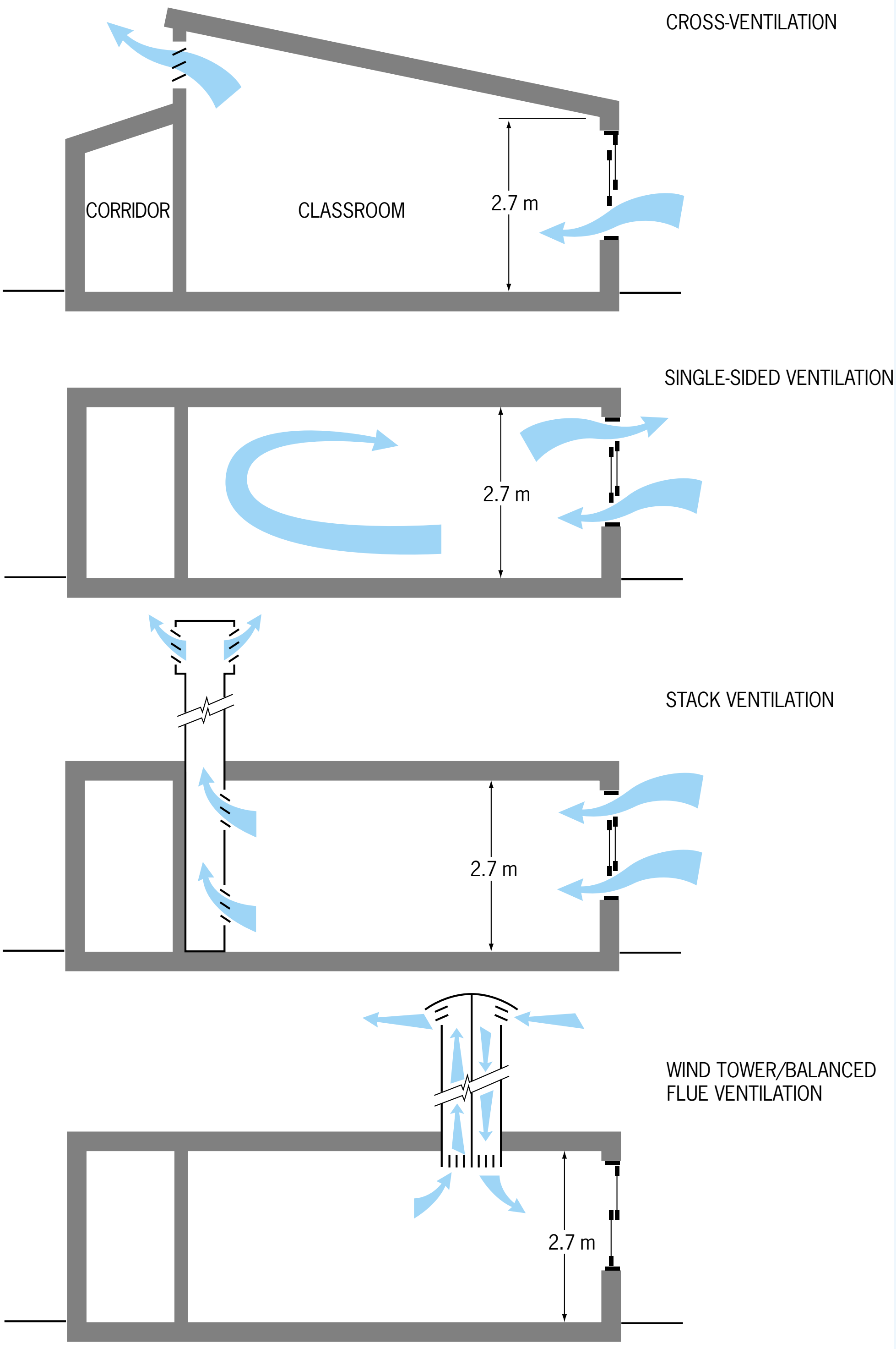
In order to satisfy the limits for the indoor ambient noise levels in Table 1.1, it is necessary to consider the sound attenuation of the ventilation openings so that the building envelope can be designed with the appropriate overall sound insulation. In calculations of overall sound insulation the attenuation assumed for the ventilation system should be for normal operating conditions.

The main choices for the natural ventilation of typical classrooms are shown in Figure 3.2. Case Studies 7.8 and 7.9 describe the recent application of two of these design solutions in new secondary school buildings.

Additional ventilation such as openable windows or vents may be required to prevent summertime overheating. Under these circumstances an increase in internal noise levels is expected and the levels in Table 1.1 may be exceeded depending on the ventilation strategy.

3.3.1 Ventilators

Passive ventilators normally penetrate the walls, but in some cases they penetrate the window frames (eg trickle ventilators) or



POSSIBLE SOUND INSULATION MEASURES

Secondary glazing with staggered openings
Acoustically treated high capacity air inlet

Secondary glazing with staggered openings

Absorbent duct lining
or
Acoustic louvres on outside
plus
- secondary glazing with staggered openings
- acoustically treated high capacity air inlet

Absorbent duct lining
Acoustic louvres on outside
Secondary glazing with staggered openings
Attenuator plenum box
Electronic noise

Figure 3.2: Possible types of natural ventilation

the windows themselves. Often windows are not used as intended as they cause uncomfortable draughts. For this reason, increased use is being made of purpose designed ventilation systems with or without acoustic attenuation.

Many proprietary products are designed for the domestic sector and in some cases they do not have large enough openings for classrooms and other large rooms found in schools. The acoustic performance of any ventilator can be assessed with laboratory sound insulation test data measured according to BS EN 20140-10:1992[7]. Because of the complexity of the assessment of the acoustic performance of a ventilator, advice may be needed from a specialist acoustic consultant. To maintain adequate ventilation, it is essential that the effective area of the ventilator is considered as it may be smaller than the free area (see prEN 13141-1[8]).

It is important, particularly in the case of sound-attenuated products, that a good seal is achieved between the penetration through the wall or window and the ventilator unit. Where through-the-wall products are used, the aperture should be cut accurately and the gap around the perimeter of the penetrating duct should be packed with sound insulating material prior to application of a continuous, flexible, airtight seal on both sides.

In some schools bespoke ventilator designs, such as that shown in Figure 3.3, are needed. For more examples of ventilator solutions see Case Studies 7.8 and 7.9.

3.4 External Windows

The airborne sound insulation of windows can be assessed from laboratory measurements of the sound reduction index according to BS EN ISO 140-3:1995[5]. When choosing suitable windows using measured data, care must be taken to differentiate between measured data for glazing and measured data for windows. The reason is that the overall sound insulation performance of a window is affected by the window frame and the sealing as well as the glazing.

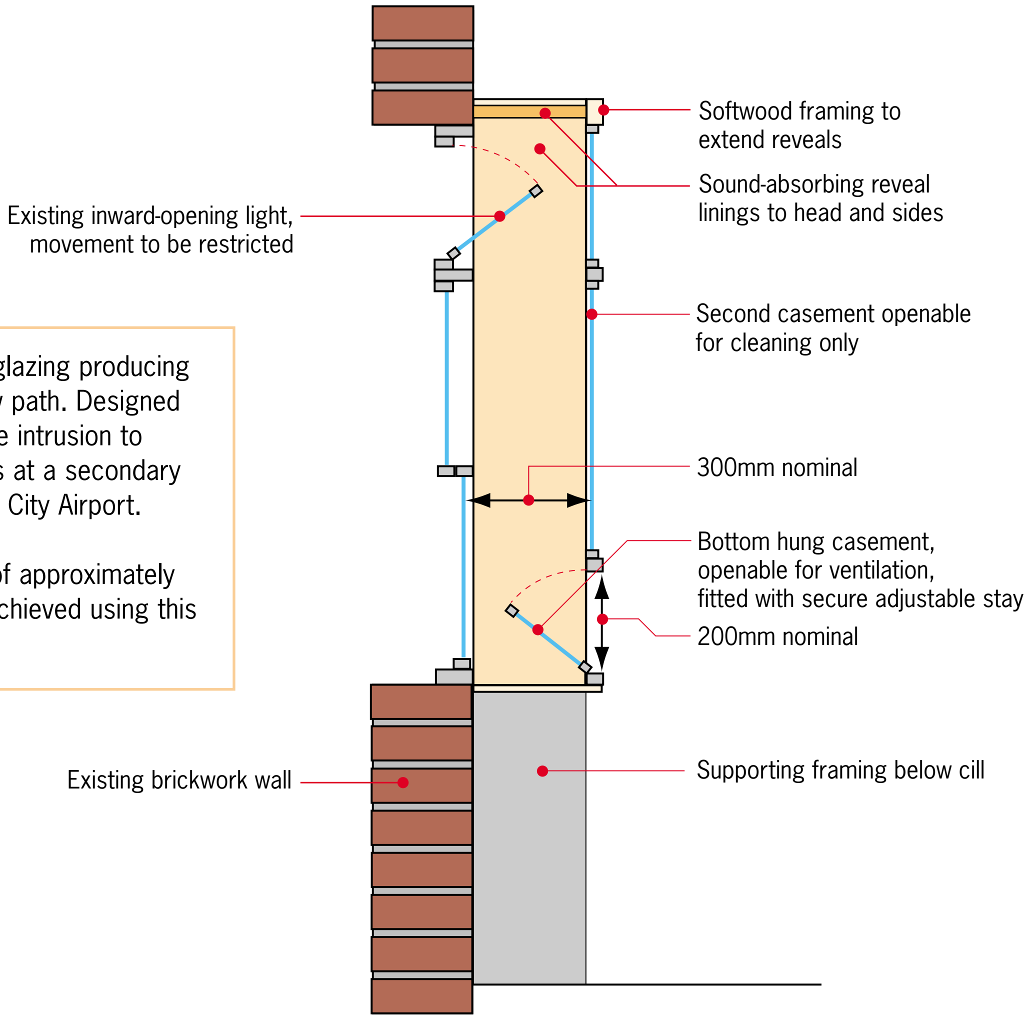
To achieve the required sound insulation with thin glass it is often necessary to use two panes separated by an air (or other gas) filled cavity. In theory, the wider the gap between the panes, the greater the sound insulation. In practice, the width of the cavity in double glazing makes relatively little difference for cavity widths between 6 mm and 16 mm. Wider cavity widths perform significantly better.

In existing buildings, secondary glazing may be installed as an alternative to replacing existing single glazing with double glazing. The effectiveness of secondary glazing will be determined by the thickness of the glass and the width of the air gap between the panes. Another alternative may be to fit a completely new double-glazed window on the inside of the existing window opening, leaving the original window intact. The use of sound absorbing reveal linings improves the performance of double-glazed windows, but the improvement is mainly in the middle to high frequency region, where it has little effect on road traffic and aircraft noise spectra.

To achieve their optimum performance, it is essential that the glazing in windows makes an airtight seal with its surround, and that opening lights have effective seals around the perimeter of each frame. Neoprene compression seals will provide a more airtight seal than brush seals. The framing of the window should also be assembled to achieve an airtight construction.

It is equally important that an airtight seal is achieved between the perimeter of the window frame and the opening into which it is to be fixed. The opening should be accurately made to receive the window, and the perimeter packed with sound insulating material prior to application of a continuous seal on both sides.

For partially open single-glazed windows or double-glazed windows with opposite opening panes, the laboratory measured airborne sound insulation is approximately 10-15 dB R_w . This increases to an Rw of 20-25 dB in the open position for a secondary glazing system with partially open ventilation



Retrofit secondary glazing producing a staggered air flow path. Designed to limit aircraft noise intrusion to science laboratories at a secondary school near London City Airport.

A sound reduction of approximately 20-25 dB R_W was achieved using this design.

Figure 3.3: Secondary glazing producing a staggered air flow path

openings, with the openings staggered on plan or elevation, and with absorbent lining of the window reveals (see Figure 3.3). In situ, the degree of attenuation provided by an open window also depends on the spectrum of the noise and the geometry of the situation.

The spreadsheet of sound reduction indices on the DfES website (www.teachernet.gov.uk/acoustics) gives values of R_W for various types of window, glazing thickness, and air gap. Indications are also given of the sound reduction indices of open windows.

3.5 External Doors

For external doors the airborne sound insulation is determined by the door set, which is the combination of door and frame. The quality of the seal achieved around the perimeter of the door is crucial in achieving the potential performance of the door itself. Effective seals should be provided at the threshold, jambs and head of the door frame. As with windows, neoprene compression seals are more effective than brush seals, but their effectiveness will be strongly influenced by workmanship on site. Brush seals can however be effective and tend to be more hard wearing than compression seals.

It is also important that an airtight seal is achieved between the perimeter of the door frame and the opening into which it is to be fixed. The opening should be accurately made to receive the door frame and any gaps around the perimeter packed with insulating material prior to application of a continuous, airtight seal on both sides.

A high level of airborne sound

insulation is difficult to provide using a single door; however, it can be achieved by using a lobby with two sets of doors, as often provided for energy efficiency, or a specialist acoustic doorset.

Calculations and tests for sound insulation of the building envelope

There are two methods by which it is possible to calculate the indoor ambient noise levels due to external noise.

The first method is to calculate the indoor ambient noise level according to the principles of BS EN 12354-3:2000[9]. An Excel spreadsheet to calculate the sound insulation of building envelopes, based on BS EN 12354-3:2000 is available via the DfES website (www.teachernet.gov.uk/acoustics). The principles of this calculation spreadsheet are given in Appendices 5 and 6

The second method is to calculate the indoor ambient noise level using the measured façade sound insulation data from an identical construction at another site.

3.6 Subjective characteristics of noise

The indoor ambient noise levels in Table 1.1 provide a reasonable basis for assessment, but some noises have tonal or intermittent characteristics which make them particularly noticeable or disturbing, even below the specified levels. This is most common with industrial noise. At a minority of sites, achieving the levels in Table 1.1 will not prevent disturbance from external industrial sources, and additional noise mitigation may be required. In these cases advice from an acoustic consultant should be sought.

The potentially beneficial masking effect of some types of continuous broadband external noise (such as road traffic noise) must also be borne in mind, see Section 2.12. This noise may partially mask other sounds, such as from neighbouring classrooms, which may be more disturbing than the external noise. There are acoustic benefits, as well as cost benefits, in ensuring that the level of insulation provided is not over-specified but is commensurate with the external noise.

3.7 Variation of noise incident on different facades

It may be convenient to determine the external noise level at the most exposed window (or part of the roof) of a building, and to assume this exposure for other elements too. This may be suitable at the early design stage for large schools. However, where external noise levels vary significantly, this approach can lead to over-specification and unnecessary cost.

3.8 Calculations

A calculation of the internal noise level according to BS EN 12354-3:2000 can be used to estimate whether, for the levels of external noise at any particular site, a proposed construction will achieve the levels in Table 1.1. By estimating the internal levels for various different constructions, designers can determine the most suitable construction in any given situation. BS EN 12354-3:2000 allows the effect of both direct and flanking transmission to be calculated, but in many cases it is reasonable to consider only direct transmission.

3.9 Test method

Field testing of an existing building envelope should be conducted according to BS EN ISO 140-5:1998[10], with reference to the clarifications given in this section.

BS EN ISO 140-5:1998 sets out various test methods. The three ‘global’ tests using the prevailing external noise source(s) (road traffic, railway traffic, air traffic) are preferable. At most sites road traffic is likely to be the dominant source of noise, and the corresponding standardised level difference is denoted $D_{tr,2m,nT}$. Where aircraft noise is the major concern measurements should be made accordingly, and the standardised level difference denoted $D_{at,2m,nT}$. Similarly the standardised level difference using railway noise as the source is denoted $D_{rt,2m,nT}$.

The global loudspeaker test method (which generates $D_{ls,2m,nT}$ values) may be used only if the prevailing external noise sources are insufficient to generate an adequate internal level.

It is reasonable, under certain conditions as specified below, to use the test results to indicate the likely performance of building envelopes of a similar construction, exposed to similar sources. If the conditions are not met then it is not reasonable to infer the performance from existing sound insulation test results and the calculation procedure should be used.

3.9.1 Conditions for similar constructions

The following features of any untested construction should be similar to those of the tested construction:

- type and number of ventilators
- glazing specification, frame construction and area of windows
- type and number of doors
- external wall construction and area
- roof construction and area.

3.9.2 Conditions for similar sources

Only test results in terms of $D_{tr,2m,nT}$, $D_{at,2m,nT}$, $D_{rt,2m,nT}$ and $D_{ls,2m,nT}$ values are applicable, and these should not be used interchangeably. The following features concerning the prevailing sources of noise should be similar to those of the previously tested construction:

- relative contributions of road traffic, railway and aircraft noise
- orientation of the building relative to the main noise source(s)
- ground height of the building relative to the main noise source(s)

SOUND INSULATION BETWEEN ROOMS

This section describes constructions capable of achieving the different levels of sound insulation specified in Tables 1.2 and 1.4.

Appendix 1 describes how sound insulation between adjacent rooms is measured and calculated.

In addition to the transmission of direct sound through the wall or floor, additional sound is transmitted into the receiving room via indirect, or 'flanking' paths, see Figure 3.4.

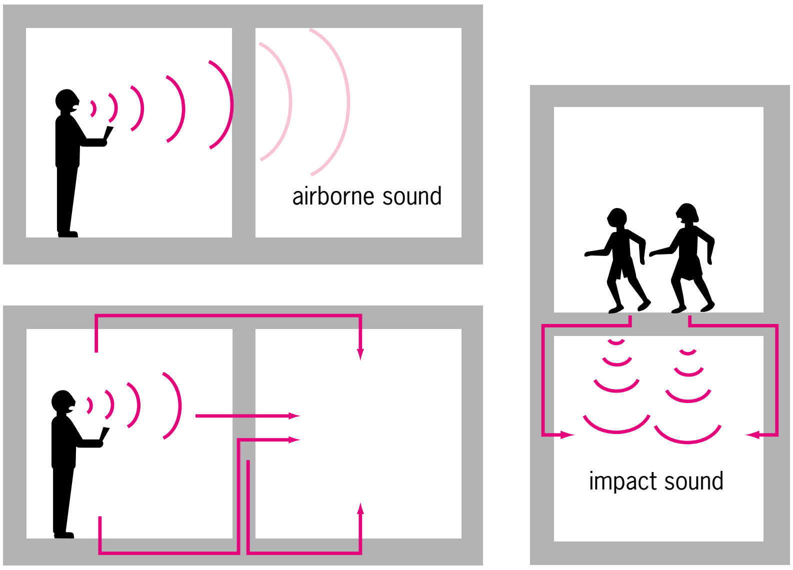


Figure 3.4: Sound transmission paths between adjacent rooms: direct sound paths through the wall and floor and flanking paths through the surrounding ceiling, wall and floor junctions

3.10 Specification of the airborne sound insulation between rooms using R_w

Table 1.2 describes the minimum weighted sound level difference between rooms in terms of $D_{nT(T_{mf,max}),w}$. However, manufacturers provide information for individual building elements based on laboratory airborne sound insulation data measured according to BS EN ISO 140-3:1995[5], in terms of the sound reduction index, R_w. Figure 3.5 shows the values of R_w for some typical building elements.

This section provides some basic guidance for the designer on how to use laboratory R_w values to choose a suitable separating wall or floor for the initial design. However, specialist advice should always be sought from an acoustic consultant early on in the design stage to assess whether the combination of the separating and flanking walls is likely to achieve the performance standard in Table 1.2. An acoustic consultant can use advanced methods of calculation to predict the sound insulation (eg Statistical Energy Analysis or BS EN 12354-1:2000[11]). The correct specification of flanking walls and floors is of high importance because incorrect specification of flanking details can lead to reductions in

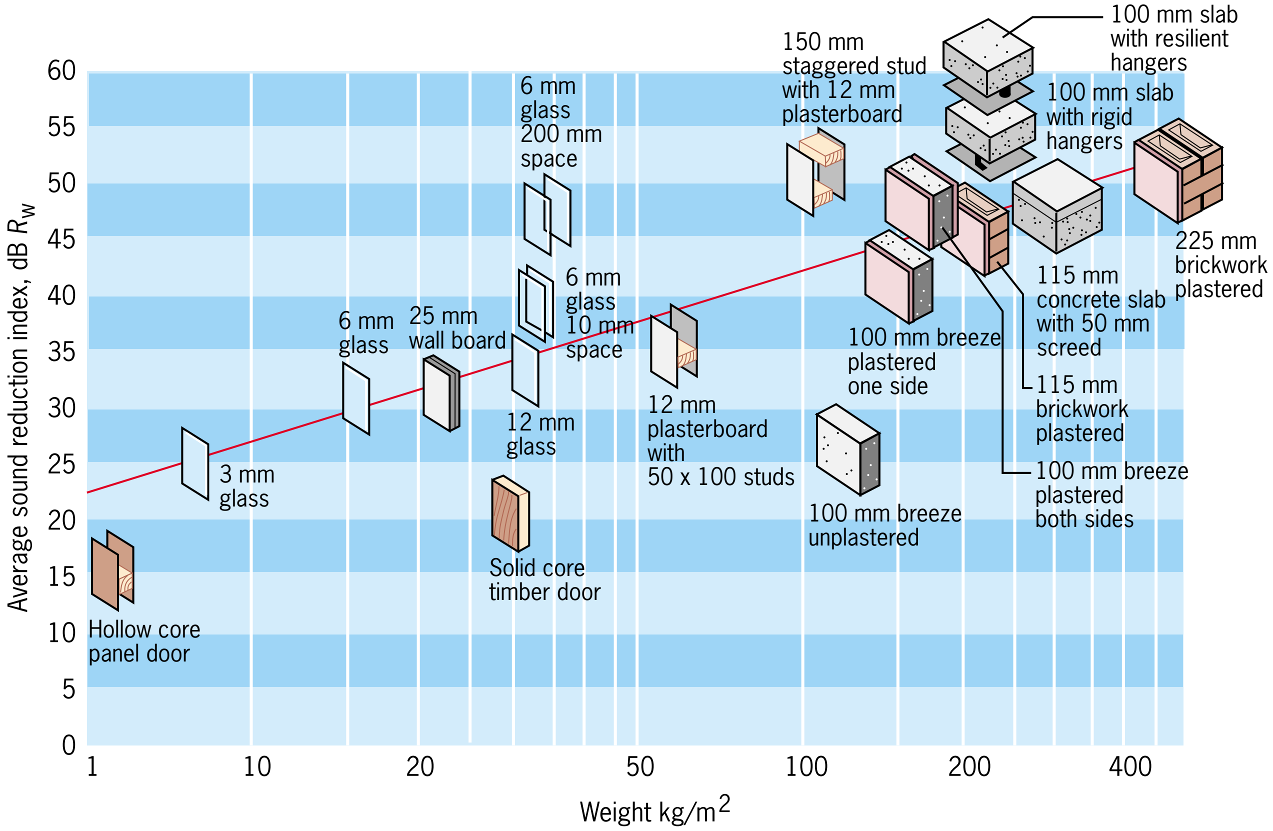


Figure 3.5: Typical sound insulation figures for construction elements, dB R_w

the expected performance of up to 30 dB.

The following procedure can be used to choose an appropriate type of separating wall or floor before seeking specialist advice on appropriate flanking details.

1. Determine from Table 1.2 the required minimum weighted BB93 standardised sound level difference between rooms, $D_{nT(T_{mf,max}),w}$.

2. Estimate the required weighted sound reduction index for the separating wall or floor.

a. Use the following formula to provide an initial estimate of the measured sound reduction index ($R_{w,est}$) that should be achieved by the separating wall or floor in the laboratory.

$$R_{w,est} = D_{nT(T_{mf,max}),w} + 10 \lg \left(\frac{S T_{mf,max}}{V} \right) + 8 \text{ dB}$$

where $D_{nT(T_{mf,max}),w}$ is the minimum weighted BB93 standardized level difference between rooms from Table 1.2.

S is the surface area of the separating element (m^2)

$T_{mf,max}$ is the maximum value of the reverberation time T_{mf} for the receiving room from Table 1.5 (s)

V is the volume of the receiving room (m^3).

b. Estimate the likely reduction in the airborne sound insulation that would occur in the field, to account for less favourable mounting conditions and workmanship than in the laboratory test. X can be estimated to be 5 dB assuming that flanking walls and floors are specified with the correct junction details. However, if flanking walls and floors are not carefully designed then poor detailing can cause the airborne sound insulation to be reduced by up to 30 dB. To allow the designer to choose a suitable separating wall for the initial design it is recommended that X of 5 dB is assumed and an acoustic consultant is used to check the choice of separating element and ensure that the correct flanking details are specified.

c. Calculate the final estimate for the weighted sound reduction index R_w that should be used to select the separating wall or floor from laboratory test data:

$$R_w = R_{w,est} + X \text{ dB}$$

3.10.1 Flanking details

A simplified diagram indicating the main flanking transmission paths is shown in Figure 3.6. General guidance on flanking details for both masonry and framed constructions can be found in Approved Document E. Specific guidance on flanking details for products can also sometimes be found from manufacturers' data sheets, or by contacting manufacturers' technical advisers.

3.10.2 Examples of problematic flanking details

In some buildings it is considered desirable to lay a floating screed (eg a sand-cement screed laid upon a resilient material) across an entire concrete floor and build lightweight partitions off the screed to form the rooms, see Figure 3.7(a). This allows the flexibility to change the room spaces. However, a continuous floating screed can transmit a significant quantity of structure-borne flanking sound from one room to another.

For example, if a lightweight partition with 54 dB R_w was built off a continuous floating screed the actual sound insulation could be as low as 40 dB $D_{nT(T_{mf,max}),w}$. In fact, even if a more expensive partition with a higher performance of 64 dB R_w was built, the actual sound insulation would still be 40 dB $D_{nT(T_{mf,max}),w}$, because the majority of sound is being transmitted via the screed, which is the dominant flanking path. This demonstrates the importance of detailing the junction between the screed and the lightweight partition. To reduce the flanking transmission, the floating screed should stop at the lightweight partition, see Figure 3.7(b).

Another flanking detail that can cause problems is where a lightweight profiled metal roof deck runs across the top of a separating partition wall. With profiles such as trapezoidal sections, it is very difficult for builders to ensure that they do not leave air paths between the top of the partition wall and the roof.

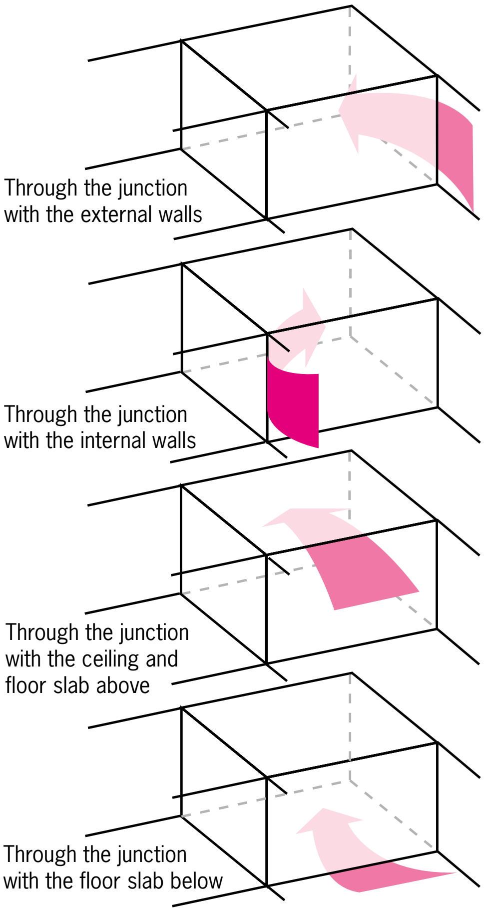


Figure 3.6: The four main flanking transmission paths

3.10.3 Junctions between ceilings and internal walls

Ceilings should be designed in relation to internal walls to achieve the required combined performance in respect of sound insulation, fire compartmentation and support.

In the case of suspended ceiling systems

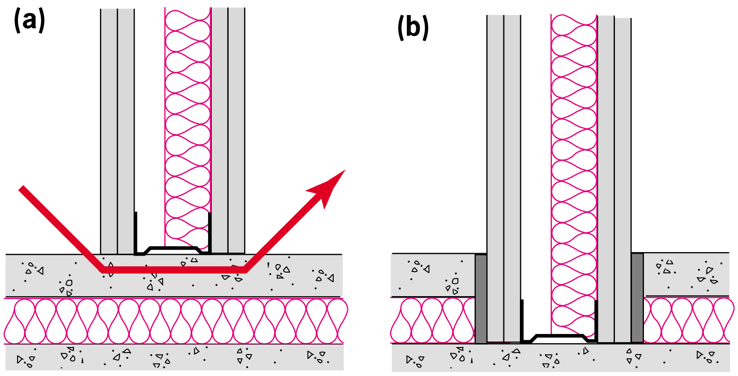


Figure 3.7:
(a) Flanking transmission via floating screed
(b) Corrective detailing

the preferred relationship is one in which partitions or walls pass through the suspended ceiling membrane, do not require support from the ceiling system, and combine with the structural soffit above to provide fire resisting compartmentation and sound insulation.

The alternative relationship in which partitions or walls terminate at, or just above the soffit of a suspended ceiling, is not recommended as it demands a ceiling performance in respect of fire resistance and sound insulation which is difficult to achieve and maintain in practice in school buildings. This is because the number of fittings required at ceiling level is incompatible with testing of fire resistance to *BS 476 Fire tests on Buildings and Structures* [12], which is based on a test specimen area of ceilings without fittings. Furthermore, the scale and frequency of access to engineering services in the ceiling void through the membrane (in respect of fire) and through insulation backing the membrane (in respect of sound) is incompatible with maintenance of these aspects of performance.

3.11 Specification of the impact sound insulation between rooms using $L_{n,w}$

Table 1.4 describes the minimum impact sound insulation between rooms in terms of $L'_{nT(T_{mf,max}),w}$. However, manufacturers usually provide information for floors based on laboratory impact sound insulation data measured according to BS EN ISO 140-6:1998[13], in terms of $L_{n,w}$.

This section provides some basic guidance for the designer on how to use laboratory $L_{n,w}$ values to design a suitable separating floor. However, specialist advice should always be sought from an acoustic consultant early on in the design process to assess whether the combination of the separating floor and flanking walls is likely to achieve the performance standard in Table 1.4. An acoustic consultant can use advanced methods of calculation to predict the sound insulation (eg, Statistical Energy Analysis or BS EN 12354-2:2000[14]).

The following procedure can be used to choose an appropriate type of separating floor before seeking specialist advice on flanking details from an acoustic consultant.

1. Determine the maximum weighted BB93 standardised impact sound pressure level, $L'_{nT(T_{mf,max}),w}$ from Table 1.4.

2. Estimate the required weighted normalised impact sound pressure level for the separating floor, as follows:

a. Use the following formula to provide an initial estimate of the weighted normalised impact sound pressure level ($L_{n,w,est}$) that should be achieved by the separating floor in the laboratory:

$$L_{n,w,est} = L'_{nT(T_{mf,max}),w} + 10 \lg \frac{V}{T_{mf,max}} - 18 \text{ dB}$$

where $L'_{nT(T_{mf,max}),w}$ is the maximum weighted BB93 standardised impact sound pressure level from Table 1.4
V is the volume of the receiving room (m^3)
$T_{mf,max}$ is the maximum value of the reverberation time T_{mf} for the receiving room from Table 1.5 (s).

b. Estimate the likely increase in the impact sound pressure level that would occur in the field (ie, account for favourable mounting conditions and good workmanship in the laboratory test), X.

X can be 5 dB assuming that flanking walls are specified with the correct junction details. However, if flanking walls are not carefully designed the impact sound pressure level can increase by up to 10 dB. To allow the designer to choose a suitable separating floor for the initial design it is suggested that an X of 5 dB is assumed and an acoustic consultant is used to check the choice of separating floor and ensure that the correct flanking details are specified.

c. Calculate the final estimate for the weighted normalised impact sound pressure level $L_{n,w}$ that should be used to select the separating wall or floor from laboratory test data.

$$L_{n,w} = L_{n,w,est} - X \text{ dB}$$

3.12 Internal walls and partitions

3.12.1 General principles

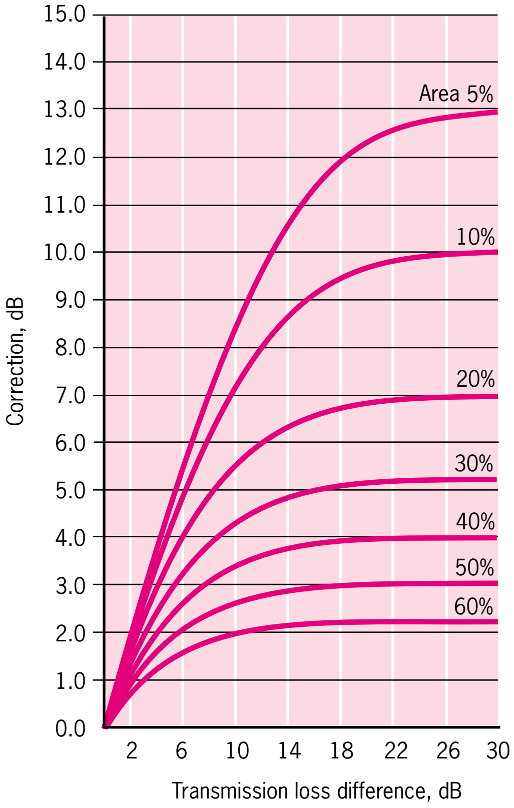
Figure 3.5 shows typical values of the sound reduction index (R_w) for different wall constructions. For comparison the performance of other constructions including doors, glazing and floors is included.

The solid line shows the theoretical value based purely on the mass law. For single leaf elements (eg walls, single glazing, doors, etc) the mass law states that doubling the mass of the element will give an increase of 5 to 6 dB in R_w . When constructions provide less sound insulation than predicted by the mass law it is usually because they are not airtight.

In general, lightweight double-leaf constructions such as double glazing, cavity masonry or double-leaf plasterboard partitions provide better sound insulation than the mass law would indicate. At medium and high frequencies, double-leaf constructions benefit from the separation of the two leaves, with performance increasing with the width of the air gap between the leaves and the physical separation of the leaves. (Note that for double-leaf plasterboard constructions, timber studwork is rarely used to achieve high standards of sound insulation because lightweight metal studs provide better mechanical isolation between the leaves.)

At low frequencies the performance of plasterboard partitions is limited by the mass and stiffness of the partition. Therefore, masonry walls can provide better low frequency sound insulation simply because of their mass. This is not obvious from the R_w figures, as the R_w rating system lends more importance to insulation at medium and high frequencies rather than low frequencies. This is not normally a problem in general classroom applications where sound insulation is mainly required at speech frequencies. However, it can be important in music rooms and in other cases where low frequency sound insulation is important.

Figure 3.8: Chart for estimating transmission loss (TL) for a composite wall consisting of 2 elements of differing transmission losses



The percentage of the total area of the wall occupied by the element with the lower transmission loss, eg a door, and the difference between the higher TL and the lower TL, are used to calculate the correction in dB which is added to the lower TL to give the TL of the whole wall.

For example: Assume a classroom to corridor wall has an R_w of 45 dB and a door in the wall has an R_w of 30 dB. If the area of the door is 0.85 m x 2.1 m = 1.785 m^2 and the area of the wall is 7 m x 2.7 m = 18.9 m^2, then the percentage of the wall occupied by the door is 1.785/18.9 x 100 = 9.4%

The difference in TLs = 15 dB.

Therefore reading from the chart gives a correction of about 9 dB to be added to the lower TL, giving a composite TL of 39 dB.

If a higher performance door of say 35 dB had been used, the composite TL would be 35 + 7 = 42 dB.

A combination of masonry and dry-lining can be very effective in providing reasonable low frequency performance linked with high sound insulation at higher frequencies. This combination is often useful when increasing the sound insulation of existing masonry walls.

While partition walls may be provided as a means of achieving sound reduction, it should be remembered that sound insulation is no better than that provided by the weakest element.

Figure 3.8 can be used to assess the overall effect of a composite construction such as a partition with a window, door, hole or gap in it. The sound insulation of the composite structure is obtained by relating the areas and sound insulation values of the component parts using the graph.

Partitions should be well sealed, as small gaps, holes, etc. significantly reduce sound insulation. (Note that this applies to porous materials, eg porous blockwork, which can transmit a significant amount of sound energy through the pores.)

3.12.2 Sound insulation of common constructions

Figure 3.9 shows the approximate weighted sound reduction index R_w for masonry and plasterboard constructions.

Using the procedures given in Section 3.10, it is possible to determine which constructions are capable of meeting the requirements between different types of rooms.

The values in Figure 3.9 are necessarily approximate and will depend on the precise constructions and materials used. Many blockwork and plasterboard manufacturers provide data for specific constructions. When using manufacturers' data it should always be ascertained that the data is tested to the standards given in Section 1, and details of the precise construction used should be sought. For example, in masonry constructions, the thickness and density of plaster and rendering have a significant effect.

Some more specific sound reduction indices, both single value and octave band data, and further references to specific manufacturers' data are in the sound reduction indices spreadsheet included on the DfES website www.teachernet.gov.uk/acoustics.

3.12.3 Flanking transmission

In general, a weighted sound level difference of up to 50 dB D_w can be achieved between adjacent rooms by a single partition wall using one of the constructions described above, provided that there are no doors, windows or other weaknesses in that partition wall, and flanking walls/floors with their junction details are carefully designed. Flanking transmission is critical in determining the actual performance and specialist advice should be sought from an acoustic consultant.

3.12.4 High performance constructions – flanking transmission

High-performance plasterboard partitions or masonry walls with independent linings can provide airborne sound insulation as high as 70 dB R_w in the laboratory. However, to achieve high performance in practice (ie above 50 dB D_w), flanking walls/floors with their junction details must be carefully designed. Airborne sound insulation as high as 65 dB D_w can be achieved on site using high performance plasterboard partitions, or masonry walls with independent linings with lightweight isolated floors and independent ceilings to control flanking transmission. This will require specialist advice from an acoustic consultant.

For rooms which would otherwise need high-performance partitions it may be possible to use circulation spaces, stores and other less noise-sensitive rooms to act as buffer zones between rooms such that partitions with lower levels of sound insulation can be used. Case Study 7.4 (see also Figure 2.4) describes a purpose built music suite which uses buffer zones effectively. In some cases, such as the refurbishment of music facilities in existing buildings, room layout may not allow this, and in these cases high levels of sound insulation between adjacent rooms will be required.

Figure 3.9: Walls - sound reduction index for some typical wall constructions

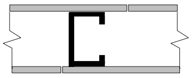
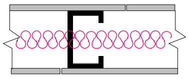
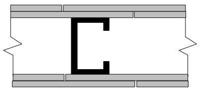
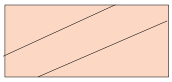
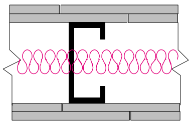
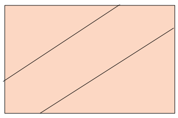
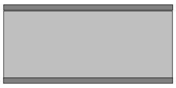
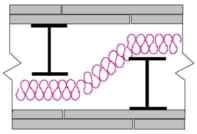
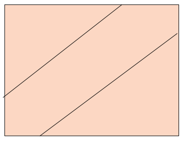
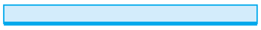
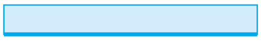
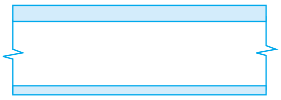
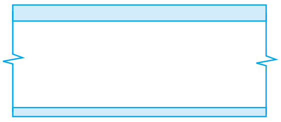
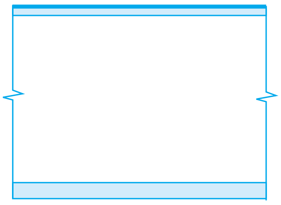
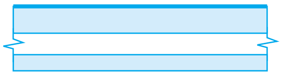
Performance R_w		**Walls - typical forms of construction**
		1x12.5 mm plasterboard each side of a metal stud (total width 75 mm)
		75 mm block (low density 52 kg/m^2) plastered/rendered 12 mm one side
40–45		1x12.5 mm plasterboard each side of a 48 mm metal stud with glass fibre/mineral wool in cavity (total width 75 mm)
		100 mm block (low density 70 kg/m^2) fair faced
45–50		2x12.5 mm plasterboard each side of a 70 mm metal stud (total width 122 mm)
		112 mm fair faced brick (unplastered)
		100 mm block (medium density 140 kg/m^2) plastered/rendered 12 mm both sides
50–55		2x12.5 mm plasterboard each side of a 150 mm metal stud with glass fibre/mineral wool in cavity (total width 198 mm)
		224 mm fair faced brick (unplastered)
		150 mm block (high density 315 kg/m^2) plastered/rendered 12 mm both sides
55–60		2x12.5 mm plasterboard each side of a staggered 60 mm metal stud with glass fibre/mineral wool in cavity (total width 178 mm)
		336 mm fair faced brick (unplastered)

Figure 3.10: Glazing - sound reduction index for some typical glazing constructions

Performance R_w (+/– 3 dB)		Glazing - typical forms of construction
25		4 mm single float (sealed)
28		6 mm single float (sealed)
		4/12/4: 4 mm glass/12 mm air gap/4 mm glass
30		6/12/6: 6 mm glass/12 mm air gap/6 mm glass
		10 mm single float (sealed)
33		12 mm single float (sealed)
		8/12/16: 8 mm glass/12 mm air gap/16 mm glass
35		10 mm laminated single float (sealed)
		4/12/10: 4 mm glass/12 mm air gap/10 mm glass
38		6/12/10: 6 mm glass/12 mm air gap/10 mm glass
		12 mm laminated single float (sealed)
40		10/12/6 lam: 10 mm glass/12 mm air gap/6 mm laminated glass
		19 mm laminated single float (sealed)
		10/50/6: 10 mm glass/50 mm air gap/6 mm glass
43		10/100/6: 10 mm glass/100 mm air gap/6 mm glass
		12 lam/12/10: 12 mm laminated glass/12 mm air gap/10 mm glass
45		6 lam/200/10: 6 mm laminated glass/200 mm air gap/10 mm + absorptive reveals
		17 lam/12/10: 17 mm laminated glass/12 mm air gap/10 mm glass

3.12.5 Corridor walls and doors

The R_w values in Table 1.3 should be used to specify wall (including any glazing) and door constructions between corridors or stairwells and other spaces. To ensure that the door achieves its potential in terms of its airborne sound insulation, it must have good perimeter sealing, including the threshold where practical.

Note that a lightweight fire door will usually give lower sound insulation than a heavier, sealed acoustic door.

Greatly improved sound insulation will be obtained by having a lobby door arrangement between corridors or stairwells and other spaces. However, this is not often practicable between classrooms and corridors. Some noise transmission from corridors into classrooms is inevitable, but this may not be important if all lesson changes occur simultaneously.

For some types of room, such as music rooms, studios and halls for music and drama performance, lobby doors should generally be used.

3.13 Internal doors, glazing, windows and folding partitions

Internal doors, glazing and windows are normally the weakest part of any separating wall. Figures 3.10 and 3.11 show the performance of a number of different types of door and window. In general, rooms which require at least 35 dB D_w should not have doors or single glazing in the separating wall or partition.

3.13.1 Doors

The choice of appropriate doors with good door seals is critical to maintaining effective sound reduction, and controlling the transfer of sound between spaces.

Internal doors are often of lightweight hollow core construction, providing only around 15 dB R_w which is about 30 dB less than for a typical masonry wall (see Figure 3.5). The sound insulation of an existing door can be improved by increasing its mass (eg by adding two layers of 9 mm plywood or steel facings) as long as the frame and hinges can support the additional weight. However, it is often simpler to fit a new door.

The mass of a door is not the only variable that ensures good sound insulation. Good sealing around the frame is crucial. Air gaps should be minimised by providing continuous grounds to the frame which are fully sealed to the masonry opening. There should be a generous frame rebate and a proper edge seal all around the door leaf. Acoustic seals can eliminate gaps between the door and the door frame to ensure that the door achieves its potential in terms of its airborne sound insulation.

As a rule of thumb, even a good quality acoustically sealed door in a 55 dB R_w wall between two classrooms will reduce the R_w of the wall so that the $D_{nT(T_{mf,max}),w}$ is only 30-35 dB. Two such doors, separated by a door lobby, are necessary to maintain the sound insulation of the wall. Figure 3.12 shows the effect of different doors on the overall sound insulation of different types of wall. In a conventional layout with access to classrooms from a corridor, the corridor acts as a lobby between the two classroom doors.

3.13.2 Lobbies

Some more specific sound reduction indices, both single value and octave band data, and further references to specific manufacturers' data are in the sound reduction indices spreadsheet included on the DfES website www.teachernet.gov.uk/acoustics. The greater the distance between the doors, the better the sound insulation, particularly at low frequencies. Maximum benefit from a lobby is associated with offset door openings as shown in Figure 3.13(a) and acoustically absorbent wall and/or ceiling finishes.

A lobby is useful between a performance space and a busy entrance hall. Where limitations of space preclude a lobby, a double door in a single wall will be more effective than a single door; this configuration is illustrated in Figure 3.13(b).

Inter-connecting doors between two music spaces should be avoided and a lobby used to provide the necessary airborne sound insulation.

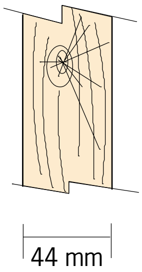
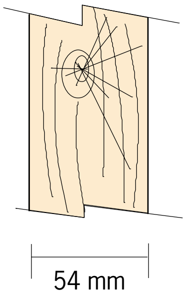
Acoustic performance	Typical construction
30 dB R_w  44 mm thick timber door, half hour fire rated	This acoustic performance can be achieved by a well fitted solid core doorset where the door is sealed effectively around its perimeter in a substantial frame with an effective stop. A 30 minute fire doorset (FD30) can be suitable. Timber FD30 doors often have particle cores or laminated softwood cores with a mass per unit area ≈ 27 kg/m^2 and a thickness of ≈ 44 mm. Frames for FD30 doors often have a 90 mm x 40 mm section with a stop of at least 15 mm. Compression or wipe seals should be used around the door's perimeter along with a threshold seal beneath. A drop-down or wipe type threshold seal is suitable. Doors incorporating 900 mm x 175 mm vision panels comprising 7 mm fire resistant glass can meet this acoustic performance.
35 dB R_w  54 mm thick timber door, one hour fire rated	This acoustic performance can be achieved by specialist doorsets although it can also be achieved by a well fitted FD60 fire doorset where the door is sealed effectively around its perimeter in a substantial frame with an effective stop. Timber FD60 doors often have particle core or laminated softwood cores with a mass per unit area ≈ 29 kg/m^2 and a thickness of ≈ 54 mm. Using a core material with greater density than particle or laminated softwood can result in a door thickness of ≈ 44 mm. Frames for FD60 doors can have a 90 mm x 40 mm section with stops of at least 15 mm. Compression or wipe seals should be used around the door's perimeter along with a threshold seal beneath. A drop-down or wipe type threshold seal is suitable. Doors incorporating 900 mm x 175 mm vision panels comprising 7 mm fire resistant glass can meet this performance.

Figure 3.11: Doors - sound reduction index for some typical door construtions

NOTES ON FIGURE 3.11

1. Care should be taken to ensure that the force required to open doors used in schools is not excessive for children. To minimise opening forces, doors should be fitted correctly and good quality hinges and latches used. Door closers should be selected with care.
2. The opening force at the handles of doors used by children aged 5–12 should not exceed 45 N.
3. Manufacturers should be asked to provide test data to enable the specification of door-sets.
4. Gaps between door frames and the walls in which they are fixed should be ≤ 10 mm.
5. Gaps between door frames and the walls in which they are fixed should be filled to the full depth of the wall with ram-packed mineral wool and sealed on both sides of the wall with a non-hardening sealant.
6. Seals on doors should be regularly inspected and replaced when worn.

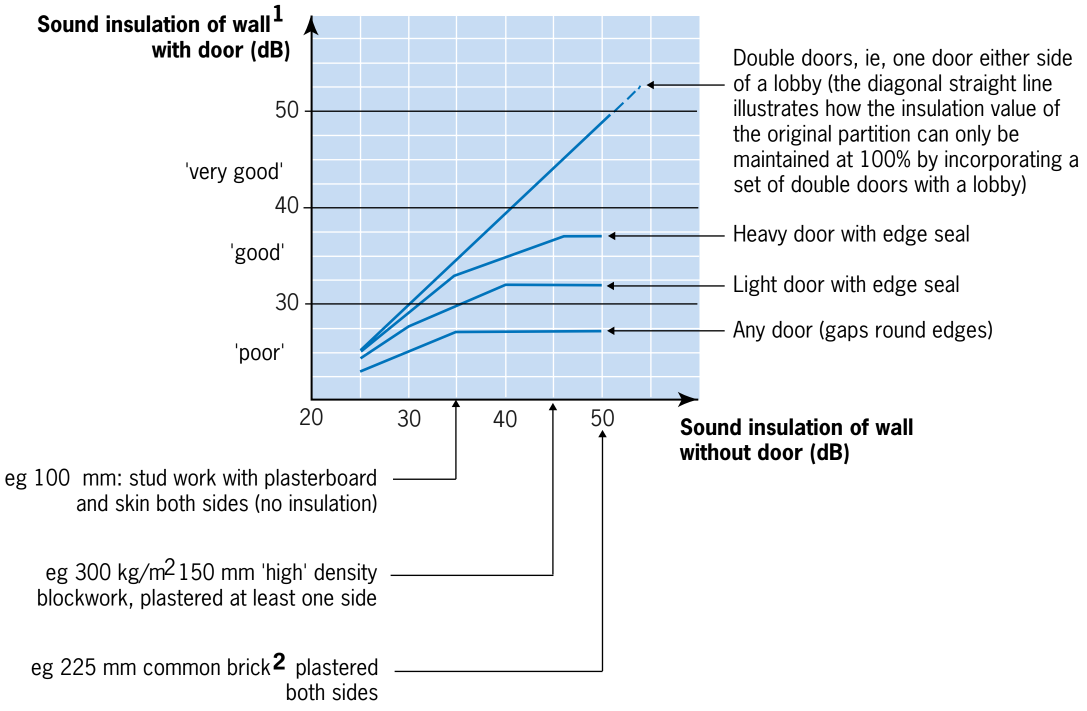


Figure 3.12: Reduction of sound insulation of a wall incorporating different types of door
1 For mean sound insulation values for various partition/door combinations refer to Figure 3.8.
2 Values in examples given are for illustative purposes only, ie, they are not absolute.

3.13.3 Folding walls and operable partitions

Folding walls and operable partitions are sometimes used to provide flexibility in teaching spaces or to divide open plan areas. A standard folding partition with no acoustic seals or detailing may provide a value as low as 25 dB R_w . However, folding partitions of very high acoustic quality are available; these can provide up to 55 dB R_w but as well as being costly these are very heavy (typically 55-65 kg/m^2) and, unless electrically operated, are time-consuming to open and close. The sound insulation depends on effective acoustic sealing and deteriorates if seals or tracks are worn or damaged.

Folding partitions are useful in many applications but they should only be used when necessary and not as a response to a non-specific desire for flexibility in layout of teaching areas.

3.13.4 Roller shutters

Roller shutters are sometimes used to separate kitchens from multi-purpose spaces used for dining. Because roller shutters typically only provide sound insulation of around 20 dB R_w it is common for noise from the kitchen to disturb the teaching activities. One solution is to provide doors in front of the shutters to improve the sound insulation.

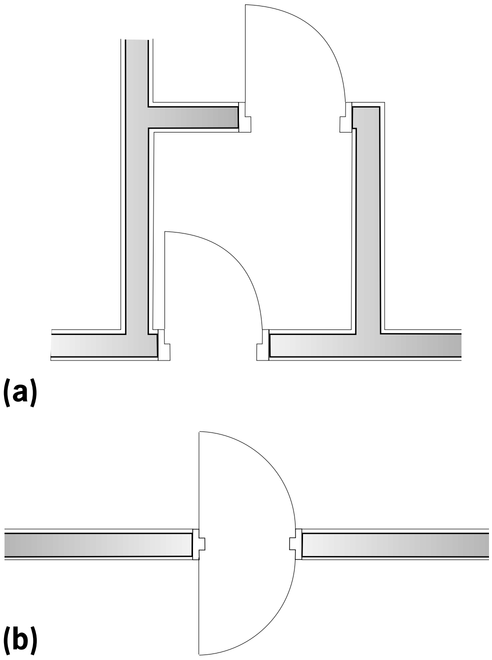
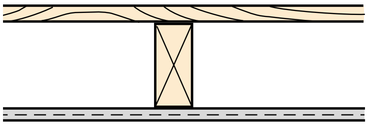
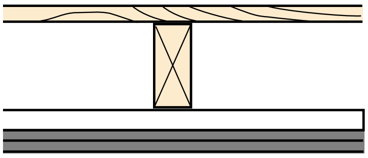
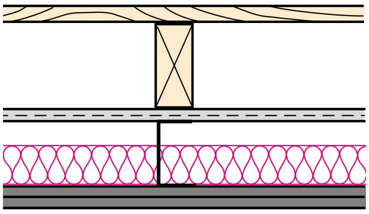
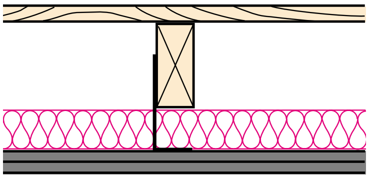
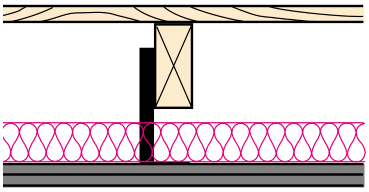
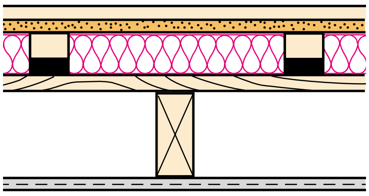
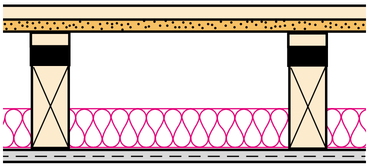


Figure 3.13: Use of lobbies and double doors
(a) Lobbied doorway
(b) Double door

Figure 3.14: Existing timber floors - sound reduction index for some typical floor/ceiling constructions

Option	**Construction - timber floors**		R_w	L_{nw}	depth mm
1	Basic timber floor consisting of 15 mm floorboards on 150-200 mm wooden joists, plaster or plasterboard ceiling fixed to joists		35–40	80–85	180–230
2	As 1, ceiling consisting of one layer of 15 mm plasterboard and one layer of 12.5 mm dense plasterboard fixed to proprietary resilient bars on underside of joists		50–55	65–70	220–270
3	As 1, ceiling retained, with suspended ceiling consisting of 2 layers of 15 mm wallboard or 2 layers of 12.5 mm dense plasterboard, suspended on a proprietary metal ceiling system to give 240 mm cavity containing 80-100 mm lightweight mineral wool (>10 kg/m^3)		55–60	60–65	450–500
4	As 1, ceiling removed, with suspended ceiling consisting of 2 layers of 15 mm wallboard or 2 layers of 12.5 mm dense plasterboard, suspended on a proprietary metal ceiling system to give 275 mm cavity containing 80-100 mm lightweight mineral wool (>10 kg/m^3)		55–60	60–65	450–500
5	As 1, ceiling removed, with suspended ceiling consisting of 2 layers of 15 mm wallboard or 2 layers of 12.5 mm dense plasterboard, suspended special resilient hangers to give 275 mm cavity containing 80-100 mm lightweight mineral wool (>10 kg/m^3)		60–65	55–60	450–500
6	As 1 with proprietary lightweight floating floor using resilient pads or strips (eg 15 mm tongue-and-groove floorboards on a 15 mm plywood, chipboard or fibre-bond board supported on 45 mm softwood battens laid on 25 mm thick open-cell foam pads). 80-100 mm lightweight mineral wool (>10 kg/m^3) laid on top of existing floorboards		50–55	60–65	270–320
7	As 1, floorboards removed and replaced with 15 mm tongue-and-groove floorboards on a 15 mm plywood, chipboard or fibre-bond board supported on 12 mm softwood battens laid on 25 mm thick open-cell foam pads bonded to the joists, 80-100 mm lighweight mineral wool (>10 kg/m^3) laid on top of existing ceiling		55–60	55–60	240–290

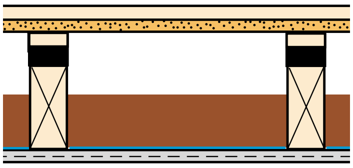
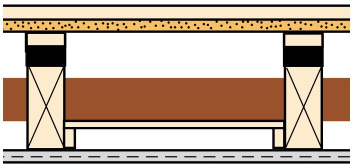
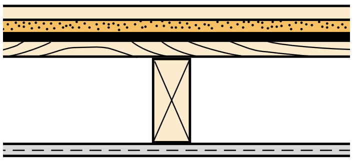
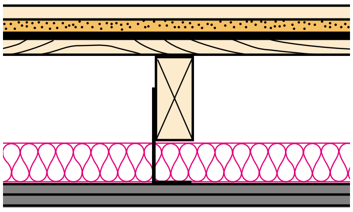
Option	Construction - timber floors		R_w	L_{nw}	depth mm
8	As 7 but mineral wool replaced by 100 mm pugging of mass 80 kg/m^2 on lining laid on top of ceiling		55–60	50–55	240–290
9	As 8 but with 75 mm pugging laid on top of board fixed to sides of joists		50–55	55–60	240–290
10	As 1 with proprietary lightweight floating floor using a continuous layer (eg 15 mm tongue-and-groove floorboards on a 15 mm plywood, chipboard or fibre-bond board on 6-12 mm thick continuous open-cell foam mat)		50–55	55–60	220–270
11	As 10, ceiling removed and replaced with suspended ceiling consisting of 2 layers of 15 mm wallboard or 2 layers of 12.5 mm dense plasterboard, suspended on a proprietary metal ceiling system to give 275 mm cavity containing 80-100 mm lightweight mineral wool (>10 kg/m^3)		60–65	50–55	360–410

Figure 3.14 Continued

NOTES ON FIGURE 3.14

1. Where resilient floor materials are used, the material must be selected to provide the necessary sound insulation under the full range of loadings likely to be encountered in that room and must not become over-compressed, break down or suffer from long-term ‘creep’ under the higher loads likely to be encountered. Where large ranges of loading are encountered, or where there are high point loads such as pianos, heavy furniture or operable partitions, the pad stiffness may have to be varied across the floor to take account of these.

2. All figures are approximate guidelines and will vary between different products and constructions. Manufacturers' data should be obtained for all proprietary systems and constructions. These must be installed in accordance with good practice and manufacturers' recommendations and all gaps sealed.

3.14 Floors and ceilings

Sound transmission between vertically adjacent rooms occurs through:

- airborne noise where the sound power is input into the room and is transmitted through the separating floor and its associated flanking constructions.
- impact noise where the structural power is input into the floor (eg through footfalls, chairs scraping, etc) and is transmitted through the separating floor and its associated flanking constructions.

Vertical noise transmission between classrooms can be a problem in older multi-storey buildings with wooden floors, such as traditional Victorian school buildings. Both airborne noise and impact noise can be problematic with wooden floors, and both problems need to be considered when dealing with vertically adjacent spaces. Adding carpets or other soft coverings to wooden floors reduces impact noise but has very little effect on airborne noise.

Impact noise can also be a problem with concrete floors (although airborne noise may not be a problem); this can sometimes be solved by adding a carpet.

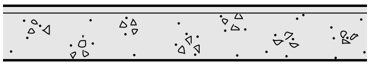
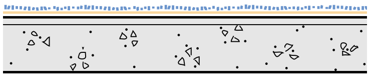
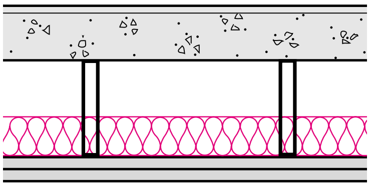
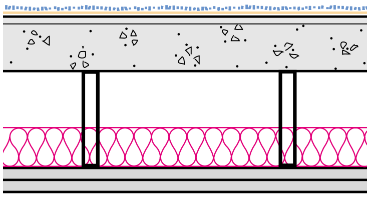
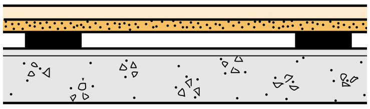
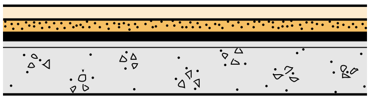
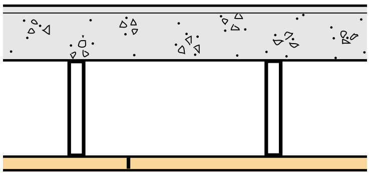
Option	**Construction - lightweight concrete floors**		R_w	L_{nw}	depth mm
1	Lightweight floor consisting of concrete planks (solid or hollow) or beam and blocks, with 30-50 mm screed, overall weight approximately 100 kg/m^2, no ceiling or floor covering		35–40	90–95	100–150
2	As 1 with soft floor covering >5 mm thick		35–40	75–85	105–155
3	As 1 with suspended ceiling consisting of 2 layers of 15 mm wallboard or 2 layers of 12.5 mm dense plasterboard, suspended on a proprietary metal ceiling system to give 240 mm cavity containing 80-100 mm lightweight mineral wool (>10 kg/m^3)		60–65	55–60	370–420
4	As 3 with soft floor covering >5 mm thick		60–65	50–55	375–425
5	As 1 with proprietary lightweight floating floor using resilient pads or strips (eg 15 mm tongue-and-groove floorboards on a 15 mm plywood, chipboard or fibre-bond board on 25 mm thick open-cell foam pads)		50–60	50–60	155–205
6	As 1 with proprietary lightweight floating floor using a continuous layer (eg 15 mm tongue-and-groove floorboards on a 15 mm plywood, chipboard or fibre-bond board on 6-12 mm thick continuous open-cell foam mat)		50–55	55–60	150–200
7	As 1 with heavyweight proprietary suspended sound insulating ceiling tile system		45–55	60–70	250–500

Figure 3.15: Lightweight concrete floors - sound reduction index of some typical constructions

3.14.1 Impact sound insulation

Impact noise on floors may arise from:

- foot traffic, particularly in corridors at break times/lesson changeover
- percussion rooms
- areas for dance or movement
- loading/unloading areas (eg in kitchens and workshops)
- machinery.

In general, impact noise should be reduced at source through use of soft floor coverings or floating floors.

Planning and room layout can be used to avoid impact noise sources on floors above noise-sensitive rooms. Soft floor coverings and floating floor constructions and independent ceilings are the most effective means of isolation, and resilient

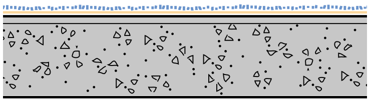
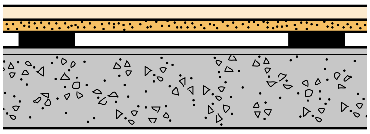
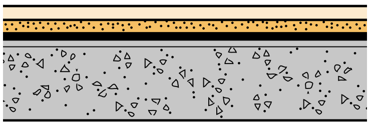
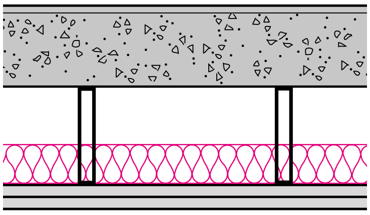
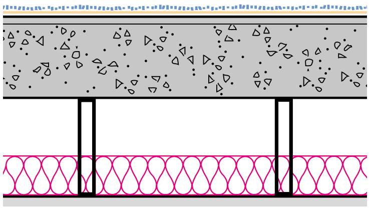
Option	**Construction - heavyweight concrete floors**		R_w	L_{nw}	depth mm
1	Solid concrete floor consisting of reinforced concrete with or without shuttering, concrete beams with infill blocks and screed, hollow or solid concrete planks with screed, of thickness and density to give a total mass of at least 365 kg/m^2, with soft floor covering >5 mm thick		50–55	60–65	150–200
2	As 1 with proprietary lightweight floating floor using resilient pads or strips (eg 15 mm tongue-and-groove floorboards on a 15 mm plywood, chipboard or fibre-bond board on 25 mm thick open-cell foam pads)		55–60	50–55	200–250
3	As 1 with proprietary lightweight floating floor using a continuous layer (eg 15 mm tongue-and-groove floorboards on a 15 mm plywood, chipboard or fibre-bond board on 6-12 mm thick continuous open-cell foam mat)		55–60	50–60	175–230
4	As 1 with suspended ceiling consisting of 2 layers of 15 mm wallboard or 2 layers of 12.5 mm dense plasterboard, suspended on a proprietary metal ceiling system to give 240 mm cavity containing 80-100 mm lightweight mineral wool (>10 kg/m^3)		60–70	55–60	420–470
5	As 4 with soft floor covering >5 mm thick		60–70	50–55	425–475

Figure 3.16: Heavyweight concrete floors - sound reduction index of some typical constructions

NOTES ON FIGURES 3.15 AND 3.16

1. Where "soft floor covering" is referred to this should be either a resilient material, or material with a resilient base, with an overall uncompressed thickness of at least 4.5 mm ; or any floor covering with a weighted reduction in impact sound pressure level of not less than 17 dB when measured in accordance with BS EN ISO 140-8:1998[15] and calculated in accordance with BS EN ISO 717-2:1997[16].

2. Where resilient floor materials are used, the material must be selected to provide the necessary sound insulation under the full range of loadings likely to be encountered in that room and must not become over-compressed, break down or suffer from long-term ‘creep’ under the higher loads likely to be encountered. Where large ranges of loading are encountered, or where there are high point loads such as pianos, heavy furniture or operable partitions, the pad stiffness may have to be varied across the floor to take account of these.

3. All figures are approximate guidelines and will vary between different products and constructions. Manufacturers' data should be obtained for all proprietary systems and constructions. These must be installed in accordance with good practice and manufacturers' recommendations and all gaps sealed.

floor finishes are also appropriate for some sources.

Typical airborne and impact noise performance are listed for a number of constructions in Figures 3.14, 3.15 and 3.16. Note that, unlike airborne sound insulation, impact sound insulation is measured in terms of an absolute sound level, so that a lower figure indicates a better standard of insulation. (See Appendix 1 for a more detailed explanation of airborne and impact sound insulation.)

3.14.2 Voids above suspended ceilings

Where partitions run up to the underside of lightweight suspended ceilings, the airborne sound insulation will be limited by flanking transmission across the ceiling void, which will often prevent the minimum values for airborne sound insulation in Table 1.2 being achieved. Therefore, partitions should either be continued through the ceiling up to the soffit, or a plenum barrier should be used.

3.14.3 Upgrading existing wooden floors using suspended plasterboard ceilings

Figure 3.14 shows the airborne and impact noise performance of a standard wooden floor with various forms of suspended plasterboard ceiling.

Option 2 is possibly the most widely used system of increasing both impact and airborne sound insulation, with or without the original plaster ceiling. In small rooms good results can be achieved using timber studs fixed only to the walls, but large timber sections are needed to span wider rooms.

In wider span rooms it is generally more convenient to suspend the plasterboard from the floor joists above, fixing through the existing ceiling if this is retained, using a proprietary suspension and grid system (option 4). The grid can be hung from simple metal strips or, for higher performance, special flexible ceiling hangers.

The major manufacturers of dry-lining systems all provide their own systems for these options, and provide sound insulation data and specifications for a variety of configurations. The performance for both airborne and impact sound improves with the depth of the ceiling void, with the mass of the ceiling and with the deflection of the ceiling hangers under the mass of the ceiling. Adding a layer of lightweight acoustically absorbent glass wool or mineral wool in the ceiling void increases the sound insulation, typically by 2-3 dB, but there is no point in adding more than specified.

Performance on site is strongly dependent on good workmanship to avoid air gaps, so careful attention should be given to ensuring that joints are close-butted, taped and filled and that all gaps are properly sealed. At the perimeter a small gap should be left between the plasterboard and the walls, and this should be sealed using non-setting mastic to allow a small amount of movement without cracking.

Penetrations through the ceiling need to be properly detailed to maintain an airtight seal while allowing movement, and services should not be allowed to provide a rigid link between the ceiling and the floor above. This can be a particular problem with sprinkler pipes. A problem with these constructions is that recessed light fittings, grilles and diffusers significantly reduce the sound insulation so any services should be surface-mounted.

The plasterboard finish is acoustically reflective whereas in some rooms an acoustically absorbent ceiling is required, to meet the specifications for room acoustics and reverberation times. One solution to this, if there is sufficient height, is to suspend a separate lightweight sound absorbing ceiling under the sound insulating plasterboard ceiling. This can be a standard lightweight composite or perforated metal tile system. These lightweight, acoustically absorbent, ceilings add very little to the sound insulation but do provide acoustic absorption. Lights and services can be recessed in the absorbent ceiling.

The term ‘acoustic ceiling’ generally refers to lightweight acoustically absorbent ceiling tile systems, designed to provide acoustic absorption. Note that these systems do not always increase the sound insulation as well.

There are, however, some systems which use relatively heavy ceiling tiles which are designed to fit into ceiling grids to provide a reasonably airtight fit. These may consist of dense plasterboard or mineral fibre products, or perforated metal tiles with metal or plasterboard backing plates. If properly installed and maintained these can provide a useful increase in sound insulation as well as acoustic absorption. Manufacturers of these systems can provide both airborne and impact sound insulation figures, as well as acoustic absorption coefficients. If no measured sound insulation data are provided, it is better to err on the side of caution and assume that the tile will not provide a significant increase in sound insulation.

The sound insulation performance figures quoted in Figure 3.14 all assume that the floorboards are in good condition and reasonably airtight, with thin carpet laid on top. If retaining the original floorboards it is good practice to fill in any gaps with glued wooden strips, caulking or mastic, or to lay hardboard on top, to provide an airtight seal. If not retaining the original boards, 18 mm tongue-and-grooved chipboard can be used to achieve the same effect, with all joints and gaps properly sealed, especially at the perimeters.

3.14.4 Upgrading existing wooden floors using platform and ribbed floors

The systems discussed in Section 3.14.3 all maintain the original wooden floor mounted directly on joists. This has the advantage of maintaining the original floor level at the expense of loss of ceiling height below. An alternative approach is to provide a floating floor system either on top of the existing floorboards (a platform floor) or to remove the existing floorboards and build a new floor on resilient material placed on top of the floor joists (a ribbed floor). In both cases the increase in both airborne and sound insulation relies on the mechanical isolation of the floor from the joists using resilient material.

Figure 3.14 shows a number of typical lightweight floating floor constructions and indicative sound insulation figures. There are many proprietary systems using a wide range of isolating materials and manufacturers should supply test data in accordance with ISO 140 measurements.

The isolating layer will typically consist of rubber, neoprene, open-cell or closed-cell foams, mineral fibre or composite materials. The isolating layer can be in the form of individual pads, strips or a continuous layer of material.

The sound insulation increases with the deflection of the resilient layer (up to the limit of elasticity for the material), with the mass of the floating layer and with the depth of the cavity. Adding a layer of lightweight acoustically absorbent glass wool or mineral wool in the ceiling void increases the sound insulation, typically by 2-3 dB, but there is no point in adding more than specified. In each case the deflection of the material under the permanent ‘dead’ load of the floating layer and the varying ‘live’ loads of occupants and furniture must be considered. If the material is too resilient and the floating layer is insufficiently heavy or rigid, the floor will deflect under the varying loads as people move about the room. For this reason it is advantageous for the floating layer to be as heavy and as stiff as practicable, in some cases using ply or fibre-bond board (for mass) laid on top of the resilient layer, with tongue-and-grooved chipboard on top of this.

If there are likely to be very heavy local loads in the room (eg pianos) it may be necessary to increase the stiffness of the resilient material, or, in the case of pads, to space the pads more closely together to support these loads.

Junctions with walls and at doors need to be designed to maintain an effectively airtight seal while allowing movement of the floating layer. Manufacturers generally provide their own proprietary solutions for this, with or without skirtings.

Lightweight floating floors are quite specialist constructions, and achieving the correct deflection under varying live loads without overloading the resilient material

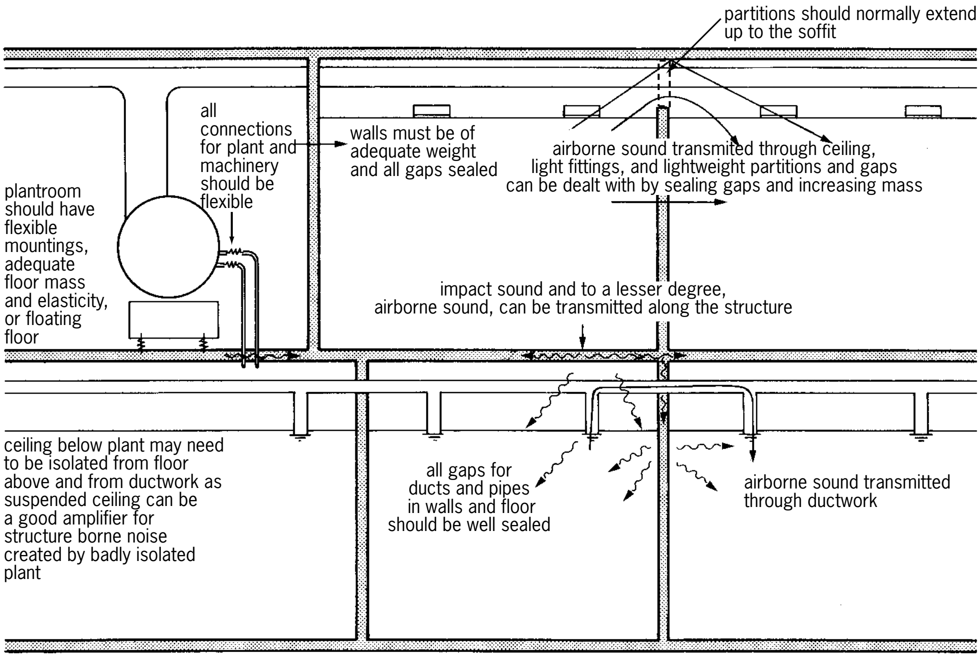


Figure 3.17: Possible sound transmission paths and their prevention

can be difficult. Most materials suffer from long term loss of elasticity or 'creep' under permanent loads and this should be taken into account in the design and selection of materials. The system manufacturer should normally be provided with all of the relevant information and required to specify a system to meet all of the acoustic and structural requirements over the expected lifetime of the floor. In difficult cases the advice of an acoustics consultant and/or structural engineer should be sought.

3.14.5 Concrete floors

In general concrete floors provide much greater airborne sound insulation than wooden floors by virtue of their greater mass. There are, however, considerable variations in performance between dense poured concrete floors and comparatively lightweight precast concrete plank floors. Impact sound transmission can be a problem even in heavy concrete floors because of the lack of damping in concrete, and a soft or resilient floor covering is generally required. This may simply be carpet on suitable underlay.

Figures 3.15 and 3.16 show typical airborne sound insulation and impact sound transmission for a number of typical concrete floor constructions, with and without suspended ceilings and floating floors.

3.15 Design and detailing of building elements

Important points to remember when designing constructions to achieve adequate sound insulation are:

- Weak elements (eg doors and glazing, service penetrations, etc) will reduce the effectiveness of the walls in which they are located.
- Impact sound will travel with little reduction through a continuous member such as a steel beam or servicing pipe.
- Partitions between sensitive spaces should normally continue beyond the ceiling up to the structural soffit or roof layer, to prevent noise passing over the top of the partition above the ceiling or through a loft space.
- Openings in walls caused by essential services passing through should be acoustically sealed. Pipework passing between noise sensitive spaces should be appropriately boxed-in (see Approved Document E[1]).

Figure 3.17 shows how possible transmission paths through the structure of a building can be prevented.

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BRE & CIRIA, 1993
BRE ISBN 0 85125 559 0
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[3] J. McLoughlin, D.J. Saunders, R.D. Ford. Noise generated by simulated rainfall on profiled steel roof structures. Applied Acoustics 42 (1994) 239-255

[4] ISO 140-18 Acoustics Measurement of sound insulation in buildings and of building elements - Part 18: Laboratory measurement of sound generated by rainfall on building elements, forthcoming standard.

[5] BS EN ISO 140-3: 1995 Measurement of sound insulation in buildings and of building elements. Part 3. Laboratory measurement of airborne sound insulation of building elements.

[6] The Education (School Premises) Regulations 1999. (Statutory Instrument 1999 No 2, EDUCATION, ENGLAND & WALES). The Stationery Offiice, 1999. ISBN 0 11 080331 0 £3.00 and on website www.legislation.hmso.gov.uk/si/si1999/19990002.htm

[7] BS EN 20140-10: 1992 Acoustics, Measurement of sound insulation in buildings and of building elements. Part 10. Laboratory measurement of airborne sound insulation of small building elements.

[8] BS 98/704582 DC. Ventilation for buildings. Performance testing of components/products for residential ventilation. Part 1. Externally and internally mounted air transfer devices. Draft for Public Comment (prEN 13141-1 Current Euronorm under approval).

[9] BS EN 12354-3:2000 Building Acoustics - Estimation of acoustic performance in buildings from the performance of elements. Part 3. Airborne sound insulation against outdoor sound.

[10] BS EN ISO 140-5: 1998 Measurement of sound insulation in buildings and of building elements. Part 5. Field measurements of airborne sound insulation of façade elements and facades.

[11] BS EN 12354–1:2000 Building Acoustics. Estimating of acoustic performance in building from the performance of elements. Part 1. Airborne sound insulation between rooms.

[12] BS 476 Fire tests on building materials and structures.

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[14] BS EN 12354-2: 2000 Building Acoustics. Estimating of acoustic performance in building from the performance of elements. Part 2. Impact sound insulation between rooms.

[15] BS EN ISO 140-8: 1998 Acoustics. Measurements of sound insulation in buildings and of building elements. Part 8. Laboratory measurements of the reduction of transmitted impact noise by floor coverings on a heavyweight standard floor.

[16] BS EN ISO 717-2: 1997 Acoustics - Rating of sound insulation in buildings and of building elements. Part 2. Impact sound insulation.