HOUSING AND SOUND INSULATION

Improving existing attached dwellings and designing for conversions

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Note: The photographs of dwellings that appear in this document have been chosen to represent architectural styles and periods. This does not infer that these dwellings require improvements in sound insulation.

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Preface

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History of Building Regulations for sound insulation

Sound insulation is one of many issues architects have had to encompass within their designs for buildings and specifically for attached dwellings. Each period throughout history has been guided by the building requirements or regulations of its time.

The earliest attempt at building control within the United Kingdom was the requirement, recorded in the Fitz Alwynne Assize of 1189, for party walls to be built of stone at least three feet thick, essentially for reasons of structural stability. Whilst no specific mention of sound insulation was made in the regulations, it is recorded that one of the reasons for the requirements in the Assize was *"for appeasing contention which sometimes arise between neighbours"*.

In Scotland in 1292, King David I introduced powers to set up Dean of Guild Courts to control matters including building, although it took a further 400 years before this became regulated into building control as it is known today. Following the Great Fire in 1666, the London Building Act called for a solid masonry wall between dwellings of nine inches minimum thickness. In 1926 under the Edinburgh Corporation (Streets, Buildings and Sewers) Order – Confirmation Act (Section 46), the Building Rules provided quite clear details on the heavy construction requirements for walls and floors including, under Article 15, the requirement of floor deafening.

Whilst the model byelaws included some requirements for sound insulation, it was not until publication of the Technical Memorandum 3 'Sound Insulation in Houses' in 1957 that full guidelines for sound insulation were made available. Interestingly, this Technical Memorandum was published by the Department of Health for Scotland.

Following the recommendations of the Guest Committee, which informed the Building (Scotland) Act 1959, national unified standards were introduced in Scotland in 1963 and later consolidated in 1971. The Regulations were revised in 1981 but were effectively the same as those published in 1971 as regards sound insulation.

In 1984 a legal judgement (Scottish Special Housing Association v City of Glasgow District Council) stated that sound insulation tests could be used "as a means to determine whether the workmanship was satisfactory". This then allowed Scottish Building Control departments the potential to request a sound insulation test be undertaken on any attached new build dwelling or conversion.

Prior to 1987, the method used to calculate the sound insulation performance was the Aggregate Adverse Deviation (or AAD). In 1987 new methods were introduced to the Regulations for the pass/fail criteria and were changed from the AAD scale to the $D_{nT,w}$ criteria for airborne sound and the $L'_{nT,w}$ criteria for impact sound assessment. The new measurement criteria weakened the impact sound insulation (footstep noise) performance levels. The Technical Standards (1990) Part H: Resistance to the Transmission of Sound were updated but the criteria were very similar to those of 1987.

The Building (Scotland) Act 1959 was replaced by the Building (Scotland) Act 2003. These were superseded in May 2005 by the Technical Handbooks, with 'Section 5: Noise' replacing the old Part 4. The sound insulation performance requirements for attached dwellings were not altered, however, the primary change being a move from prescriptive ('deemed to satisfy') constructions to guidance.

Approximately 55% of Scotland's housing stock was built prior to sound insulation standards were introduced and the current performance requirements have not significantly altered in the last 18 years. The levels and types of noise found within dwellings have increased however and improved levels of sound insulation may therefore be required. It is hoped that the information presented in this document may serve as a helpful guide to improving sound insulation and understanding the factors to be considered prior to undertaking any work.

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Chronological changes relative to sound insulation in dwellings

1189	Fitz Alwynne Assize makes reference noise from neighbours
1292	David 1st introduces Dean of Guild Courts to cover matters including building
c.1650	Building Control introduced into Dean of Guild Courts
1666	Great Fire of London – London Building Act introduces 9″ masonry party wall
c.1920	Local byelaws introduce first reference to floor deafening
1948	British Standard Code of Practice confirms sound insulation values for building elements.
1957	Technical Memorandum 3: “Sound Insulation in Houses” introduces first specifications for sound insulation
1963	Building Standards (Scotland) Regulations 1963 introduces ‘deemed to satisfy’ designs and performance grading curves using Aggregate Adverse Deviation (AAD).
1970	Building Standards (Scotland) Regulations consolidated.
1981	Building Standards (Scotland) Regulations 1981 introduces minor changes to ‘deemed to satisfy’ designs.
1984	Legal Judgement - Local authority could carry out a sound insulation test to ensure workmanship was satisfactory.
1987	Building Standards (Scotland) Regulations 1987 introduces ‘specified constructions’ and new grading curves using $D_{nT,w}$ and $L'_{nT,w}$. Performance standard for impact sound reduced by approximately 4dB.
1990	Building Standards (Scotland) Regulations 1990 removes clause permitting testing of specified constructions.
2003	Building (Scotland) Act 2003; Building (Scotland) Regulations 2004 formulate Building Standards as functional requirements with guidance in Technical Handbooks.
2005	Building (Scotland) Regulations 2004 came into effect, including Building Standard 5.1.

Quick guide to dwelling types discussed in this document

This table illustrates examples of different types of dwelling commonly found across Scotland. Using this table the user may be able to quickly identify the section relevant to their dwelling or project for sound insulation improvements.

Chapter 5
Stone, rubble and brickwork walls
Section 5.2
Ash-deafened floors
Section 5.3

Chapter 5
Stone, rubble and brickwork walls
Section 5.2
Ash-deafened floors
Section 5.3

Chapter 5
Masonry walls and brick spine walls
Section 5.2
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Chapter 6
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Section 7.2
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Section 7.3

Note: The photographs of dwellings that appear in this document have been chosen to represent differing architectural styles and periods. This does not infer that these dwellings require improvements in sound insulation.

1

Introduction

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Sound or noise transmission may be an everyday occurance and, for some occupants, a series of random and uncontrollable events. This can lead to frustration, anger and stress for occupants. In some cases the persons generating this noise are unaware of the repercussions on their neighbours' quality of life. One method of addressing noise intrusion from the neighbouring dwelling is to improve the sound insulation.

The purpose of this guide is to provide methods and descriptions of how to improve sound insulation between attached dwellings, to assist in deciding on what levels of sound insulation may be required and to inform on key separating wall and floor types and influences of remedial treatments.

The guidance presented in this document is targeted towards general living noise, where the reason that noise is intrusive due to poor sound insulation of the separating wall or floor. Although some of the treatments may be useful in significantly increasing sound insulation in particular dwellings, they are not designed to deal with noise arising from anti-social behaviour.

Scotland contains 10% of the UK's housing stock and its wealth of architectural styles, construction methods and design features provide an excellent opportunity to review the sound insulation characteristics of a wide range of dwellings. At least four out of five Scottish dwellings share an adjoining wall with another dwelling and as found in flats, almost two out of every five share a separating floor.

Figure 1.1a provides a pictorial overview of some of the range of attached dwelling types found across Scotland. It should be noted that a dwelling's external fabric does not always reflect the construction system used for separating walls and floors.

GO TO MAIN INDEX

Figure 1.1a

Examples of attached housing found across Scotland

Note: The photographs of dwellings that appear in this document have been chosen to represent differing architectural styles and periods. This does not infer that these dwellings require improvements in sound insulation.

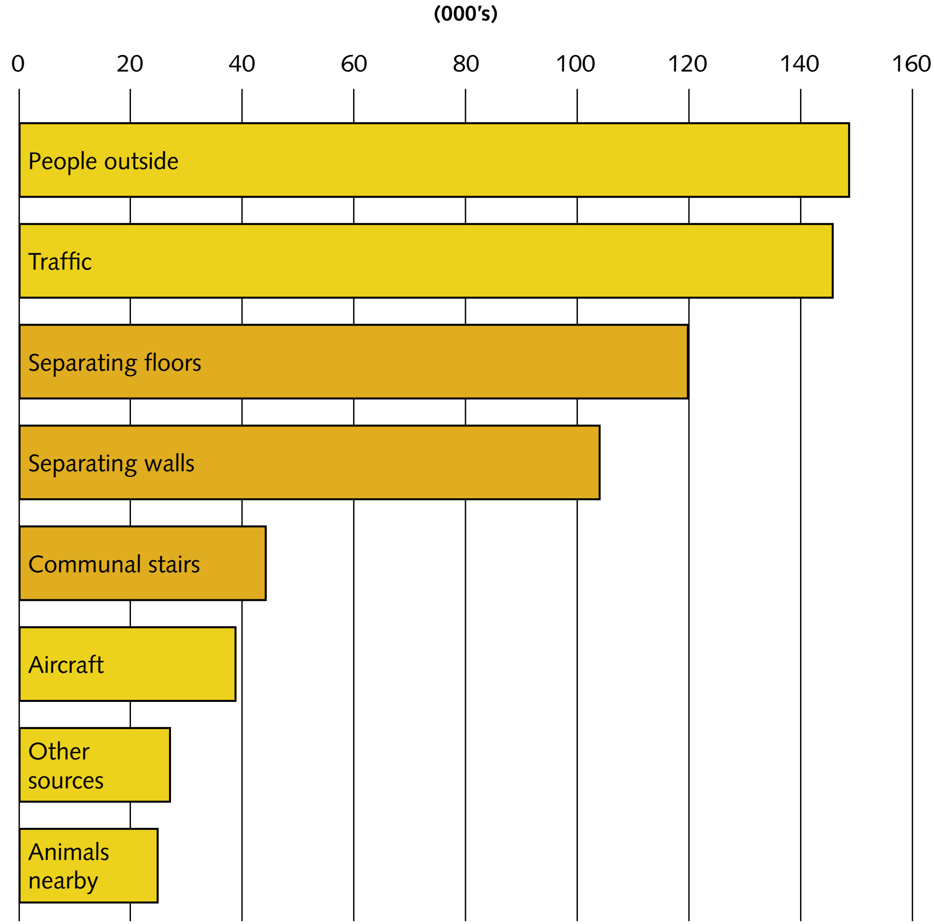
Generally occupants have a wide range of requirements, experiences and expectations in relation to sound insulation. In addition, the noise generated within dwellings and from occupant life styles varies significantly between households.

Firstly, growth in the use and number of noise-generating electrical appliances within the home and rapid technological advancements in entertainment systems have increased the levels of noise within today's 21st century home. Second, changes in work patterns and the ways in which homes are used may result in diverse neighbour lifestyles. Third, the fast moving pace of modern living and diverse employment patterns not only limit the quantity of time spent within the home but also place more importance on this restricted quality time. Thus the disruption to occupants and annoyance caused by sound from neighbouring dwellings plays a major role in a person's quality of life.

In the last 15 years, domestic complaints about noise have increased five-fold. This noise can result in frustration, anger and sleep disturbance. It can also act as a catalyst for other effects on health. Figure 1.1b reflects the importance that separating walls and floors have in relation to other sources of noise.

Figure 1.1b

Number of respondents bothered by different sources of noise
(Scottish Homes 1996)



1.2 REASONS TO IMPROVE SOUND INSULATION

There are a variety of reasons why sound insulation may need to be improved. Some of the typical reasons given by occupants, property managers and developers are:

- the original construction was never suitable to meet the insulation standards required of a separating wall or floor structure;
- the separating wall or floor design is not adequate for modern living;
- the existing wall or floor components have deteriorated over time and are in need of replacement;
- alterations have damaged original components;
- poor workmanship at the time of construction has led to poor sound insulation;
- the occupants may feel that existing sound insulation levels are inadequate;
- new neighbours have a different life style to that of previous occupants and noise transmission has now become an issue;
- the installation of double/triple glazing has reduced external or background noise, thus making it easier to hear neighbour noise through separating walls and floors;
- a change in material of wall or floor finishes (e.g. carpet to laminate flooring), has increased the level of noise transmitted to the dwelling below;
- a building is converted and requires separating wall and floor sound insulation performance levels in compliance with Building Standard 5.1 (see Chapter 8).

The level of sound insulation achieved by a separating wall or floor will be influenced by:

- the original design;
- the materials used;
- structural junctions with other walls and floors;
- the quality of workmanship;
- previous work or alterations;
- changes to components as a result of damage or wear and tear.

In addition, plan layout, materials used and interior architecture have varied between periods of construction and architectural styles. The sound insulation performance of identical dwelling types may be similar, but often are different due to the influences outlined above.

Chapters 2–4 identify the sources of sound insulation problems in Scotland's housing stock and indicate available remedial treatments.

Chapters 5–8 examine key construction issues relating to heavyweight construction typical of pre-1919 buildings; lighter masonry construction from the 1920s onwards; timber frame construction and conversions of buildings from all periods.

Chapter 8 discusses the importance of 'pre-conversion' or 'deterministic' sound tests of the existing construction, prior to work commencing, in order to identify whether appropriate remedial treatments are required.

The remedial treatments selected for separating walls and floors will depend on the level of sound insulation improvement necessary and also the type of existing wall or floor structure. Chapter 4 details the influences and implications that remedial treatments may have on existing interiors, architectural heritage and period features (see Figure 4.3a).

Dwellings and other buildings constitute a historical record of architectural styles, construction methods and interiors. It is essential to evaluate the importance of these period features prior to any sound insulation improvement work being undertaken.

The application of remedial treatments may be quite straightforward in some buildings, e.g. where a property manager applies a resilient floor covering to reduce the transmission of footstep noise into the dwelling below. Some treatments involving the insertion of materials into the existing wall and floor may be undertaken without significant alteration to the existing room interiors. However, in many buildings the application of remedial treatments to walls and floors will require changes to the existing interiors.

Prior to any work commencing, owners, occupants and property managers should identify whether their building or dwelling is:

- Specifically listed as having special architectural or historic interest (Categories A, B or C);
- Under consideration for Listed status;
- Located within a conservation area

Information can be obtained from Historic Scotland and/or the local Planning Authority of the status of the building being considered.

Two primary types of sound are measured for determining the insulation performance between attached dwellings:

- airborne sound (e.g. noise from people talking, radios, TV's)
- impact sound (e.g. footstep noise).

Airborne sound insulation is measured for separating walls and floors and is the level of sound prevented from transmitting through to the neighbouring dwelling. The higher the measured value, the better the sound insulation. The measurement criteria is $D_{nT,w}$ and is expressed in decibels (dB).

Impact sound transmission is the quantity of sound that arrives within the dwelling below from an impact on the floor surface above (i.e. footstep noise). The level of sound measured is only related to the noise arriving in the room below. The lower the measured value the better the sound insulation. The measurement criteria is $L'_{nT,w}$ and is expressed in decibels (dB).

Sound insulation levels are measured using a decibel scale (dB). This not only involves a logarithmic calculation but is made more confusing by the methods used to measure for airborne and impact sounds described above. As a way of reducing this confusion, the Building Performance Centre at Napier University developed the Occupant Equivalent Rating (OER).

The OER compares the measured sound insulation performance of a separating wall or floor with a rating given by occupants during interviews. Based on hundreds of interviews with occupants on each side of the measured walls or floors, it embraces a wide variety of dwelling types and diverse room functions. This is discussed further in Chapter 3: Section 3.4 and in Case Study (3A).

Sound insulation testing can play a major role in distinguishing between 'neighbour noise' and a 'noisy neighbour'. Both terms are often conflated by occupants when complaints are made.

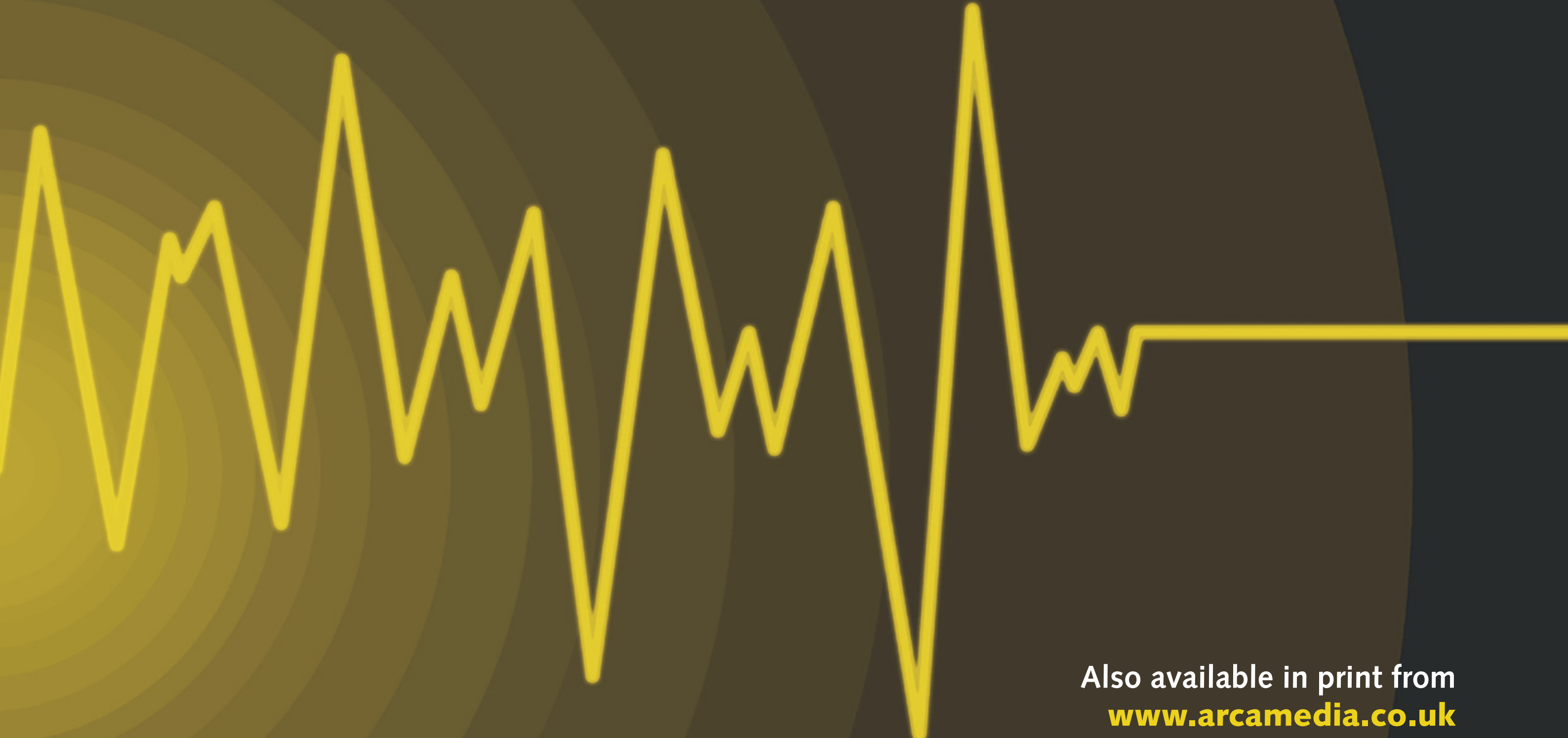
'Neighbour noise' generally relates to normal living noise, such as walking, talking, watching television and undertaking normal household activities within normal 'living hours'.

'Noisy neighbour' usually relates to anti-social or unreasonable behaviour. This may involve undertaking normal household activities (such as using a vacuum cleaner or carrying out DIY, during 'sleep hours'), playing amplified music systems very loudly, shouting or unnecessarily banging doors, each of which is quite obviously going to be heard by the adjacent occupants.

With the introduction of the Anti-Social Behaviour etc. (Scotland) Act 2004, the terms 'neighbour noise' and 'noisy neighbour' may more often be treated separately. This may help to provide more understanding between neighbours, assist Local Authorities and provide a useful platform to review the insulation performance of the dwelling stock.

2

Sound insulation in Scottish housing



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Scotland has approximately 2.2 million dwellings covering a wide range of dwelling types, of which 80% have been constructed within the last 90 years. The level of existing sound insulation will depend upon the type of dwelling, the build date and the construction method and materials used.

In attached housing such as semi-detached or terraced housing, a separating wall will be present, whilst flats will have both separating walls and floors. Attached houses account for 43% and flats 38% of Scotland's housing stock, as shown in Figure 2.1a.

The term **'separating wall'** covers both separating walls between dwellings and walls between a flat and a common area. A pair of semi-detached houses share a separating wall. A mid-terraced house shares separating walls with two neighbours. A flat may share one or more separating walls with neighbouring dwellings but may also have a separating wall to a common hall or stairway.

The term **'separating floor'** is only used for flatted dwellings, such as tenements, four-in-a-block, tower blocks and upper and lower villas. It means the floor between two dwellings, one above the other. In unusual situations it could mean the floor between a corridor and a dwelling below and vice versa. It does not refer to the intermediate floor in houses or maisonettes.

A high proportion of Scotland's housing stock is urban based. The country has a significantly higher proportion of flats (two out of every five dwellings) than any other part of the UK (in England the proportion is one in five, whilst Wales and Northern Ireland have approximately one in 13). Figure 2.1b illustrates the percentage of dwellings in Scotland with separating walls and/or floors. Approximately 81% of the dwelling stock has separating walls.

Figure 2.1a

Proportion of Scottish dwelling stock types
(Scottish House Condition Survey 2002)

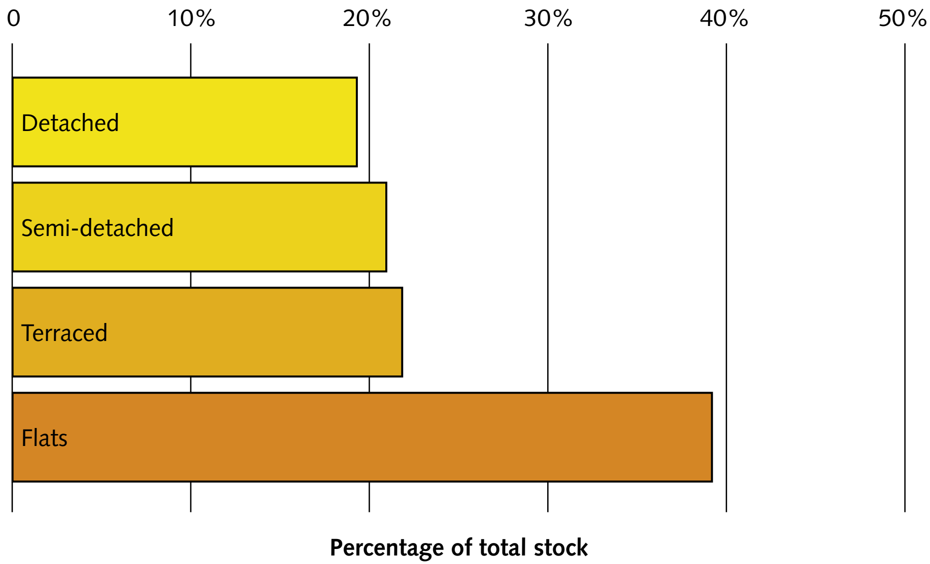
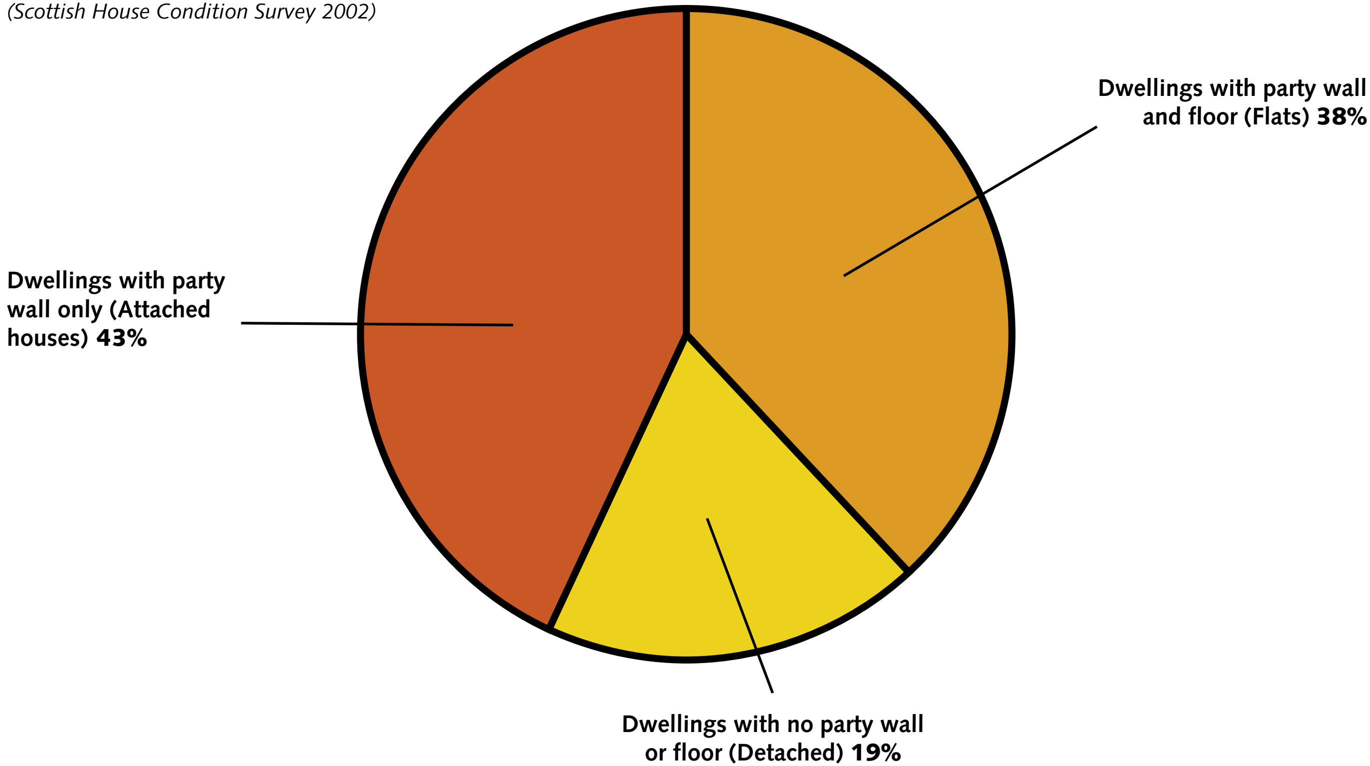


Figure 2.1b

Proportion of Scottish dwelling stock with or without a separating wall or floor
(Scottish House Condition Survey 2002)



2.2.1 Attached houses (separating walls only)

Of the total housing stock, 21% is semi-detached and 22% is terraced. Attached housing primarily requires sound insulating separating walls to reduce airborne noise or sound between adjoining dwellings. Airborne sound insulation is intended to reduce the transmission of speech, television and normal living noise between adjoining dwellings. Separating walls may consist of masonry or frame construction.

Separating walls of masonry construction may be either solid or cavity walls and built using stone, rubble, brickwork or blockwork. These walls may be lined with lath and plaster, plaster only, or drylining boards such as plasterboard. For some walls, an additional parge or internal render coat is applied to the wall face prior to drylining.

Separating walls of frame construction include lightweight twin frames in timber or metal studs with double layers of gypsum-based board and absorbent quilt insulation in the cavity.

The separating wall construction may be the same over its full height (foundation to roof), but is structurally connected to foundations, floors, internal walls, roof and external walls where each junction and material make-up influences the sound insulation properties of the wall. The sound insulation performance of a separating wall between two attached houses can vary at each floor level due to the different structural junctions and construction materials used.

Sound transmitted at these junctions is commonly referred to as **flanking sound**. Flanking sound transmission will influence and sometimes control the separating wall's sound insulation performance.

Flanking transmission

Flanking Transmission is sound or vibration which travels along a pathway that includes structures or voids that are not part of the separating wall or floor. The pathway may include separating wall or floor elements.

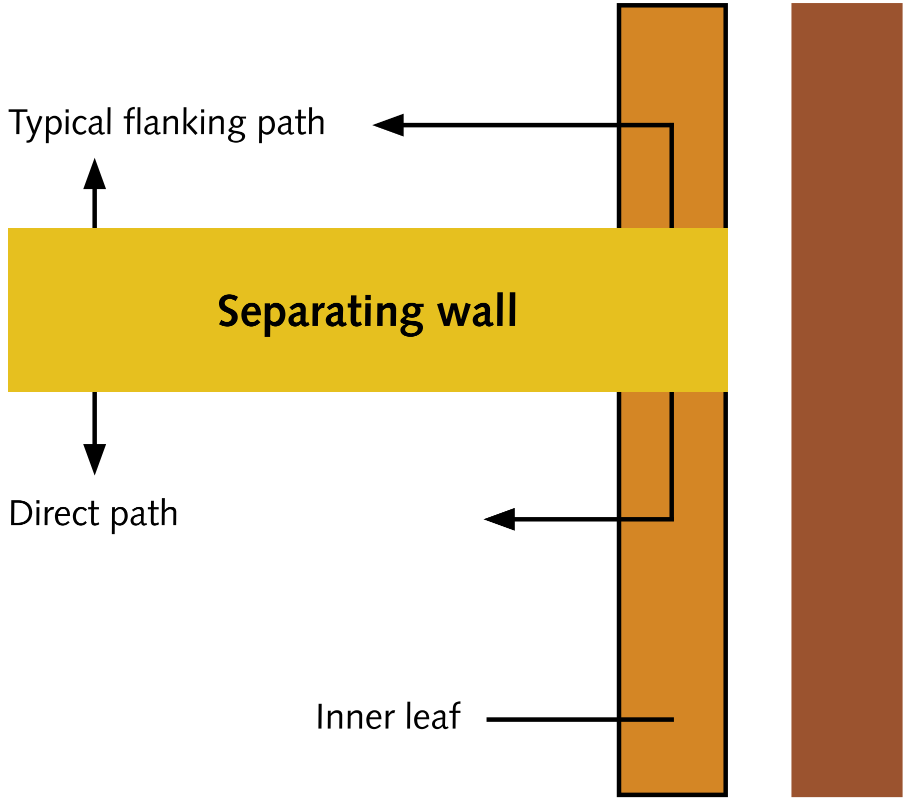


Figure 2.2a

Estimated statistics for attached houses and flats
(Scottish House Condition Survey 2002)

Attached houses

Semi-detached houses

A house that is only attached to one other dwelling. The two dwellings taken together should be detached from any other dwellings.	■ Approximately 460,000 ■ 34% of all houses, 21% of all dwellings ■ 88% were built post-1919 ■ 70% have 2 or more storeys

Terraced houses

A house forming part of a block where at least one house is attached to two or more dwelling units.	■ Approximately 495,000 ■ 36% of all houses, 22% of all dwellings ■ 89% were built post-1919 ■ 84% have 2 or more storeys

Flats

Tenements

Flats within a block with shared access, i.e. a common stair serves two or more flats and less than five storeys in height. *(NB: In Chapter 5 the term tenement is used solely for pre-1919 flats built with stone walls and timber floors with ash-deafening.)*	■ Approximately 497,000 ■ 60% of all flats, 23% of all dwellings ■ 38% built pre-1919 ■ 59% have 2-3 storeys, 40% 4–5 storeys ■ 63% have floor areas 50–89 m^2

Four-in-a-block

Each flat in the block has its own independent access. Flats on the upper level are reached by their own internal or external stair.	■ Approximately 231,000 ■ 28% of all flats, 11% of all dwellings ■ 73% built 1919–1964 ■ 99% have 2–3 storeys ■ 73% have floor areas 50–79 m^2

Tower/Slab

Maisonettes and flats in a multi-storey or tower building with five or more levels. Typical examples would be 1960s high-rise flats.	■ Approximately 60,000 ■ 7% of all flats, 3% of all dwellings ■ 98% built 1945–1997 ■ 87% have 4 rooms or less ■ 63% have 10+ storeys ■ 71% have floor areas 50–79 m^2

2.2.2 Flats (separating walls and floors)

Occupants living in flats have adjoining dwellings horizontally and vertically and require separating walls and floors with airborne sound insulation properties. Any flat that has another flat above will also experience impact noise (e.g. footsteps) and require impact sound insulation.

As mentioned previously for attached houses, structural junctions or flanking paths for sound can have a controlling influence on sound insulation performance. This is even more important in flats given the number of junctions that are present between multiple adjoining dwellings.

2.2.2 Flats (separating walls and floors)

Tenements

Almost a quarter of all dwellings in Scotland are flats in tenement blocks. Traditional tenements built pre-1919 have solid stone and rubble walls and timber floors with ash-deafening laid between the joists. Walls were finished in lath and plaster, with hung ceilings and often with ornate cornicing. Tenements built between 1919–44 typically have cavity external walls of blockwork and stone and lighter weight timber floors with quilt insulation. Ceilings are less ornate and the floor to ceiling heights are lower. After 1945, tenements were commonly built with concrete floors.

Tenements were not always built with one flat immediately above another, or they may have been adapted to create one large flat spanning over two smaller flats below. The number of flats per storey generally varies from two to five and the number of separating walls between dwellings for a tenement flat may vary from one to four. All flats will typically share a separating wall with a common stairwell which also has a passageway or 'close'. (Sound insulation issues for traditional tenements are discussed in more detail in Chapter 5.)

Four-in-a-block

Four-in-a-block designs have external or internal stairs to upper levels and sometimes a common passageway or 'close' to the rear gardens. A separating floor will always be present. Most four-in-a-block flats were built in the inter-war period and have masonry-supported timber separating floors and plaster wall finishes. Floors are often comprised of flooring boards, joists and ceiling boards with combinations of deafening boards, thin quilt insulation in the cavities or between the floorboards and joists (as a resilient layer) and sometimes counter-battened ceilings.

Tower and slab blocks

High-rise blocks, involving 10 or more storeys, account for 63% of tower and slab-type dwellings. Blocks were built either with in-situ poured systems, such as slipform, or prefabricated cast slab wall and floor panels. All adjoining dwellings can have several flanking pathways that allow sound to travel between them. The structural design of 'tower and slab' buildings often results in particularly complex flanking sound transmission factors.

2.3 TRADITIONAL AND NON-TRADITIONAL CONSTRUCTIONS

2.3.1 Construction systems and materials

The type of dwelling, the construction materials used and the number built has often led to two distinct categories of dwelling: traditional and non-traditional. Traditional generally covers dwelling types that were mass-produced and built across Scotland in a wide range of towns and cities. Non-traditional housing, representing approximately 100,000 dwellings (5% of the total housing stock), are either relatively few in number or where the combination of design and materials was only adopted for a short time. Examples of traditional and non-tradition constructions are shown in Figure 2.3a.

Figure 2.3a

Types of traditional and non-traditional construction

Note: This document primarily covers the traditional dwelling types commonly found across Scotland. However, the techniques and materials of improving sound insulation for walls and floors, outlined in Chapter 4, may sometimes also be applied to non-traditional building types.

Traditional construction	Non-traditional construction
Stone and rubble walls supporting ash-deafened floors	Foamed slag
Masonry supported lightweight timber floors	No-fines blockwork
Blockwork walls	Metal frames
Concrete precast slab floors	Masonry separating walls with a timber outer skin
High-rise using in-situ concrete walls and floors	System building
Timber frame	Beam and block floors*

* Unlike other parts of the UK, beam and block separating floors are relatively unusual in Scotland.

Information about some non-traditional construction, built between 1923–1955, is given in *A Guide to Non-Traditional Housing in Scotland*.

2.3.2 Architectural features and plan arrangements

Flats and attached houses often incorporate architectural features or plan arrangements that can reduce the level of sound insulation or introduce additional sources of noise. These include:

Attached houses

- Internal stairs beside a separating wall;
- Chimney stacks, flues and fireplaces built within a separating wall;
- Recessed cupboards (presses) within a separating wall;
- Rooms-in-the-roof and converted attics.

Flats

- A flat spanning over several flats below, for instance a penthouse;
- Communal stairs beside a separating wall;
- Communal vertical soil vent pipes and horizontal service pipes within a separating floor;
- Lifts beside separating walls;
- Water pumps used to raise water pressure;
- Chimney stacks, flues and fireplaces built within a separating wall;
- Recessed cupboards (presses) within a separating wall.

2.4 EFFECTS OF NOISE AND COMPLAINTS BY OCCUPANTS

2.4.1 Effects on occupants

General exposure to noise from adjacent dwellings may act as a catalyst affecting the occupant's health and well being. The extent of the effect on health depends on an individual's sensitivity, health profile, circumstance and perception of – or control over – the noise problem. A review by Stansfield, Haines and Brown identified non-auditory effects of domestic noise as:

- sleep disturbance
- annoyance
- activity disturbance
- emotional response

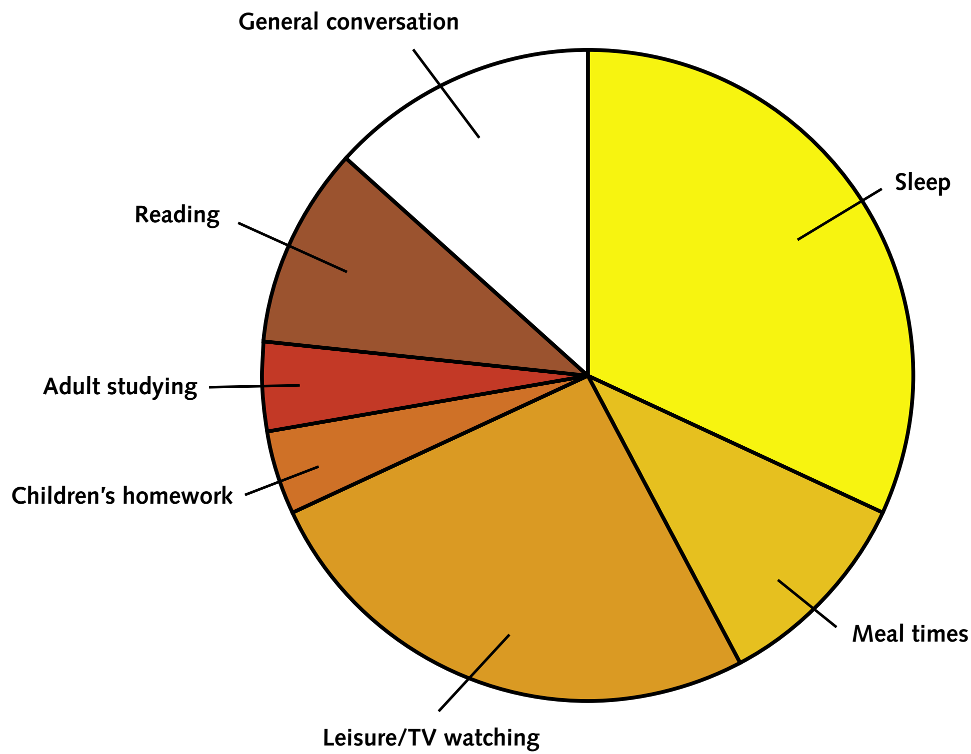
The disturbance to sleep by noise depends on the stimulus (type of noise, intensity, duration, repetition etc.) on the stage of sleep at which the disturbance occurs, on the environment together with individual variables such as age or state of health.

Figure 2.4a illustrates the findings of the Scottish House Condition Survey 2002 where occupants were asked to identify which aspects of their daily life within the home were disturbed by noise.

Noise that is unavoidable, unimportant or emotive is often the most annoying. Disrupted sleep and listening to television/radio are the most common noise-disrupted activities. Noise transmission between dwellings and its non-auditory effects causes increasing tensions between neighbours and leads to disputes, which may result in physical assaults.

Figure 2.4a

Aspects of daily life disturbed by noise
(Scottish House Condition Survey 2002)



2.4.2 Complaints by occupants

A recent study (*Hazards in the Home, 2001*) cited domestic noise as the leading cause for complaint to local authorities across the UK. Over the last two decades complaints have continued to increase. Although this may partly be due to improved systems to record complaints, the increase in domestic noise complaints is possibly also related to a number of other factors, such as:

- changing lifestyles;
- home improvement work, especially DIY;
- advances in music sound system technology;
- increased use of noise producing domestic appliances;
- increased use of noise producing equipment per room in each dwelling;
- societal structure;
- inadequate design of sound insulation in housing;
- increasing occupant expectations;
- increasing density of dwellings, including increase in flatted developments;
- neighbour behaviour.

Occupants' perception of noise and their response or reaction to sound transmission from adjoining dwellings varies. Their reaction to neighbour noise may be influenced by the type of relationship that already exists with their neighbours. Some occupants may accept that it is not possible to prevent all noise transmitting into their house, but would not find it acceptable to hear moderate levels of noise from televisions and radios, conversations and general living.

There are a number of frequently recurring complaints concerning the types of noise people can hear from the adjoining dwelling. In addition, a diverse range of sound frequencies or pitch may be involved. Figure 2.4b provides a summary of the types of noise from adjoining dwellings and frequency range (or pitch) involved.

2.4.2 Complaints by occupants

Figure 2.4b

Potential noise sources from adjoining dwellings relative to airborne or impact type noise and sound frequencies (pitch) involved.

Potential noise sources from adjoining dwellings	Airborne Noise	Impact Noise	Noise frequencies influenced
Teenagers or adult voices	■		mid–high
TV	■		mid–high
Doors closing		■	low–mid
Radio/Music	■		all*
Domestic equipment (e.g. vacuum cleaners)	■		all
Plugs being inserted into sockets		■	low–mid
Switches being turned on or off		■	mid
Cupboard doors closing		■	low–mid
Services noise (e.g. downpipes, water pumps)	■		all
Footsteps		■	low–mid
Children playing	■	■	all
DIY	■	■	all
Dogs barking	■		low–mid

** Amplified modern music often has a high level of bass frequency output*

FREQUENCIES:

Low	Mid	High	All
40Hz–200Hz	250Hz–1KHz	1.25Kz–5KHz	wide range of frequencies

2.4.2 Complaints by occupants

In 2002 the Scottish House Condition Survey included questions for occupants about dwelling type and sound insulation. Figure 2.4c provides a breakdown of dwelling type relative to households that were ‘fairly often’ and ‘very often’ bothered by noise.

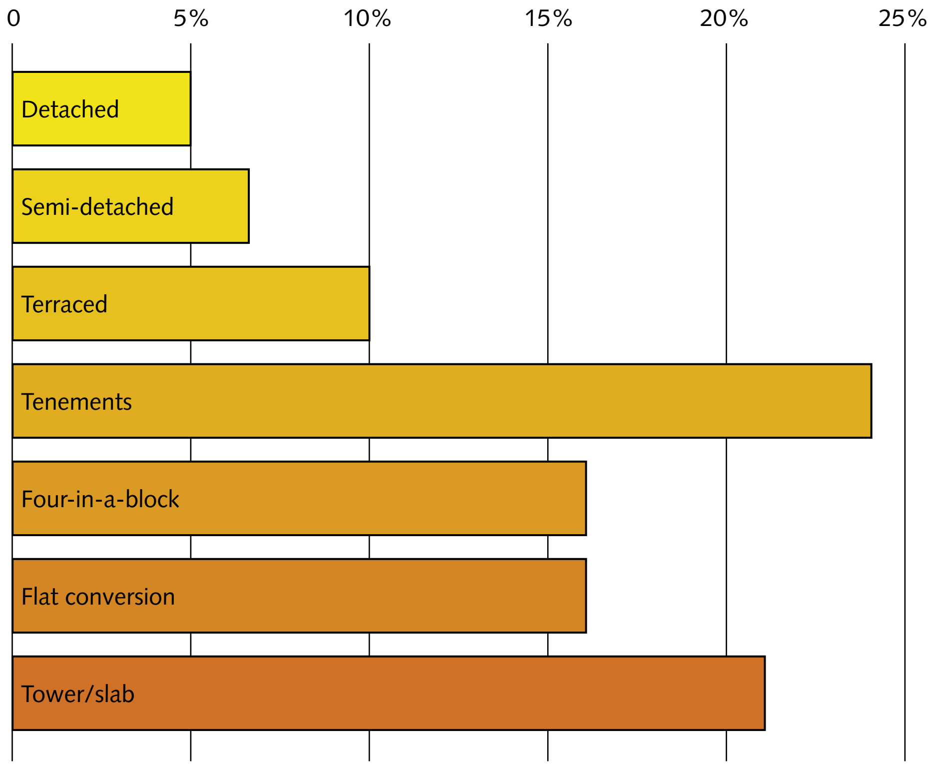
Due to the presence of separating walls and floors, flatted developments often have at least twice as many possibilities as attached houses to hear occupants from neighbouring dwellings compared to attached houses. The level of occupants stating that they are bothered ‘fairly often’ and ‘very often’ by noise has a direct relationship to the:

- number of adjoining separating walls or floors;
- build period;
- construction;
- materials used;
- perception or subjective assessment (see Chapter 3: Section 3.3).

2.4.2 Complaints by occupants

Figure 2.4c

Households bothered by noise "fairly often" and "very often" by type of dwelling
(Scottish House Condition Survey 2002)



3 Establishing sound insulation performance

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Landlords or housing managers may need to improve sound insulation over a wide range of houses and flats. This may be in response to complaints or as part of a general refurbishment programme. It can be useful to survey the occupants concerned before undertaking any work. A survey should generally include questions for occupants relating to:

- the types of noise or sounds being heard;
- the direction(s) sound is coming from (i.e. separating wall or floor between dwellings, common stairwells, outside);
- the most annoying sound;
- how they rate their sound insulation.

If the noise described by occupants is from an external source, this may not relate to the separating walls or floors and may be an issue that should be dealt with by the local authority's environmental health department.

If there are numerous dwellings of the same build and design layout it is not necessary to undertake sound insulation testing in every dwelling or on every wall or floor. Where there are different dwelling types it is useful to:

- establish the typical or average measured sound insulation level of each dwelling type;
- set an appropriate target level of insulation; and
- identify typical remedial measures and works required, preferably with some standardisation that will reduce workmanship errors, allow bulk purchase and ease administration.

Assessing multiple dwellings can be summarised into four key stages (A, B, C and D) as shown in Figure 3.1a.

It is important to identify what level of sound insulation performance is being achieved by the separating wall or floor. In addition, identifying the causes and paths of the sound being transmitted assists in determining the appropriate remedial treatment.

There are a number of methods that can be used to establish or assess the relative sound insulation performance. These involve both objective measurements and subjective occupant assessments.

Information gathered from sound insulation testing, diagnostic work, construction details and discussion with occupants can all assist in identifying the optimum solution for the required needs. It may not always be possible to undertake a complete assessment of the insulation, in particular when it is not possible to access the adjoining dwellings that share the separating wall or floor.

Figure 3.1a

Key stages for evaluating sound insulation in multiple dwellings

Key stages for evaluating sound insulation in multiple dwellings

Stage A
Initial assessment

(Property owners/managers)

- Survey of occupants and possible noise issues
- Identify common noise source issues
- Focus on dwelling types, location, room function and wall or floor related to noise issues.

Once Initial assessment complete, contact acoustic consultant for Stage B

Stage B
Measurement and interview assessment

(Acoustic consultant in collaboration with owners or managers)

- Occupants should be informed of what is required of them during a sound test (see Figure 3.2a)
- Inform dwellers of the benefits by allowing access for testing
- Undertake phased testing of multiple dwellings
- Once completed assemble a works plan based on addressing the worst first.

Stage C
Remedial works

Stage D
Sample review

(Acoustic consultant in collaboration with owners or managers)

- On completion of first phase of works undertake sample testing and interviews to assess improvements achieved
- If required review solutions for next works phase
- Feedback on successful work can encourage other occupants to permit access for next phase.

A number of issues arise preparatory to carrying out sound insulation tests in occupied dwellings and Figure 3.2a summarises the key matters affecting occupants if a sound insulation test is to take place in their dwelling. When occupants are forewarned on these points, the potential for delays or influences on test data is reduced.

Figure 3.2a

Key points for occupants to know about a sound insulation test

Preparing for a sound test – an occupant guide All sound insulation tests	
Access to dwellings	For separating wall tests access will be required to both dwellings either side of the wall. For separating floor tests in flats access is required above and below the floor.
Occupants	Ensure that all occupants know of the sound tests. Ensure that you and your neighbour arrange a mutually suitable time to allow the consultant access. During the test avoid generating noise as this will influence the test results.
Pets	Pets should either be moved to other rooms that will not require access during the test or be moved outside the test dwelling. Dogs, cats or birds will find the noise levels and frequencies of the sound test uncomfortable. Dogs barking will adversely affect the test results.
Entering test rooms	Avoid entering the room during the test because this can influence the results and noise levels generated will be very high and may result in hearing damage. Even if the room sounds quiet do not enter the test rooms as the equipment may be at rest before starting another test phase. *NEVER enter the test rooms until the consultant has finished or has given the all clear.*
Doors/ windows	Doors and windows should be shut tight during the testing period.
Power supply	The test equipment can be powered from a 240V household electrical socket. You may be asked to identify a socket that will avoid switching off your household appliances.
Furniture	Removal of furniture is not required, but the consultant may ask to move the furniture slightly as it may interfere with the equipment or test procedures.
Queries	If you have any queries you should ask.
Specific factors for impact tests on floors	
Carpets	Carpets will need to be pulled back at the corner of the rooms to expose the base floor surface. To avoid test delays this should be done prior to the consultant's arrival.
Laminate/ wood floors or tiles	The tapping machine may be used on laminate and wood floor surfaces and should not leave any marks. However, testing on ceramic tiles should be avoided due to the risk of cracking.
Vibration	Crystal, glass or delicate small items on shelves should be removed to prevent their shifting due to vibrations generated by the tapping machine.

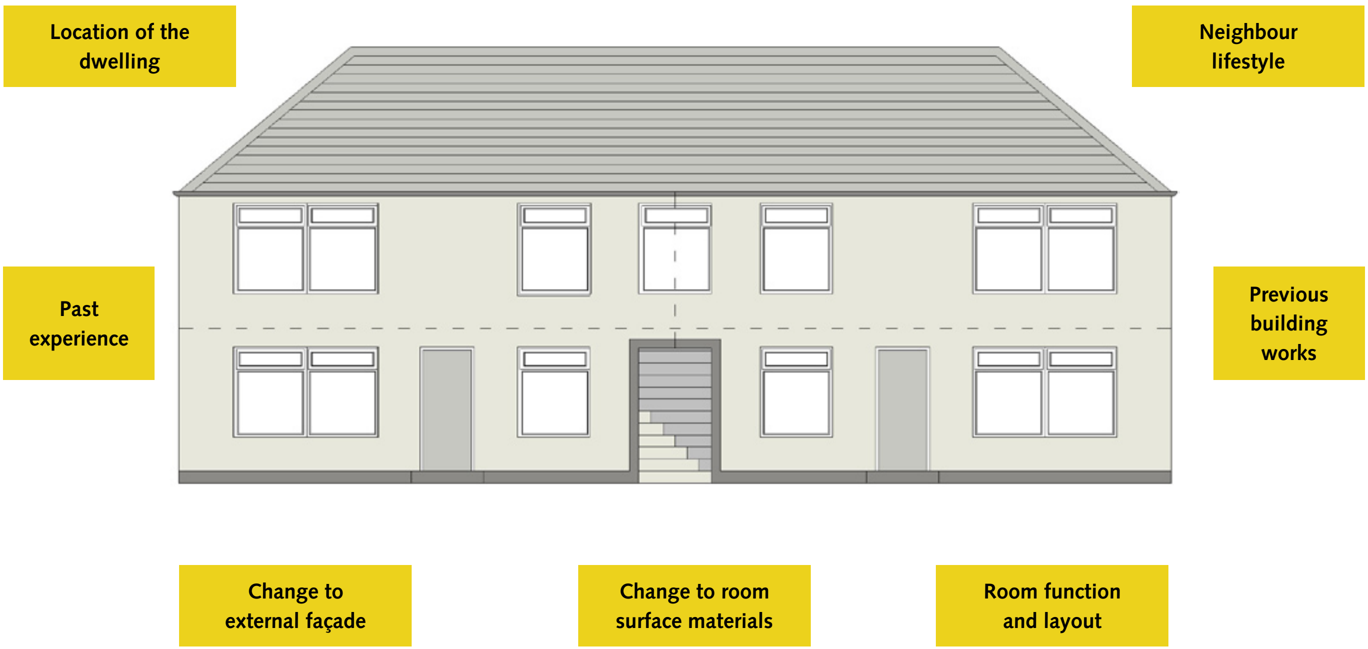
Other methods to assess sound insulation, such as interviews, surveys and discussions with occupants can be very helpful. Care should be taken however, when analysing such information. When asked about their sound insulation, it is common for occupants who have experienced problems with noise to respond that they can hear “everything”. It is important, therefore, to establish which sounds are actually being heard.

Speech, television and service/water noise are concentrated around specific frequencies and thus may require similar remedial measures. Noises such as low frequency output (e.g. bass music) from stereo systems and impact sounds from footsteps will require more elaborate remedial solutions.

A number of factors may influence the subjective assessment by a dweller of how good or bad the level of sound insulation is that they are experiencing. Figure 3.3a summarises these factors and the following section discusses these influencing factors in more detail.

Figure 3.3a

Factors that may influence the subjective assessment by occupants



Location of the dwelling

The location of the dwelling plays an important role in relation to the level of ambient or background noise that surrounds the occupants. Roads with high traffic volumes, railway lines or airports can provide a high level of ambient background noise, which may 'mask' noise that is being transmitted between dwellings.

Room function and layout

Good planning and layout can reduce the number of noise problems that occur. Kitchens or living rooms, which back onto bedrooms of the adjacent dwelling, are more likely to lead to noise complaints. Kitchen cupboards with hinged doors, mounted on the separating wall, may transmit impact noise through to the bedroom next door. The random nature of cupboard doors and drawers closing can lead to annoyance and frustration for the neighbour.

Layout and the use of rooms are particularly important when neighbours have different working patterns. Complaints about noise may more often result when the living room of one dwelling is over a bedroom of another dwelling, for example.

Changes to the external building façade

Replacement of single leaf glazing by double or triple glazing can reduce the level of external noise (termed background noise) entering the dwelling. As such, there may be less background noise and neighbours may hear each other more easily. It may be useful to ask when the noise became noticeable and if it is connected with works to external wall or windows.

Relationship with neighbour

Occupant's assessments of their sound insulation may also be influenced by the relationship with their neighbour. If the relationship is amicable then the noise intrusion and the level of noise may be more acceptable than in situations where there is disagreement or hostility between neighbours.

Change of neighbour lifestyle

Noise issues may only become apparent when there is a change in the lifestyle or when new neighbours move in. People may also be more aware of sound insulation issues due to different living patterns between neighbours.

Previous building works

Previous service works for water pipes, drainage and heating systems can influence the overall performance of a wall or floor. During such work parts of the existing structure, such as ash-deafening in floors or wall plaster, may have been removed or damaged and openings not properly sealed. This can lead to a wide disparity in performance between damaged and undamaged floors or walls.

Change of room surface material (e.g. carpet to laminate flooring)

One of the most common triggers for complaints is the change of room surface treatments or materials. A significant problem is the removal of carpets and installation of hard floor finishes (e.g. laminate or sanded floors). This can typically lead to a 20dB reduction in insulation performance. This can lead to occupants below this floor changing their assessment of impact noise from “acceptable” to a level they may describe as “intolerable”.

Past experience

People who live in detached houses or well-insulated attached houses may never have experienced hearing noise from neighbours, so when they move into a flat or attached dwelling they may feel that the level of sound insulation is poor.

Expectation

Recent research suggests that sound insulation dominates housing complaints because of people’s levels of expectation. Occupants may feel upset that they can hear some noise from a neighbour. Expectation and subjective assessments of sound insulation can vary.

Case Study 3A provides an example of two quite different subjective descriptions of the sound insulation of a separating wall by occupants on either side of the same wall.

Sound insulation is measured in decibels (dB). The decibel uses a logarithmic scale and is not readily quantifiable or meaningful for occupants. Further confusion can arise from the inverse nature of describing airborne and impact sound. Airborne sound is rated by *the higher the value the better the insulation*, whereas, for impact sound *the lower the value, the better the insulation*.

Several extensive studies undertaken by *The Building Performance Centre* at Napier University have involved the comparison of measured sound insulation levels in dwellings with occupant interviews for the attached dwellings on each side of the separating wall or floor.

In these studies, occupants are asked a number of questions relating to what sound they can hear and what causes them most annoyance. In addition, they are asked to rate the level of sound insulation on a banded scale (A*, A, B, C … to G, where A* is termed excellent and G is intolerable).

From over 800 such interviews and measurements undertaken in a wide range of dwellings over the past 15 years, an Occupant Equivalent Rating (OER) system has been developed. Figure 3.4a shows the OER average banding relative to measured airborne sound insulation levels.

For impact sound insulation, the OER rating only involves the occupants on the lower dwelling beneath the separating floor. Figure 3.4b shows the average banding of OER relative to measured impact sound transmission levels.

Figure 3.4a

Occupant Equivalent Rating (OER) for airborne sound insulation.

Comparison of measured airborne sound insulation levels (dB) with the average response grading by occupants relative to A* = excellent to G = intolerable.

Note: the higher the value, the better the insulation.

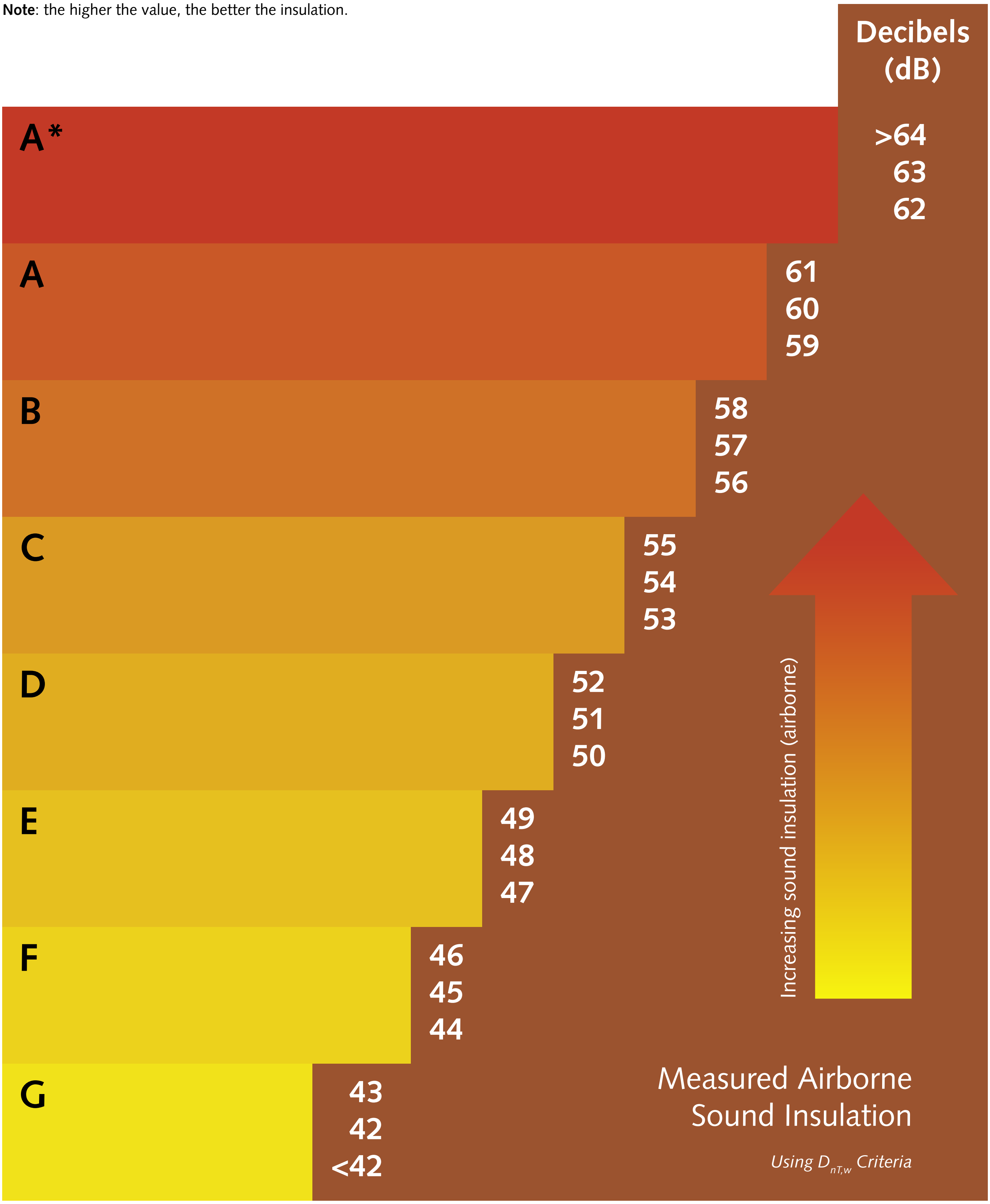
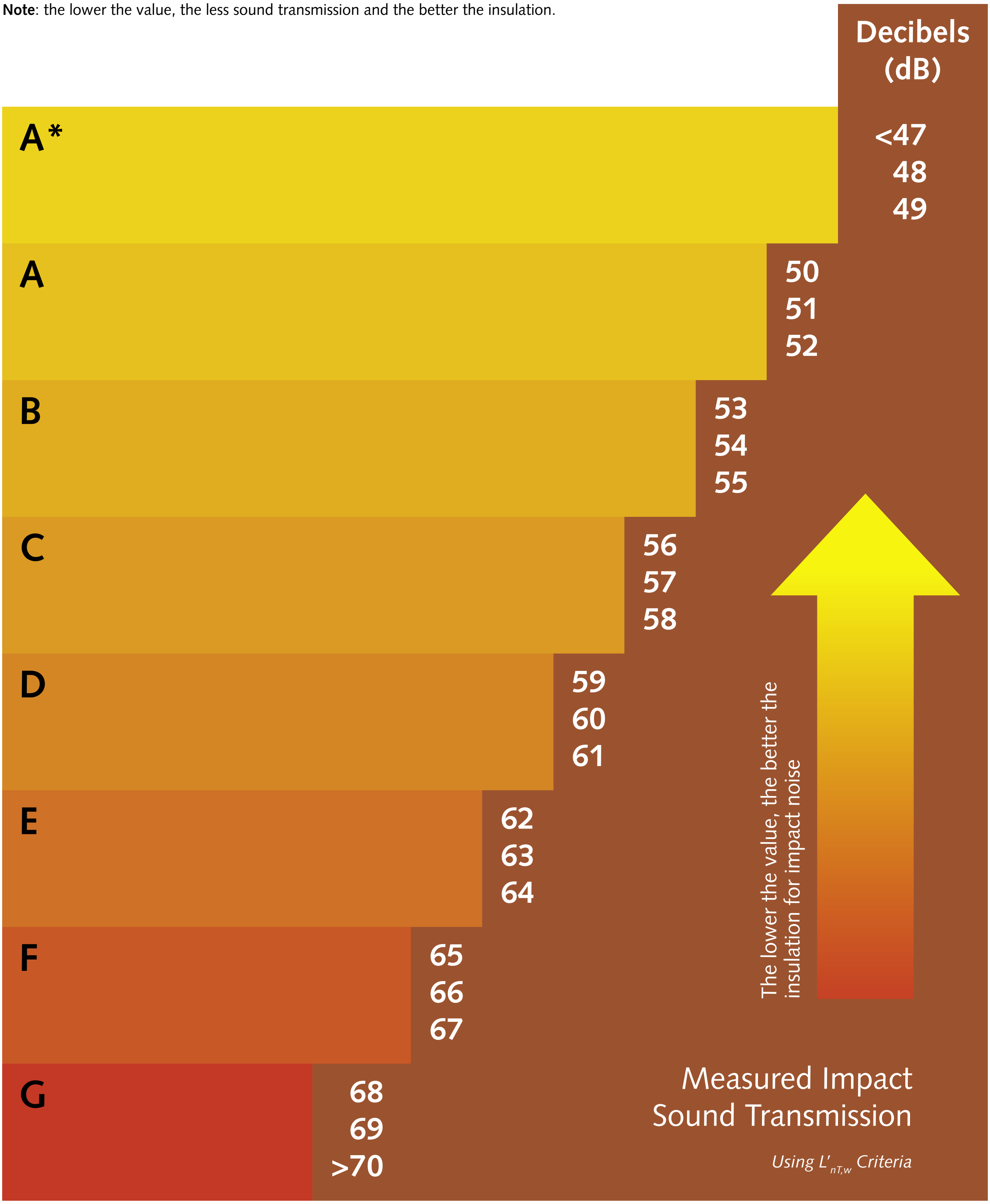


Figure 3.4b

Occupant Equivalent Rating (OER) for impact sound transmission.

Comparison of measured impact sound transmission levels (dB) with the average response grading by occupants relative to A* = excellent to G = intolerable.

Note: the lower the value, the less sound transmission and the better the insulation.



Sound insulation testing requires measurements to be undertaken in the rooms directly adjacent to the separating wall, or in the rooms directly above or below the separating floor. Testing not only assesses how much sound is prevented from being transmitted through the wall or floor but can also take account of whether the rooms have additional sound absorption (e.g. due to furniture and curtains). Sound insulation tests can be undertaken in empty, bare rooms or in fully-furnished rooms. Testing for impact (footstep) noise through separating floors should not be undertaken with carpets in place (see section 3.5.2).

For separating walls, a sound test typically involves the measurement of the airborne sound insulation, room-to-room, on each side of the wall. For separating floors (e.g. in flats) a sound test includes the measurement of airborne sound insulation and impact sound transmission. All sound insulation testing should be carried out in accordance with ISO 140 and calculation procedures and reports should be displayed in accordance with ISO 717. Both airborne and impact tests require access to the dwellings on each side of the separating wall or floor.

There are two national organisations that register acoustic consultants for sound insulation testing, these are:

- The Association of Noise Consultants (ANC)
- United Kingdom Accreditation Service (UKAS)

Figure 3.5a

Typical sound level meter for measuring sound insulation

3.5.1 Testing for airborne sound insulation

Testing for airborne sound insulation measures the degree of insulation a wall or floor achieves over a range of sound frequencies associated with speech, television, radio and normal living noise.

Measurements involve loudspeakers being placed on one side of the wall or floor to generate a source noise. Microphones record the level of sound within the room where the loudspeaker is located ('the source room'), and how much sound is transmitted through the wall or floor into the adjoining dwelling room ('the receiving room'). Measurements and calculations are also carried out to assess the absorption properties of the receiving room. The final calculation of the difference between the source and receiving rooms provides an indication of how much insulation is provided by the wall or floor. Thus for an airborne sound test the higher the value the better the sound insulation. Full requirements and more detailed information on measuring airborne sound insulation can be found in ISO 140 Part 4.

Figure 3.5b

Typical loudspeakers used during sound insulation tests

3.5.2 Testing for impact sound transmission

Impact sound transmission testing measures the quantity of impact sound (related to noise sources such as footsteps) transmitted from the upper flat to the lower flat. As with airborne sound insulation tests, access is required to both of the dwellings above and below the separating floor.

For an impact test a tapping machine (see Figure 3.5.c) is placed on the surface of the floor in the upper flat. This machine is comprised of metal hammers that strike the surface of the floor. The sound transmitted through to the lower room is then measured ('the receiving room'). Similar to airborne sound tests, measurements and calculations are undertaken to determine the receiving room's absorption properties. Full requirements and more detailed information on measuring impact sound transmission can be found in ISO 140 Part 7.

Impact tests have microphones in the lower or receiving room only since the level of sound generated in this room is of interest here. As such, the lower the value the less sound is being transmitted and the better the impact insulation for footstep noise.

The tapping machine should not be placed on carpets or rugs but on the hard floor surface, e.g. floorboards or screed finish, because carpets are regarded as temporary finishes and do not permit a full understanding of the floor's real performance. The use of tapping machines on tiled floors should be avoided as the surface may be damaged by the impact of the hammers.

Figure 3.5c

Typical tapping machines for impact noise measurements

Non-measurement methods may involve diagnostic inspections and/or interviews with occupants. Although more subjective they can provide very useful information to a consultant when determining the best solution for the occupants. Diagnostic evaluations involve:

- inspection of the construction and layout to identify the key locations of sound transmission;
- listening, e.g. with a stethoscope, to wall surfaces and surrounding room surfaces for sound frequency patterns.

Knowledge of the existing construction and materials greatly assists diagnosis. Almost all construction elements have natural resonances that reduce sound insulation performance at certain frequencies. Having established the construction and materials, the consultant may be able to quickly identify the areas of the wall or floor that have insufficient insulation properties.

Interviews with occupants can identify the noise problem, sound transmission paths and range of frequencies involved. The subjective reaction of occupants will vary and care must be taken when evaluating the real noise issues and key frequencies that affect them.

4

Methods of improving sound insulation

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Consideration of three primary factors is required to obtain suitable levels of sound insulation between attached dwellings:

- Design layout;
- Construction system and materials;
- Workmanship tolerance.

4.1.1 Design layout

The layout of rooms in adjoining dwellings is an important factor to be considered, whether for adaptations, conversions or new build. Quiet rooms (e.g. bedrooms), should be located away from potentially noisier areas like kitchens and living rooms. This may not always be possible in existing dwellings where the layout is already fixed. As such the sound insulation should be designed to accommodate these scenarios. (Appropriate planning layout is still possible for conversions and further information can be found in Chapter 8.)

4.1.2 Construction system and materials

A separating wall and floor between dwellings generally has at least one of five key factors. All together or in various combinations they provide sound insulation properties for a wide range of frequencies. These factors are:

- Isolation;
- Mass;
- Absorption;
- Resilience;
- Stiffness.

Simply constructing a good separating wall or floor may not in itself provide sufficient sound insulation, as the junctions of each separating wall and floor with other parts of the building are equally as important. This is due to the flanking sound transmission (as described in Section 2.2) that will occur via construction components such as:

- the inner leaf of the external wall;
- the external wall cavities;
- the external façade or outer leaf;
- the internal partitions;
- the roof structure;
- the foundations.

The whole construction system should therefore be considered and not just the separating wall or floor. Flanking sound transmission may in some cases be the dominant pathway between adjoining dwellings.

4.1.3 Workmanship tolerance

No matter how well-designed the layout or the care taken to select materials, workmanship plays a crucial factor. It is often the case that a significant sum is spent on design and materials only for poor workmanship to reduce the potential sound insulation performance. Equally, good design, material choice and detailing are essential to facilitate good workmanship.

There are a number of common materials that can be applied to walls, floors and ceilings to improve sound insulation. These materials include absorption layers, additional board linings and appropriate fixing mechanisms. There are also proprietary systems to treat walls, floor surfaces and/or ceilings. Remedial treatments covered here are:

- Common treatments — Section 4.4
- Wall treatments — Section 4.5
- Floor system and insertion treatments — Section 4.6
- Ceiling treatments — Section 4.7
- Service pipe treatments — Section 4.8
- Product specification — Section 4.9
- Alterations to existing dwellings — Section 4.10

The case studies presented at the end of this document also provide examples of remedial treatments applied and the consequent sound insulation improvements achieved.

Treatments need not always be applied to both sides of the separating wall or floor. In the case of separating walls, it is often possible to provide suitable improvement in performance by the application of remedial treatments in only one dwelling. This saves on cost, time, preparatory work and materials and makes it easier to arrange as well as limiting the disturbance to occupants.

Most remedial treatments applied to the existing wall, floor or ceiling surface will affect the existing interior décor. They may also require work to electrical services, radiators etc.

4.3 IMPLICATIONS OF REMEDIAL TREATMENTS FOR INTERIORS

Some remedial treatments for sound insulation lead to significant changes to the size of rooms and architectural features. Where possible, the drive to improve performance should not be to the detriment of existing interiors, particularly in the case of historic buildings.

In some dwellings it may be both structurally feasible and aesthetically acceptable to make changes, but in others there may be alternative means to improve sound insulation without sacrificing the room proportions or other features of the interiors. Information on remedial treatments for older dwellings, such as tenements and Georgian buildings, can be found in Chapter 5.

Before undertaking detailed drawings or works, a survey of the implications these treatments may have on the interiors should be carried out, as shown in Figure 4.3a.

Figure 4.3a

Implications of wall, floor surface and ceiling lining treatments for interiors and other issues.

Influence of lining treatments on interiors

	Treatments		
	Wall	Floor surface	Ceiling
Room size	■	■	■
Accessibility (steps and changes in height)		■	
Existing interior features	■	■	■
Skirtings	■	■	
Pipework & radiators	■	■	
Door returns and jambs	■		
Door heights and architraves		■	■
Electrical services (e.g. sockets & lighting)	■		■
Sanitary fittings	■	■	
Mid span loading conditions of floor		■	■
Floor to window cill heights		■	
Floor to ceiling heights		■	■
Ceiling to window soffit heights			■

4.4.1 Absorptive insulation for cavities

Materials that have high acoustic absorption, such as blown fibre and mineral wool based quilts or batts, are useful when insulating against general living noise and speech. Absorption is less effective, however, for the low frequency or "bass" component of noise emitted, for example, by amplified music systems.

Mineral wool quilts (density 10–33kg/m^3) provide high levels of acoustic absorption and are often used in floor, wall and ceiling cavities. Sometimes a higher mass of mineral wool may be required (density 80–200kg/m^3), for example, to pack voids and seal openings or weaknesses within the structure. It may not always be possible to add linings due to limited space in rooms or where the architectural interiors and finishes would be adversely affected by applying such treatments. In some circumstances, blown fibre insulation can be injected into cavities within the existing core structure.

Care should be taken when using blown fibre insulation, as some products may sag, leaving unfilled voids. Also, injecting too much material can exert pressure on the existing linings. Injection of expanded foams should generally be avoided unless they provide acoustic absorption. Many foams harden on drying and can have minimal sound absorption properties. When blown fibre is being used in cavities, it is generally preferable that the perimeter surfaces create an enclosed housing for the insulation, since otherwise, the materials will feed into areas where they are not required.

Examples of mineral wool batt of different density

4.4.2 Wet treatments

The application of wet treatments such as screeds, grouts, parge coats and plaster are useful in sealing existing masonry or concrete structures and surfaces. Although they take time and may require special installers or skilled labour, the acoustic benefits often outweigh the time factor and cost implications.

Particular care should be taken with wet treatments such as floor screeds, since they will normally require an isolation layer to prevent impact noise transmitting into the lower dwelling. If the isolation layer is damaged or torn, the screed will have direct contact (known as bridging) with the core floor and perimeter walls. The perimeter edge isolation of screeds is as essential as isolation from the core floor. Generally, dual isolation layers with overlapping joint systems are preferable for screed floors.

4.4.3 Additional gypsum-based board linings

The addition of a dry lining using gypsum-based board will increase the mass, stiffness and acoustic performance of existing wall or ceiling linings. However, in some situations adding another layer of gypsum-based board may only slightly increase performance. Additional linings to the wall or floor may not change the acoustic performance if the wall or floor is not the principal pathway of sound transmission and flanking sound transmission is dominant.

There are a number of proprietary gypsum-based boards that have enhanced fire resistance, sound isolation or moisture resisting properties. Board densities typically range from 7–20kg/m^2 with thicknesses varying from 9–19mm. If secondary board linings are applied to an existing board lining, the secondary board should be of a higher density and/or thickness than the existing board.

4.4.4 Fixing mechanisms

Sound insulation performance is improved when the fixing mechanism is resilient or has low stiffness. In addition, the less contact there is between components (which reduces bridging), the better the acoustic insulation. Generally, for wall or ceiling treatments, metal straps or ties provide better acoustic performance than continuous timber branders or straps, as they have less contact area. Fixing mechanisms that incorporate resilience, such as spring hangers or resilient bars also improve isolation and can have less impact on ceiling void depth and room dimensions.

Various remedial treatments can be applied to separating walls between dwellings, such as cavity fill insulation, wet and dry treatments and free standing independent linings. A range of generic wall treatments and their applicability and suitability to various wall types is described in Figure 4.5a.

Linings may be applied to one side only and still achieve a suitable improvement in sound insulation. Where the separating walls are solid (without a cavity between two leafs), flanking sound transmission via the inner leaf of the external wall can play an important role.

Figure 4.5a Types of wall lining and insertion treatments for separating walls

Separating walls: Lining and insertion treatments				
Remedial	**Existing construction**	**May be used with**	**Do not use with**	**Change in wall thickness**
Blown fibre or mineral wool quilt or batt insulation or equivalent absorption layer		Masonry or blockwork cavity walls, twin frame walls with cavity sheathing board	Solid walls Twin frame walls **with no** cavity sheathing board	n/a
13mm Internal render or parge coat with gypsum-based board 10kg/m^2 on dabs	Strip back current dry lining and apply direct to original core block or brick face	Masonry or blockwork solid or cavity walls.	Timber or metal frame walls	13mm
42mm mineral fibre backed board	May be applied to existing wall linings or core wall	All wall types		42mm
8mm render + 42mm mineral fibre backed board	Strip back current dry lining and apply direct to original core block or brick face	Masonry or blockwork solid or cavity walls.	Timber or metal frame walls	50mm
Resilient wall lining – metal or timber straps through 13 or 25mm mineral wool layer with 10kg/m^2 dry lining board	For block or brick walls strip back existing dry lining and apply to core wall face. Apply direct to timber or metal frame over existing linings	All walls		40–65mm
Independent wall lining	Leave existing lining	All walls		70–100mm

4.5.1 Internal render or parge coats

Existing masonry or blockwork walls that only have dry lining finishes may perform poorly due to open mortar joints or a porous blockwork face. The application of parge or internal render coats to the block face, prior to drylining, is effective in improving sound insulation of masonry walls by:

- sealing the block face and closing any open joints or perpends;
- increasing the mass of the wall;
- increasing the 'acoustic damping' of the wall;
- reducing the "drum effect" that commonly occurs with dry lined walls.

The application of internal render or parge coats has become increasingly popular as a technique to reduce sound transmission through existing blockwork and masonry separating walls and reduce the drum effect. These wet treatments are commonly used prior to lining with board finishes on dabs and are composed of cement sand mix. There are also gypsum-based parge or internal render coats available in pre-bagged formats. Figure 4.5b outlines key issues of relating site mixed parge coats.

The parge coat wall is normally finished with a gypsum-based board or dry lining board mounted on dabs. The combination of parge coats and dry linings on dabs allows similar acoustic performance to that of a wet plaster finish, but with the added benefit of a cavity to locate wiring and sockets. The parge coat should be scratch finished or applied in an uneven manner to create a better bond for the drylining dab. The parge coat mix should never be stronger than the background blockwork otherwise during drying stage cracking of mortar joints may occur.

Drum Effects occur when small cavities are formed between panels. These create resonance effects and reduce sound insulation. An example is dry lining mounted on dabs direct to the block face of a masonry wall, which forms a cavity behind the dry lining. At a certain frequency the air in this cavity behaves like a spring and a resonance effect takes place. This is known in acoustic terms as a "mass-spring-mass" resonance.

Figure 4.5b

Features of site mixed parge coats.

Sand : Cement parge coats (mixed on site):

- 8–13 mm thick
- sand : cement mix:
  - for aggregate concrete blockwork 4:1 to 6:1
  - for aircrete blockwork maximum strength of mix 6:1
- parge coat should never be stronger than the background blockwork
- can add lime or plasticiser, 0.5 to 1.0 for 1.0 cement
- apply with a trowel in an uneven manner and/or scratch finished
- should be dry within 48 hours to apply dry lining boards.

Example of a parge coat applied with scratch finish to a block wall up to internal joist level

4.5.2 Mineral fibre backed board

Walls can be lined with mineral fibre backed boards to increase insulation against speech and general living noise. If these boards are being applied to the separating blockwork wall they are best used with 8mm internal render or parge coat. Mineral fibre backed boards vary in thickness, typically 32–52mm. Figure 4.5c shows the stages of build when using mineral fibre backed boards.

Such treatments perform well when mounted on the dwelling side of a separating wall to a communal area (e.g. corridors, stairwells or hallways). It is usually better to use impact resistant boards or plaster finish within communal areas.

Mineral fibre backed gypsum board

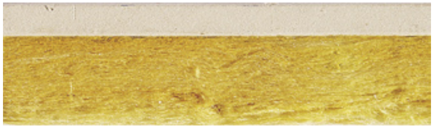

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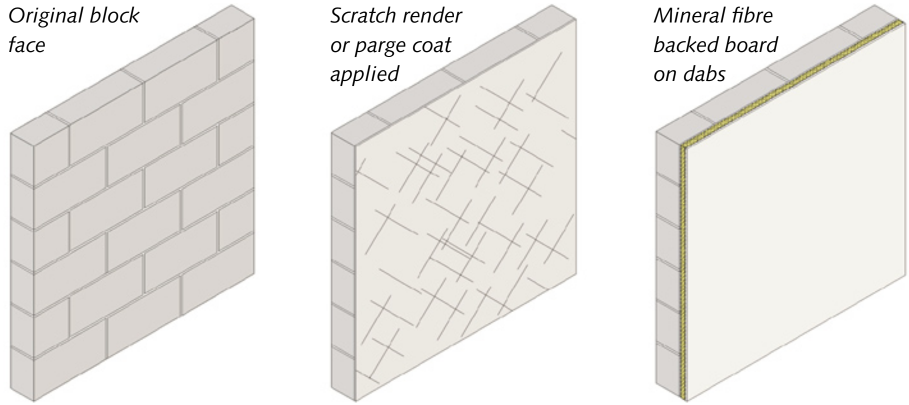
Figure 4.5c

Combined parge coat and mineral fibre backed board stages of build



4.5.3 Resilient wall lining treatments

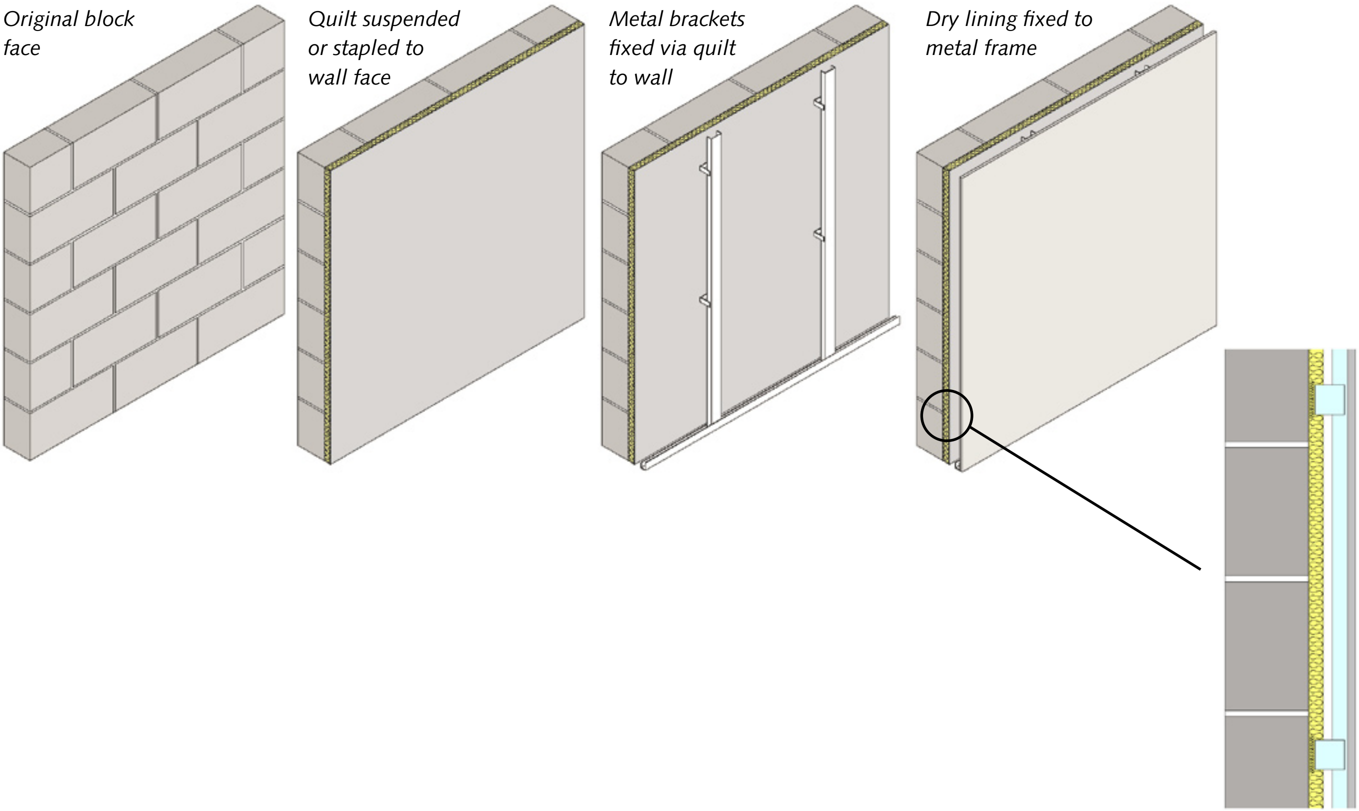
Resilient wall linings are one of the most popular treatments for existing dwellings in Scotland. Where an increase in wall thickness is acceptable this construction system provides a combination of key ingredients including isolation, resilience and absorption.

An absorption lining composed of 13mm (33–36kg/m^3) or 25mm mineral wool (10–20kg/m^3) or equivalent absorption material is applied to the wall face. Metal or timber straps are then fastened to the wall through the quilt layer, creating a resilient connection. The straps then support vertical channels or ribs for the fixing of dry lining boards. Metal straps generally perform better than timber straps as the fixings create less contact between the wall and the lining. Metal straps also make it easier to vertically align the wall.

This technique is very useful in providing resilience to horizontal impact sounds, e.g. closing doors or plugs being inserted into sockets, from the adjoining dwelling and may avoid the need for independent linings.

Figure 4.5d

Resilient wall lining stages of build



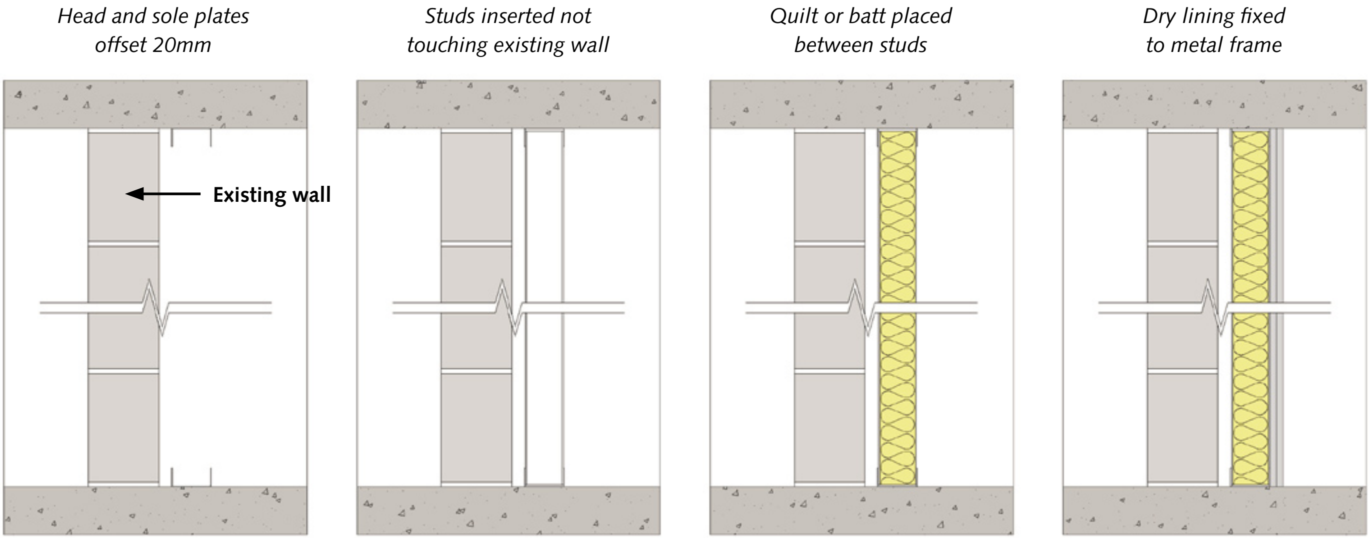
4.5.4 Independent wall lining treatments

Independent wall linings offer some of the best sound insulation improvements, providing high isolation and acoustic absorption. Independent wall linings, do however impact more on room size and existing features than other lining treatments.

The independent lining is a metal or timber frame offset from the existing wall by a minimum of 20mm. The size of the metal or timber stud frame will depend on the floor to ceiling heights and potential loads being applied to the wall, such as cupboards. The independent frame should not come into direct contact with the existing wall and normally is only connected to the floor and ceiling. An absorption layer of 25–100mm mineral wool or equivalent is suspended between the frames and either one or two layers of gypsum-based board are then mounted on the frame.

Figure 4.5e

Independent wall lining treatment (sections) stages of build



Flanking Walls

Sound may not only be transmitting directly between dwellings at the separating wall or floor, but also via the adjacent walls, such as the inner leaf of the external wall. Sound that is transmitted via these other structures (through indirect pathways) is known as flanking sound.

Flanking sound varies with types of construction and types of materials. The appropriate remedial treatment will vary according to the following factors:

- the level of sound being transmitted via flanking pathways;
- the construction of the flanking wall;
- the interaction with the separating wall or floor.

In all cases where remedial treatments are applied to an external wall, care should be taken not to compromise performance with regard to moisture, ventilation, energy efficiency or fire safety (see relevant Building Standards).

There are generally four main types of remedial treatments:

- insertion of an absorption layer within the inner leaf or cavity;
- lining with 42mm mineral fibre backed boards;
- resilient wall lining treatment; or
- independent wall lining.

The best method of reducing impact noise, such as footsteps, is to install a resilient floor surface treatment, commonly termed by industry as FFT's (floating floor treatments). Proprietary insertion treatments may also be used in timber floors between floorboards and joists.

There are many types of remedial treatments for impact sound, including:

- bonded soft floor coverings (or overlay mat systems);
- insertion systems (for timber floors);
- resilient battens;
- resilient cradles;
- platform floors.

Most of the aforementioned impact treatments may also slightly improve airborne sound insulation. A summary of the key types of floor surface treatments is provided in Figure 4.6a.

Figure 4.6a

Types of remedial flooring surface treatments

Types of remedial flooring surface treatments

Remedial treatment type	Thickness	Conditions of use
soft floor coverings	4–22mm*	Do not mechanically fix flooring board through soft floor covering
shallow platform floors (FFT5)	17–35mm	Do not insert pipe services within floor treatment
standard platform floors (FFT4)	35–55mm	Do not insert pipe services within floor treatment
resilient batten floors (FFT3 or 1)	65–90mm	Ensure fixings for flooring board to batten do not penetrate into resilient layer
cradle/saddle batten floors (FFT2)	65mm or more	Ensure cradle or saddle batten system is level prior to fixing flooring board

** thickness stated for soft floor covering does not include flooring board finish*
FFT = generic product descriptor categories of Floating Floor Treatments.

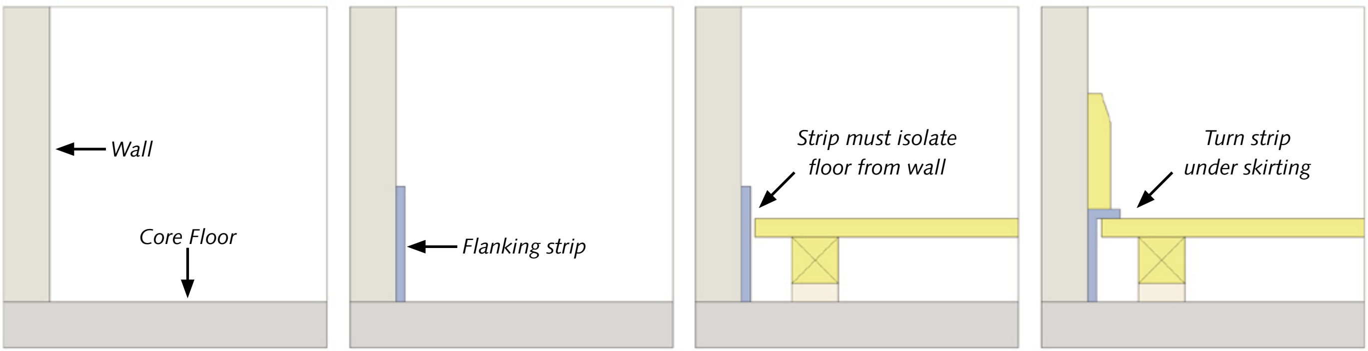
Floor lining treatments such as batten, cradle or platform floor systems affect floor heights. Floor linings may create a change in level (such as a step) within the dwelling or at the entrance door. Level or ramped access is required for upper storey flats that are accessed by lifts and careful design may be required to prevent a tripping hazard being created.

When installing resilient floor surfaces care should be taken to:

- avoid puncturing or bridging the resilient layer;
- sweep clean the existing floor deck to avoid laying the treatments on sharp objects;
- ensure any screws or fixings are the correct length to avoid bridging the resilient layer;
- use screws for fixing or adhesive where mechanical fixing is not permitted;
- follow manufacturer's instructions at all times;
- use flanking edge strips for battens, cradles and platform floors to isolate the floorboard edge from the perimeter walls and skirtings. Some flanking strips have a pre-bonded adhesive layer for ease of fixing to walls.

Figure 4.6b

Flanking strip installation at floor perimeter



4.6.1 Bonded soft floor coverings

Bonded soft floor coverings are the easiest to install and also have the least impact on existing interiors. Carpet underlay may appear similar, but bonded soft floor coverings are more robust and are likely to have higher acoustic performance. Thickness may vary from 4–22mm (depending on the type of material) and they are normally fixed by adhesive bonding.

If carpets are being replaced by hard floor surfaces such as wood or laminate, it is important to use a resilient underlay. It should be noted that some underlay linings sold with laminate floors do not provide any significant improvement in airborne sound insulation and often provide little impact noise resistance. If replacing carpets with tiles seek specialist acoustic advice (laminate and wood finish floors are discussed further in Section 4.10).

If a board surface (e.g. laminate) is applied on top of a soft floor, mechanical fixings should be avoided and an adhesive bond should be used where possible. The boards should be isolated from the perimeter walls and skirtings either by a flanking strip or by stopping the boards short of the perimeter walls or skirtings by 5mm (see section 4.10). If the finished floor surface boards touch the perimeter walls or skirtings, a 'bridge' will be created that allows noise from footsteps to enter into the surrounding walls and skirtings and flank into the dwelling below.

Example of soft floor treatments

4.6.2 Insertion systems and materials

Insertion systems and materials make use of existing voids within the depth of the floor. Insertion materials may include blown fibre, quilt or batt insulation or deafening, such as sand. Insertion systems may also involve resilient layers between floorboards and joists.

Once a resilient insertion system has been placed on top of the joists, the floorboards are adhered to the product surface. Mechanical fixings such as screws are not normally used, as these will ‘bridge’ the resilient layer and allow vibration to transmit directly from the floorboard into the joist. As the floorboards are not directly fixed to the joists this can reduce the overall stiffness of the floor. Dwangs or noggings should be inserted between the joists to provide additional bracing. Mineral wool based products should not be sandwiched between joists and floorboards, as these will deteriorate over time.

Where there are cavities between the joists, insulation in these areas can be further improved by inserting a heavy deafening or dense mineral wool batt.

Traditionally ash-deafening was used to provide sound insulation in timber floors but is now quite difficult to source. Modern equivalents are graded stone chips, dry sand or other crushed dense materials. Deafening generally has a mass per unit area of 70–80 kg/m^2.

A structural engineer should be consulted prior to the introduction of heavy insertion materials. Particular care should be taken to fill the void between the joists and perimeter walls as this is often left unfilled or has very little deafening. Avoid placing deafening directly on ceilings and preferably use support boards (deafening boards) between the joists. If sand or other fine particles are used, the boards should be lined with a polyethylene sheet or similar.

If using mineral fibre batts between the joists (normally 100mm deep and 140–200 kg/m^3) these should be cut to fit tightly. Blown fibre may also be used in floor or ceiling cavities.

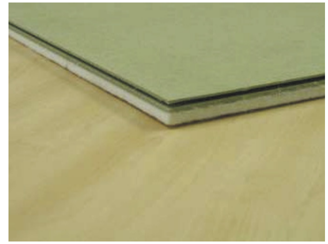
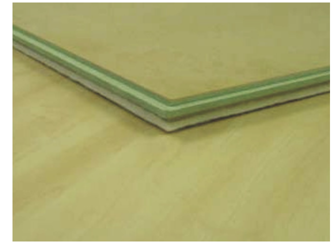
4.6.3 Platform floor systems

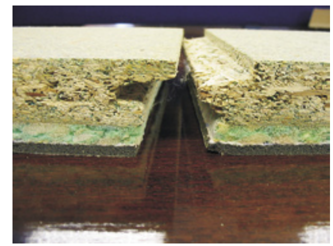
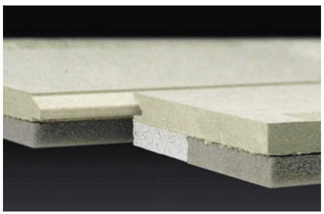
Platform floor systems are primarily composed of a resilient layer underneath a decking with tongue and grooved edges, such as chipboard. Treatments vary in thickness from 15–55mm. Shallow platform floor systems of 15–35mm thickness often have the resilient layer pre-bonded to the decking surface.

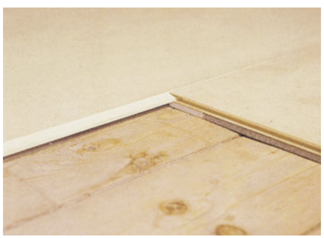
A pre-bonded resilient layer ensures that the whole floor surface is being treated and avoids gaps being left between the lining elements. In addition, its pre-attached hard surface board reduces the potential for the resilient layer to be damaged or torn.

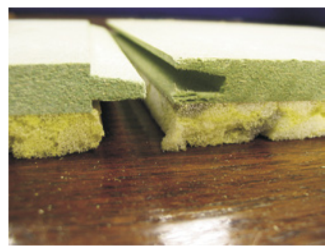
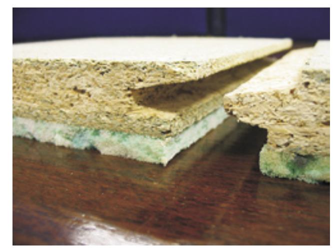
For most platform floors, services and underfloor heating should not be installed within the ‘resilient layer zone’ as this may cause bridging, reducing the potential impact performance.

Examples of (shallow depth) platform treatments commonly termed by industry as FFT5 systems.



4.6.4 Resilient battens (high performance and standard performance)

Two types of timber floating floor systems that permit the installation of services and generally perform well are:

- resilient batten floors;
- cradle/saddle floors.

Over 90% of the separating floors built in Scotland in recent years have used timber floating floor treatments due to their having higher impact sound insulation performance than floating screed floors.

Resilient battens generally involve timber bearers which have a pre-bonded resilient strip. This resilient layer may involve foams, cellulose compounds or man-made fibrous polyesters. Some battens use two or more densities or two or more compounds of material within the resilient strip. Systems vary in the degree of resilience, isolation and performance. Most resilient battens have the prebonded resilient layer beneath the batten but in some systems it is located on the top surface of the batten.

Resilient battens must always be installed onto a flat surface (e.g. decking boards or existing floorboards or concrete floors) and must never be directly laid onto joists or ribbed structures. For timber joist floors, resilient battens must always be placed on a sub-deck board.

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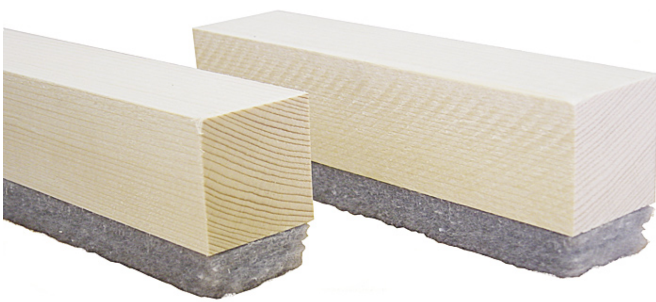
4.6 FLOOR SURFACE AND INSERTION TREATMENTS

Examples of resilient battens, commonly termed by industry as FFT1 or FFT3 systems.



Special bearer battens may be used in conjunction with the normal resilient battens for floor zones with higher potential loading. Areas where special bearer battens may be used include:

- door thresholds;
- areas of higher floor loads (e.g. under kitchen appliances);
- under bathroom fittings (showers, baths, w.c.'s);
- under internal partition walls.

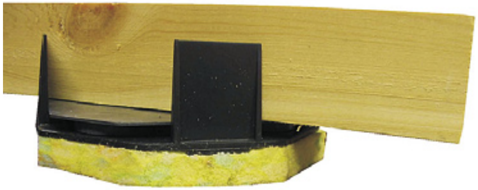
Mineral wool should not be placed directly under timber battens since repeated flexing under the load applied by footsteps will ensure the fibres deteriorate over time thus decreasing the impact insulation performance. Between 1944 and 1985 it was quite common for mineral wool to be placed directly under battens or sandwiched between the floorboards and joists. Degraded mineral wool under battens is often the source of noise problems.

One method of improving impact sound insulation without greatly influencing the existing interiors is to replace older timber battens and any remaining mineral wool with high performing resilient battens. This treatment does not usually increase the depth of the floor. To avoid the potential for "drum effects" it is normal practice – particularly in lightweight separating floors – to lay 25mm mineral wool quilt between the battens and not under the battens.

4.6.5 Cradle or saddle floor systems

Cradle or saddle systems are primarily composed of a floorboard or deck resting on timber battens which in turn are supported at set centres by resilient supports. These resilient supports are the cradle or sometimes termed 'saddle' component. They are very useful where multiple services run in several directions within the floor. They can be easily adjusted in height by the insertion of thin shims and are useful when re-levelling floors.

Examples of cradle/saddle systems, commonly termed by industry as FFT2 systems.



Ceiling treatments are the most effective method of improving sound insulation where the primary transmission of airborne sound is through a separating floor. The treatments generally involve secondary ceilings including:

- direct fix ceilings;
- special hanger ceilings;
- independent ceilings.

The introduction of secondary ceilings reduces existing floor to ceiling heights and affects interior features such as cornices and covings. Where architectural features are to be retained, it may not be possible to use some remedial ceiling treatments. Chapter 5 provides examples of insertion treatments that can be used in such circumstances (for timber floors).

The use of absorption layers, such as mineral wool or blown fibres, within the ceiling voids can improve sound insulation for speech, TV and general living noise. However, the primary pathways for sound may not always be through the floor or ceiling cavities but via the floor joists and perimeter walls. In such cases, placing quilts or absorbent layers within the floor voids will have only a limited effect.

Mounting additional ceiling boards directly to the existing ceiling, where the ceiling is directly fixed to joists, will marginally increase the ceiling stiffness and mass, but often will not make much difference to the overall sound insulation performance.

The installation of a suspended secondary ceiling can improve both airborne and impact performance, where sound transmission is predominantly through the separating floor. There is a wide range of fixing mechanisms and components that may be used within such ceiling systems, as shown in Figure 4.7a.

Figure 4.7a

Types of secondary ceilings

Ceiling treatments: Supports, absorption layers and linings					
Ceiling void	**Ceiling support**	**Ceiling board**	**Minimum absorption layer**	**Overall depth**	**Conditions**
Common secondary suspended ceilings (min. 100mm ceiling void)					
min. 100mm	50 x 50mm timber branders with 50 x 50mm counter branders	gypsum-based board min. 10–12kg/m² mass per unit area	50mm quilt, batt or blown fibre laid within void	115mm	stop timber branders 10mm short of perimeter walls
min. 100mm	suspended metal-frame ceiling	gypsum-based board min. 10–12kg/m² mass per unit area	50mm quilt, batt or blown fibre laid within void	115mm	stop timber branders 10mm short of perimeter walls
Secondary ceilings less than 100mm					
60–85mm	50 x 50mm timber branders with resilient ceiling bar	gypsum-based board min. 10–12kg/m² mass per unit area	25mm quilt, batt or blown fibre laid within void	75–100mm	resilient bar must be mounted 90° to brander **
varies with hanger depth	metal spring hangers	gypsum-based board min. 10–12kg/m² mass per unit area	25mm quilt, batt or blown fibre laid within void	varies	ensure spring hanger can support loading
Independent ceilings					
min. 125mm	min. 100 x 50mm ceiling joists* offset from original construction by 25mm	2 layers gypsum-based board min. 8kg/m² mass per unit area each layer	100mm quilt, batt or blown fibre laid within void	min. 150mm	ceiling treatment may only be fixed to perimeter walls and must not have contact with existing floor/ ceiling structure

* *size of independent joists set by loadings and span conditions*
** *See Section 4.7.1*

Typically, secondary ceilings are a minimum of 100mm deep but optimum improvements are achieved with depths of 250mm. The greater the ceiling void depth and the less direct connection between the secondary ceiling and the original floor structure, the better the improvement. Figure 4.7b shows a range of ceiling treatments for an existing concrete core floor with gypsum board on timber branders (ceiling battens).

Where secondary ceiling depth is at a premium the choice of fixing mechanism may compensate for the limited depth. Use of composite supports such as timber battens and metal resilient bars can improve sound insulation with ceiling voids depths of 70mm.

Placing absorption layers within the ceiling void can also increase sound insulation for airborne noise and impact noise (from footsteps). However, care should be taken to avoid electrical cables overheating and installation must comply with BS 7671. Also, the additional weight of fixings, boards and insulation will increase loading on the original structure. Specialist advice from structural engineers should be sought to determine if such additional loads can be accommodated by the existing structure.

Metal resilient bars introduce isolation by providing resilience at the point where the bar is fixed to the ceiling board. Resilient bars are typically 11–16mm thick and vary in design and resilience. Resilient bars should never be mounted directly to the underside of an existing ceiling as this creates full contact between the ceiling and the resilient bar for its full length.

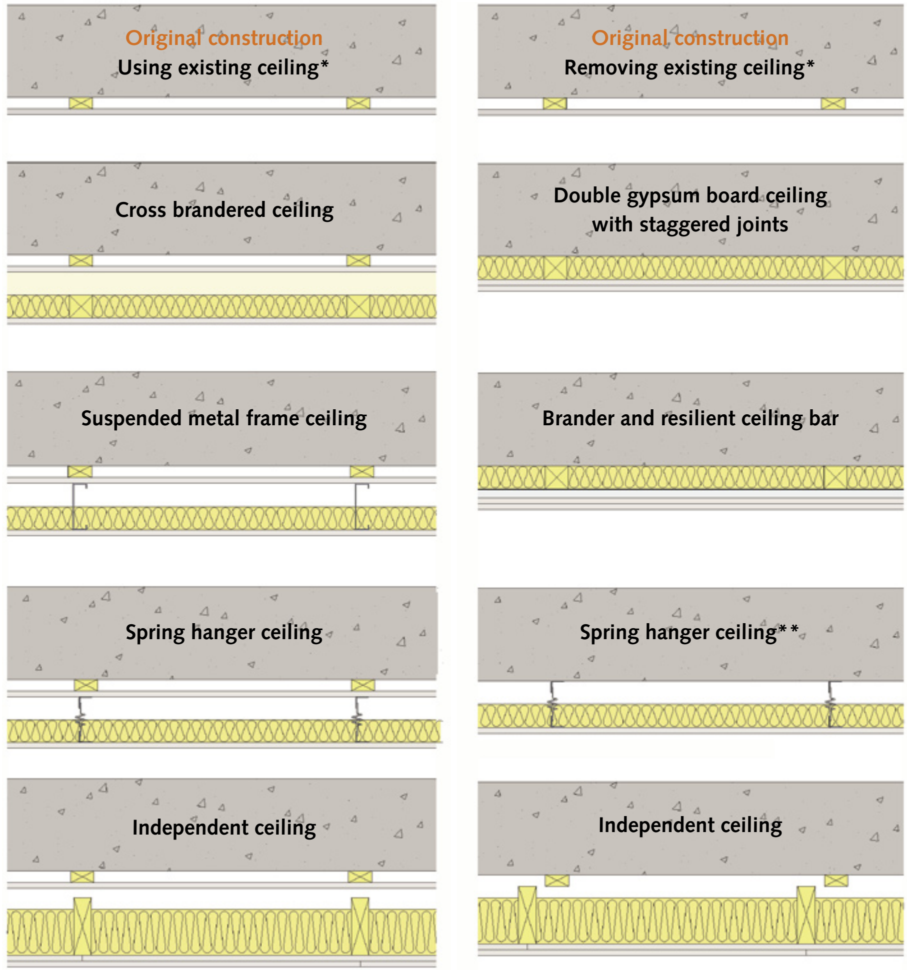
For both concrete floors and timber floors, where the existing ceiling is not being removed and resilient bars are being used, it is always preferable to install a 50 x 50mm timber brander and then mount the resilient bar perpendicular to the brander. For concrete floors, where the existing ceiling is being removed, timber branders should be used prior to installing the resilient bars. In the case of joist floors the resilient bars may be directly connected to the joists provided they are perpendicular (at right angles) to the direction of the joist.

Figure 4.7b

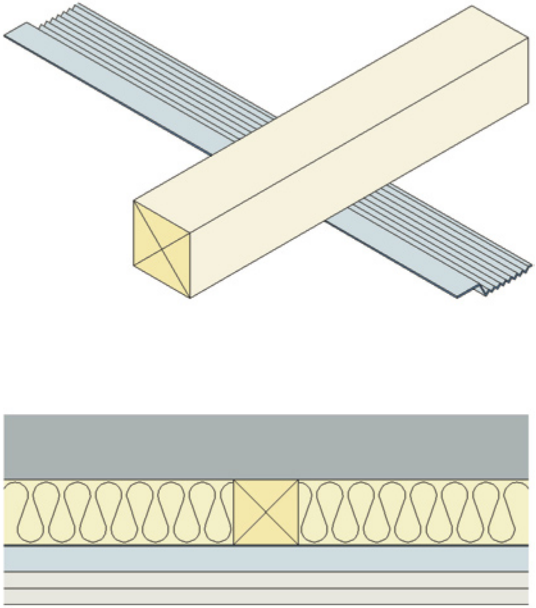
Types of ceiling treatments for concrete core separating floors

* mineral wool quilt or batt density generally 10–36kg/m^3

** suspended metal frame ceiling (shown on the left with existing ceiling) may also be directly fixed to slab



Examples of resilient bars and mounting detail to ceiling brander



Installing resilient bars to joisted floors or timber branders

When fitting ceiling boards to the resilient bars ensure that the fixing only penetrates the resilient bar and does not penetrate or touch any other component. If the fixings do connect to other components (e.g. joists or branders) this will cause bridging and reduce the performance.

4.7.2 Special ceiling hangers

Spring hangers, acoustic hangers and resilient hangers allow significant improvements with shallow ceilings by increasing the isolation but are generally more expensive than simple metal frame hanger systems.

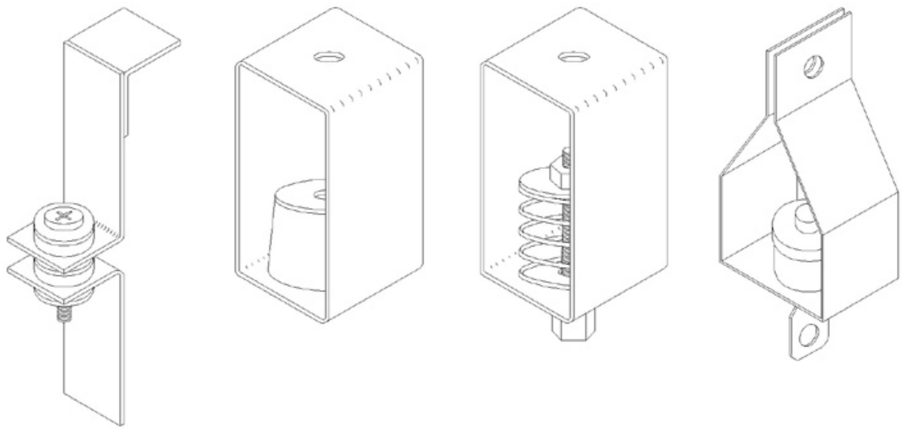


Figure 4.7c

Examples of specialist acoustic ceiling hangers

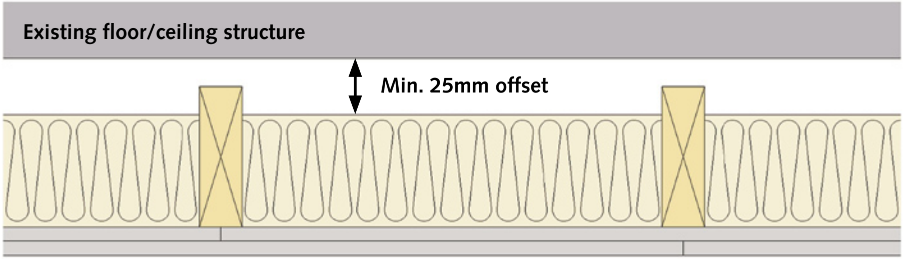
4.7.3 Independent ceilings

Independent ceilings are typically timber frames supported off a perimeter wall plate. A typical frame section is 100 x 50mm, but the size increases with the length of span. The ceiling joists should be offset at least 25mm below the existing ceiling or floor structure.

The overall minimum ceiling depth should not be less than 125mm but preferably 250mm for optimum performance. The frame should incorporate a minimum of 100mm quilt or batt insulation between the ceiling joists. The ceiling is normally lined with two layers of gypsum-based board (min 8kg/m^2 per layer) with staggered joints. Where a higher performance is required, two higher density boards of differing thicknesses should be used.

Figure 4.7d

Section through independent ceiling system



Generic lining system

25mm or 50mm mineral wool quilt wrapped completely around the pipe and boxed with two layers of gypsum-based board, minimum mass per unit area of 8kg/m² per layer.

Proprietary lining system

Proprietary specialist pipe lagging system and boxed with one layer of gypsum-based board, minimum mass per unit area of 10kg/m².

A common source of complaint in flats is noise related to drainage runs, drainage stacks or soil and vent pipes (SVPs). The most common method to reduce noise transmission from services is to enclose pipe runs or stacks in a generic lining or proprietary lining system, as detailed below:

Generic solutions are normally less expensive than proprietary systems but may be more time consuming to fit. In both cases the wrapped insulation should completely surround the pipe and the boxing and gypsum board should not come into direct contact with the pipe or pipe fixings.

Where there are horizontal pipe runs through separating floors either in the ceiling void or in floor cavities between timber joists these may require to be wrapped and boxed with two layers of gypsum-based board. In some cases it is difficult to box these services and so heavy proprietary pipe wrap systems involving multi-layered materials may be required. Alternatively additional ceiling board layers may be used with quilt insulation covering the whole of the ceiling area.

For further information on pipe services in conversions please see Chapter 8.

To specify materials and select an appropriate remedial system, component or element, it is useful to understand how the manufacturer or supplier describes the product acoustic performance.

Each material will behave differently according to the wall or floor system in which it is used. As sound travels between adjoining dwellings through multiple pathways, it is the overall system that will dictate the final performance and not one single component. It may be useful to seek advice from a building acoustic expert when assessing product performance for specification purposes.

Many products and systems are tested in a laboratory to determine their acoustic properties. But some test results only identify the potential performance and do not provide a true reflection of performance relative to real dwellings (on-site performance) with multiple sound transmission pathways. **If the only means to gauge the performance of a wall or floor system are laboratory test results, at least 6dB should be subtracted from the laboratory performance to estimate potential on-site performance.**

There are many types of alterations to dwellings and their contents that can reduce sound insulation or introduce new noise problems. Examples of such adaptations are:

- replacement of carpets with laminate or wood flooring;
- installation of downlighters into existing ceilings;
- change of room function or use;
- new domestic appliances (e.g washing machines);
- mounting of integrated entertainment systems into separating walls or floors.

4.10.1 Replacement of carpets by hard floor surfaces

The use of hard floor surfaces instead of carpets has risen sharply in the last few years. In 2005, a DEFRA research study# noted that over 40,000 complaints to local

authorities in the UK were attributed to such flooring when used in flats or split villas. These types of hard surface include:

- laminate flooring;
- real wood flooring;
- tiles;
- sanded floorboards.

Whilst some of the popularity of hard floor surfaces may be attributed to fashion, it is often installed to reduce the problem of dust mites, which are related to asthma.

The difference in impact sound insulation that results from altering depends on the type of core floor structure, the workmanship, the underlay used and flanking paths. Often laminate or real wood flooring is laid without resilient underlay or with a very thin underlay which does not provide suitable impact resilience. Also some laminates are laid unevenly which leads to further noise issues.

Figure 4.10a indicates the loss in impact sound insulation levels that results from changing the floor finish to typical timber and concrete core floors.

Laminate or wood flooring should be stopped 5–10mm short of the perimeter walls to allow for expansion and prevent direct contact with skirtings and walls. If mouse mouldings or quarter round mouldings are fitted at the base of skirtings they should be positioned so that they do not directly touch the laminate. The resilient layer under the laminate should be installed with extra length to wrap around the flooring edge and underneath the skirtings or mouse mouldings, see Figure 4.10b.

#*(Defra – NANR65 'Laminated and Wooden Flooring: A guide for noise control').*

Figure 4.10a

Reduction in impact sound insulation when replacing carpet or carpet and underlay with laminate or wood flooring

Timber floor *

Floor surface change	Reduction in impact insulation performance	Change in Occupant Equivalent Rating
Carpet and underlay to laminate	17 dB	A* to F
Carpet to laminate	9 dB	B to E
Carpet to sanded floorboards	13 dB	B to G

Concrete floor **

Floor surface change	Reduction in impact insulation performance	Change in Occupant Equivalent Rating
Carpet and underlay to laminate	34 dB	A* to F
Carpet to laminate	25 dB	A* to F

* *Typical masonry supported timber floor with only quilt insulation*
** *Typical in-situ concrete floor as found in high-rise*

NB: Examples above are for thin carpets

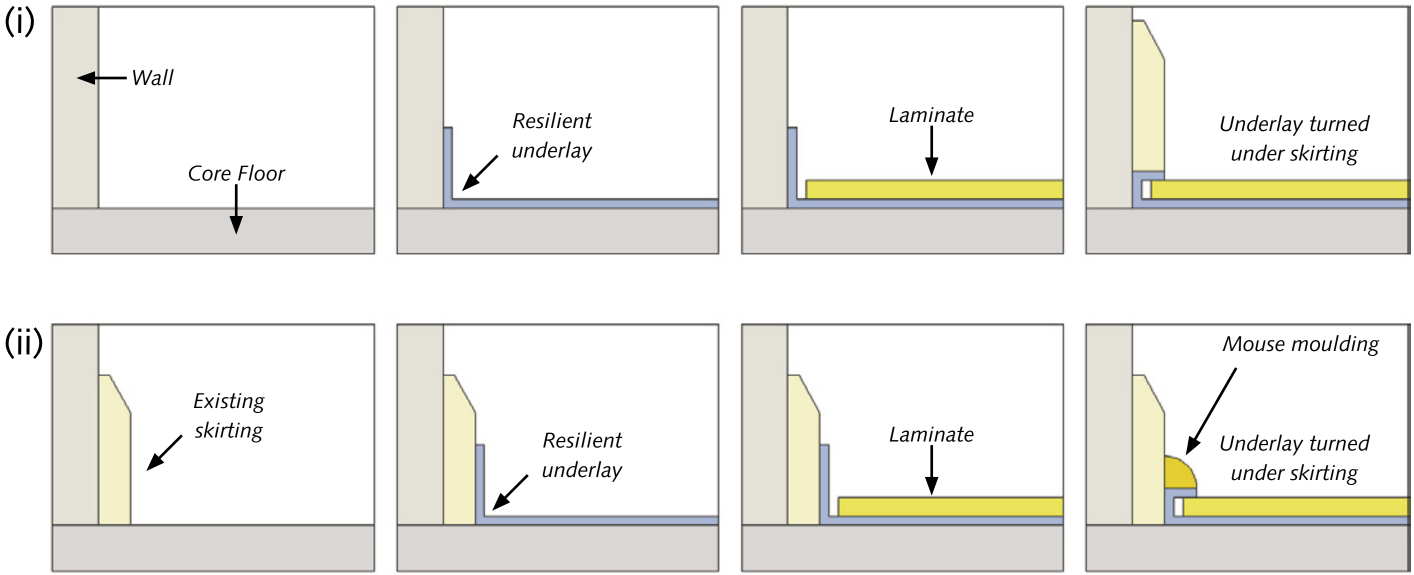


Figure 4.10b

Wrap around of underlay at edge of new wood flooring:
(i) with new skirting
(ii) leaving existing skirting in place and using mouse moulding

4.10.2 Downlighters or recessed lighting

Downlighters recessed into the ceilings, can reduce airborne and impact sound insulation performance by up to 3 dB, dependent on the type used. The reduction in insulation may be avoided by fitting them within a secondary ceiling or by using shields or covers. This ensures that neither sound insulation or fire resistance is reduced. Some downlighters are already fitted with in-built shields for fire resistance and are also useful for maintaining the sound insulation.

4.10.3 Change of room use

Within existing flatted dwellings, occupants may sometimes change the room function or use, i.e. swapping the living room for a bedroom. There may be several different reasons why an occupant may wish to change the room function (e.g. a bedroom may overlook a busy road and the occupants are having difficulty sleeping, whereas the living room overlooks a quiet location).

In flatted developments, if the initial design has not been altered, it is normal good practice for similar room uses to be stacked above each other. If the occupant changes room use it will then mean that the new living room (former bedroom) is under and/or above the bedroom of the neighbouring flats. Also their new bedroom (former living room) is under and/or above living rooms of these flats.

This will most likely lead to issues of noise disturbance, due to adjoining different room use, particularly if the sound insulation is poor. Occupants and housing managers should be aware of the potential conflicts of changing room use function that may occur.

4.10.4 Built-in entertainment systems and wall mounted systems

Developments in new technology that allow more sound power output at reduced size and cost have led to increased numbers of home entertainment systems. In addition, recent developments in speaker technology have led to in-built or flush wall and ceiling mounted systems, which increase the transmission of low frequency (bass) noise. Ceiling mounted speakers should be avoided in flats and wall mounted or recessed systems should not be installed within the separating walls of houses or flats. Built-in systems may also compromise the fire resistance of walls and floors.

4.10.5 Household appliances

The installation of household appliances such as washing machines, dishwashers or tumble dryers should be undertaken with care. Such appliances generate both noise and vibration and can be worse when appliances are built-in. All such appliances should be fully level and balanced when installed. Small resilient pads between the feet and the floor can improve acoustic damping and isolation.

5

Stone, rubble or brickwork construction

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A significant proportion of dwellings (0.5 million) were built during two primary construction periods, pre-1919 and 1920–1944, as defined in the Scottish House Condition Survey. The range of dwelling types includes Georgian, town houses,

tenement, 4-in-a-block, semi-detached and terraced houses. For the purposes of this publication, the term ‘tenement’ will refer to traditional Scottish tenements with ash-deafened timber floors, accounting for approximately 220,000 dwellings. Attached houses and flats during both periods used stone and rubble or brickwork walls to support timber floors.

From a sound insulation perspective, this introduced interesting flanking sound transmission features in flats, particularly those with half brick thick walls and thin spine walls. After 1930 the composition of the floors in flats became increasingly lighter in weight, as construction moved away from ash-deafened floors to quilt insulation such as mineral wool.

These construction features are discussed here in relation to core construction, structural junctions, surface finishes or linings, factors influencing performance and recommends remedial treatments for improving sound insulation performance.

Typical building types of the pre-1919 and 1920–1944 periods.






Common construction features (pre-1919)

- stone and rubble external solid walls
- separating walls of stone and rubble or brick spine walls
- lath and plaster wall linings
- timber separating floors with ash-deafening and deafening boards
- ceilings suspended on hangers (not for all tenements)
- heavy plaster ceilings with ornate cornices
- recesses in walls for cupboards, presses, ranges and fireplaces.

Common construction features (1920–1944)

- cavity external walls
- brick separating walls
- lath and plaster or plaster finish wall linings
- timber separating floors with relatively little deafening or lightweight floors with mineral wool in the floor cavity (1930s onwards)
- no ceiling hangers
- plaster ceilings of lower mass than pre-1919 and gypsum-based board ceilings being adopted (1930s onwards)
- less ornate cornices than pre-1919
- thinner separating wall thickness and shallower recesses for cupboards, presses and fireplaces
- wall linings of either plaster or gypsum-based-board (1930s onwards).

5.2.1 Core wall construction and linings

Attached houses and flats built pre-1919 had large rooms and long floor joist spans. Dwellings were commonly four storeys (e.g. Georgian townhouse or tenement) and the external walls were of substantial size (typically 600–800 mm) and mass (stone and rubble). Separating wall finishes included lath and plaster or plaster. Separating walls between dwellings and communal areas were often 140–200mm thick.

Floor joists in tenements were often supported on internal spine walls, such as half brick and full brick thick. These were thinner than the outer walls and often continuous through the building. Internal partitions were composed of timber studs with lath and plaster.

For separating walls between tenement blocks or attached Georgian housing the thickness can be similar to the external walls, however recesses may also be present. The variety of wall thickness and material make-up, as shown in Figure 5.2a, provides diverse levels of flanking sound transmission dwelling-to-dwelling for flats.

After 1919, external wall construction moved away from solid walls to cavity walls. In addition, stone and rubble single wall construction changed to cavity masonry construction, sometimes still using stone on the outer leaf. Separating walls were either full brick or half brick thick with plaster finish. In the early 1930s the use of plaster finishes started to be replaced by dry lining boards on straps.

The thickness of the separating walls was reduced in various locations due to fireplaces, chimneys, cupboards (presses) or wide recesses for kitchen ranges. All such recesses can reduce the sound insulation performance.

Figure 5.2a

Typical separating walls found in pre-1919 tenements:

(1) between two tenement blocks;

(2) thin spine wall with angled fireplace;

(3) flat to communal stair;

(4) fireplace and cupboard (often called a "press").

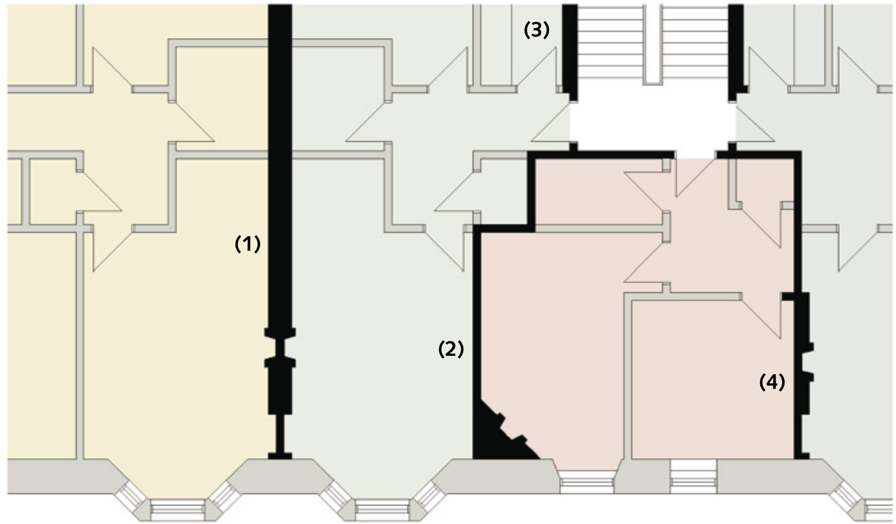


Figure 5.2b shows a sample range of separating wall types found in tenement dwellings. Solid external walls, which are substantially thick, result in limited flanking transmission between dwellings. The sound insulation is primarily controlled, by the separating wall and junctions with thin spine walls. Where thin internal spine walls form a junction with substantial stone separating walls there will be limited flanking transmission due to the mass of the separating wall.

In the case of thinner masonry separating walls the junction with other internal masonry walls may reduce the sound insulation markedly (due to flanking sound transmission). Figure 5.2c shows examples of spine wall junctions and Figure 5.2d shows flanking sound transmission paths that reduce the overall potential sound insulation performance of the separating wall.

Separating walls are also located between dwellings and communal areas such as stairwells and corridors. In traditional tenement dwellings these separating walls are generally quite thin, i.e. less than 200mm (see Figure 5.2e). Due to the presence of hard finishes to walls, floors and stair surfaces, these areas provide a very reverberant space (or high echo factor). This allows noise to remain for a longer period and reflect on many surfaces.

Figure 5.2b

Types of separating walls:

(a) stone and rubble with lath and plaster;

(b) 9″ (215mm) full brick thick with plaster;

(c) 4″ (102.5mm) half brick thick with plaster

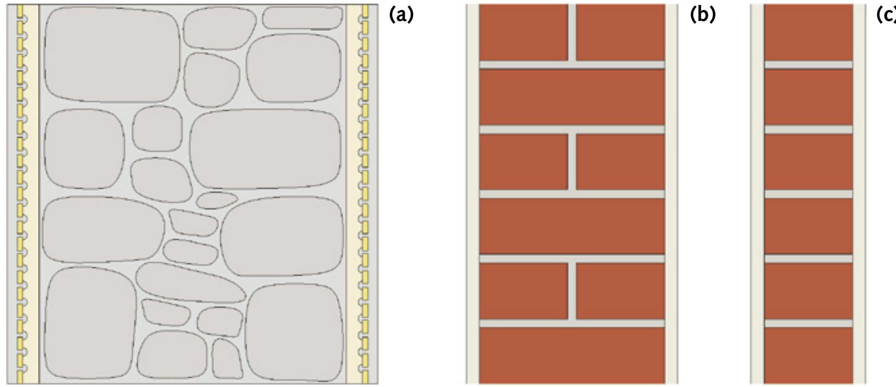
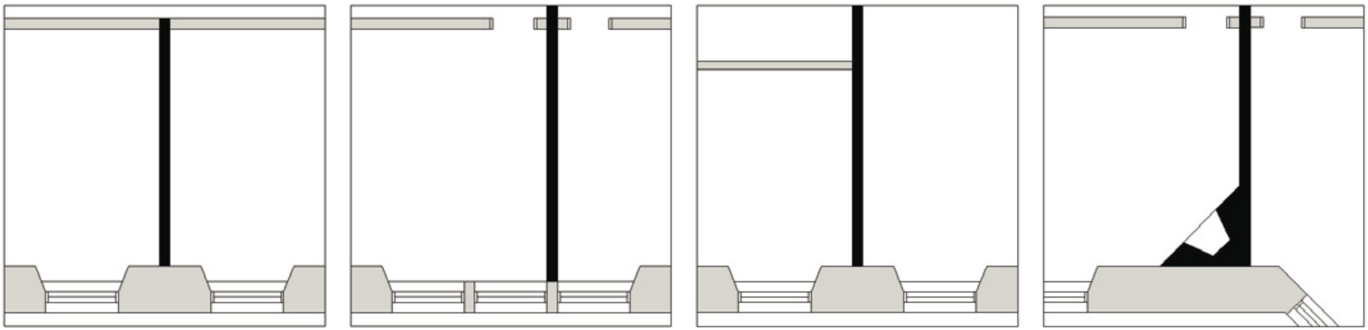


Figure 5.2c

Examples of spine wall junctions (plan view)



(a) (b) (c) (d)

Figure 5.2d

Flanking sound transmission paths, shown by arrows, present between dwellings A and B at junctions of thin spine walls (plan view)

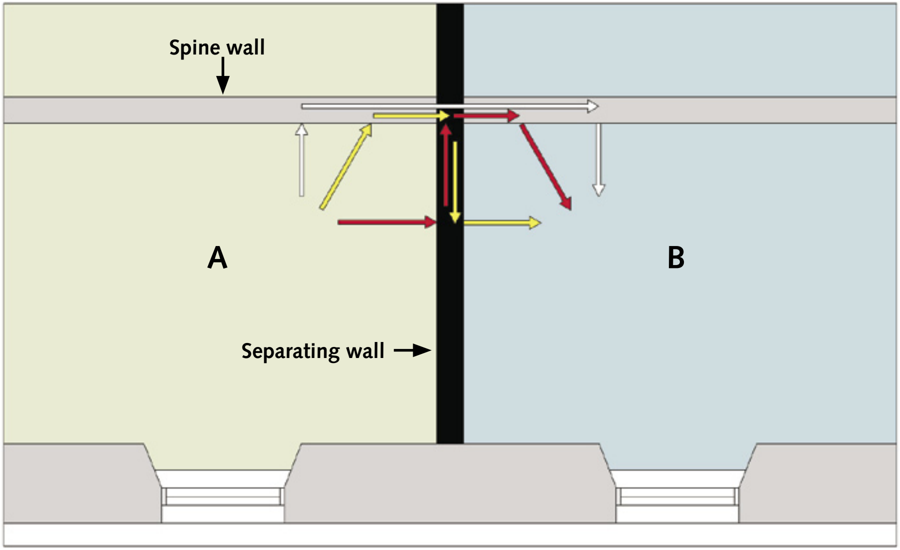
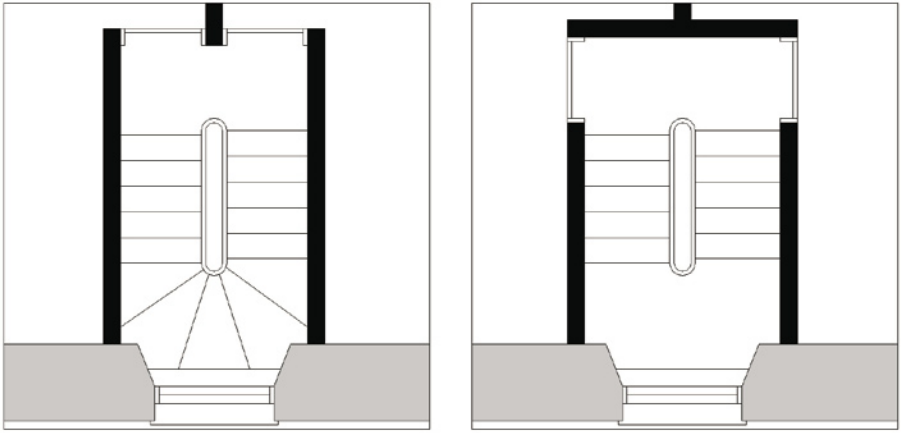


Figure 5.2e

Examples of separating wall layouts at dwelling to stairwells



Main doorways to communal areas – sound leakage points

- perimeter of door
- perimeter of door frame
- ineffective or damaged seals, particularly at door thresholds
- fan light windows or adjacent viewing windows
- letter box
- lock and hinge mechanisms.

5.2.3 Areas of weakness

As listed in Figure 5.2f, a number of factors influence the sound insulation performance of separating walls, creating concentrated weak spots for sound transmission to more easily occur. In addition, 'boss plaster' can occur as old plasterwork can lose strength and adhesive bond. When the surface is 'tapped', it may sound hollow (boss) and will most likely need to be removed and a new coating applied.

Figure 5.2g outlines typical performance values for a range of separating wall types found in dwellings built pre-1919 and 1920–44.

Figure 5.2f

Factors likely to reduce separating wall performance in traditional stone and brick built dwellings

Factors likely to reduce sound insulation for walls built pre-1919

- Flues and fireplaces in separating wall, sometimes back to back or interlocking
- Presses or cupboards in separating wall, sometimes back to back
- Recesses for kitchen ranges, sometimes back to back
- Junction of separating wall with thin spine flanking walls
- Boss plaster
- Damage to plaster or lath and plaster due to service works, or water leaks
- General breakdown of lath and plaster finish
- Damage to walls and linings by cable and service installations.

Figure 5.2g

Typical performance for stone, brick and brick spine walls

Core wall	Finish	Performance[2]	
		$D_{nT,w}$ (dB)	OER
STONE WALL min 300mm thick lath and plaster finish	no recesses or defects	56–61	B,A
	with back-to-back presses and fireplaces	51–55	D,C
	with single deep press	54–57	C,B
	with staggered thickness and fireplace	51–53	D,C
BRICK WALL 215mm full brick with plaster both sides	no recesses or defects	53–57	C,B
	with 'boss' plaster	51–53	D,C
BRICK WALL 215mm full brick with dry-lining both sides	no recesses or defects	51–55	D,C
	open mortar joints	47–51	E,D
BRICK SPINE WALL half brick thick with 20-30mm plaster both sides	no recesses or defects	47–51	E,D
	with 'boss' plaster	44–48	F,E
	with window junctions	43–47	G,F,E
	with 'T' junction at spine wall	44–48	F,E
	typical stairwell to dwelling[1]	46–51	F,E,D

Notes:
(1) Performance may be affected by sound leakage via entrance and internal doors
(2) Performance values shown are typical mean range values
OER: refer to Section 3.4

5.2.4 Remedial measures

There is understandably a reluctance to lose interior architecture such as ornate cornices, architraves and other period features. Only areas of weakness such as cupboards or recesses within the wall may require some remedial treatments without influencing the interior period features. Potential remedial treatments are outlined in Figure 5.2h. Further reference should be made to Section 4.3, ‘influences of remedial treatments’.

Common remedial treatments applied to such recesses involve linings using 42mm mineral fibre backed boards. Where work is required for the whole wall remedial treatments (in ascending order of performance) include:

- render coats;
- mineral fibre backed boards;
- resilient wall linings;
- independent wall linings.

In cases of thin spine separating walls (approximately 150mm thick) where ornate cornicing may not always be present, there are several solutions for increasing sound insulation performance, as outlined in Figure 5.2h.

Figure 5.2h

Suggested remedial treatments for pre-1919 buildings involving stone walls, with lath and plaster, and brick spine walls with plaster finish

Core wall		Separating wall: Remedial Treatments and Typical Performance Improvement ($D_{nT,w}$)						Flanking wall (spine wall)
		13mm plaster	13mm Render & drylining or plaster	42mm mineral fibre backed gypsum board	8mm render + 42mm mineral fibre backed gypsum board	Resilient wall lining treatment	Independent wall lining	42mm mineral fibre backed gypsum board
STONE WALLS/LATH & PLASTER 250mm to 450mm thick				**+4 to 8dB**	**+5 to 8dB**	**+6 to 10dB**	**+7 to 12dB**	
Noise complaint issues	Speech, TV			■		■		□
	General living noise			■		■		□
	Doors/drawers closing			■		■		□
	Low freq. music bass					■	■	□
	Appliance noise					■	■	□
Separating wall factors causing reduction in performance	Press/cupboard			■				□
	Kitchen range voids			■				□
	Flues/fireplaces			■				□
	Damaged lath & plaster	■☒	■☒	■☒	■☒	■☒	■	□
BRICK WALLS & PLASTER 140mm to 240mm thick		**+1 to 3dB**	**+2 to 5dB**	**+4 to 8dB**	**+5 to 10dB**	**+6 to 12dB**	**+7 to 15dB**	
Noise complaint issues	Speech, TV		●	■	●	■	■	□
	General living noise		●	■	●	■	■	□
	Doors/drawers closing			■	●	■	■	□
	Low freq. music bass				●	■	■	□
	Appliance noise				●	■	■	□
Separating wall factors causing reduction in performance	Boss or damaged plaster	◆	◆		●	■		□
	Varying wall thickness			■	■	■	■	□
	Press (cupboard)			■	■	■	⌘	
	Flues/fireplaces			■	■	■	⌘	
Increase in wall thickness one side		n/a	n/a	52mm	60mm	70-90mm	varies	52mm

Key:	
■	recommended ⌘ built within recess or flush with wall to seal void
□	dependent on extent of flanking contribution/applied to existing wall face
☒	apply to core wall face after damaged lath & plaster removed
◆	remove boss plaster and apply treatments to core wall face
●	do not apply render to plaster unless good adhesion is possible

Note: Where lath & plaster or plaster is damaged it is preferable to replace these linings using similar materials, if possible, to retain period features and architectural interiors.

5.3 TRADITIONAL ASH-DEAFENED FLOORS

Ash-deafened floors were the primary form of separating floor systems in Georgian, traditional tenement and four-in-a-block style dwellings built pre-1919.

5.3.1 Core construction, floor finish and ceiling linings

The core construction comprises deep timber joists with small timber battens along each side of the joist to support deafening boards. These boards provide the platform to support and contain the ash-deafening. Figure 5.3a shows two types of ash-deafened floors commonly found in Scotland, with and without suspended ceilings.

The deafening boards and the mass of the ash-deafening (typically 70mm thick) assists in stiffening the floor. The deafening was often composed of ash and small stones from builder's rubble and the diverse particle mix increased the sound insulation performance.

Solid timber dwangs or herringbone struts were commonly used to brace the floor. The top surface of the floor joist was often directly connected to the tongued and grooved (t&g) floorboards.

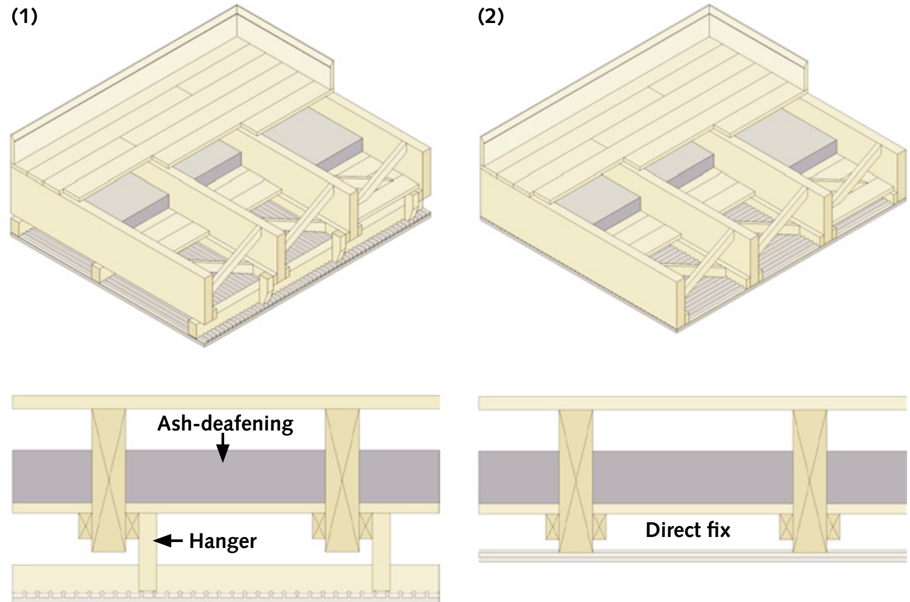
Ceilings were lath and plaster, 20–30mm thick, and either suspended on hangers or directly fixed to the joists, as shown in Figure 5.3a.

5.3 TRADITIONAL ASH-DEAFENED FLOORS

5.3.1 Core construction, floor finish and ceiling linings

Figure 5.3a

Isometric and sectional views of traditional ash-deafened floors (1) with and (2) without hangers



Joists were primarily supported on substantial solid stone and rubble walls or on full and half brick thick spine walls. Due to the mass of the stone walls, there is little, if any, flanking sound transmission vertically flat-to-flat via this path. In the case of full brick thick walls there is some flanking sound transmission. Of primary concern, however, is the situation where continuous vertical walls between flats are thin and have a low mass (e.g. half brick thick with plaster finish).

Due to the low mass of the walls, the spacing between the joists and the wall masonry rising continuously between the joists, a flanking sound transmission path is created flat to flat, as shown in Figure 5.3b.

Figure 5.3b

Flanking transmission, as shown by arrow, past timber separating floor via thin masonry spine walls

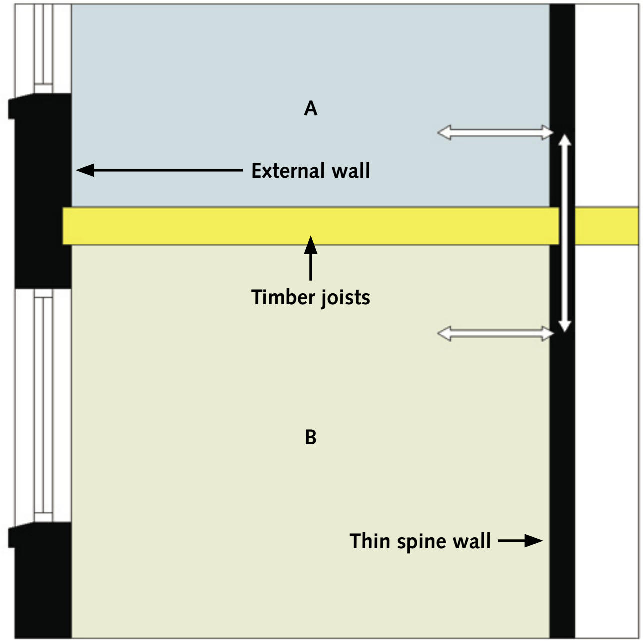


Figure 5.3c outlines some of the factors likely to reduce the performance of traditional ash-deafened floors.

Examples of post-construction works or adaptations include service installations for gas pipes, central heating, electrical cables and other service requirements. These works have often involved notching of joists (creating openings within the joists for placing service pipes and cables).

To access the floor cavities for service installation, work often involved removing, and potentially damaging, existing floorboards. The damaged floorboards not only created potential voids for sound to leak into but may also have led to loose and squeaking floorboards. In some cases the ash-deafening was removed and very often never returned or replaced. During the exposure of the joists the deafening boards supporting the ash, may have been damaged or removed and not replaced.

Previous water leaks also reduce sound insulation performance, causing floorboards to warp and ash-deafening to be washed down into the ceiling or perimeter wall voids, with consequent damage to the existing plaster ceiling.

Water damaged lath and plaster ceilings (as shown in Figure 5.3d) are more often replaced with gypsum-based boards, which are not of the same mass and thickness as the original ceiling.

Where edge joists run parallel to the walls, there is often an area of weakness where the ash-deafening may not have been inserted correctly or was removed during works or damaged by water leakage. Figure 5.3e illustrates the potential void that may occur in this edge joist-wall zone.

Figure 5.3f shows the typical performance range recorded for traditional ash-deafened floors. Examples of the influence on performance of the reduction or removal of ash-deafening, change in ceiling type and various hard floor surface linings are also provided.

Figure 5.3c

Factors likely to reduce separating floor performance in ash-deafened floors

Factors likely to reduce floor performance floors built pre-1919

- Removal of ash-deafening and/or deafening boards
- Lack of ash-deafening at room perimeter joists parallel to walls
- Water leaks causing damage to ash-deafening and ceiling
- Notching of joists for services, pipes and cables leading to reduced stiffness
- Damaged floorboards which may also lead to squeaking noise
- Replacement of thick plaster ceiling with gypsum-based boards
- Direct fixing of ceiling to joists (not suspended ceiling)
- Service pipe penetrations through separating floor
- Flanking sound via thin spine walls
- Removal of carpets and change to sanded floorboard finish
- Replacement of carpet by laminate, wood flooring, vinyl or lino
- Changes to length of joist span by removal of intermediate support beams.

5.3.3 Areas of weakness

Figure 5.3d

(1) Floorboards damaged due to installation of services

(2) Lath and plaster ceiling damaged by water leaks

(1)

(2)

Figure 5.3e

Section showing weak area for sound insulation where edge joists are parallel to the walls

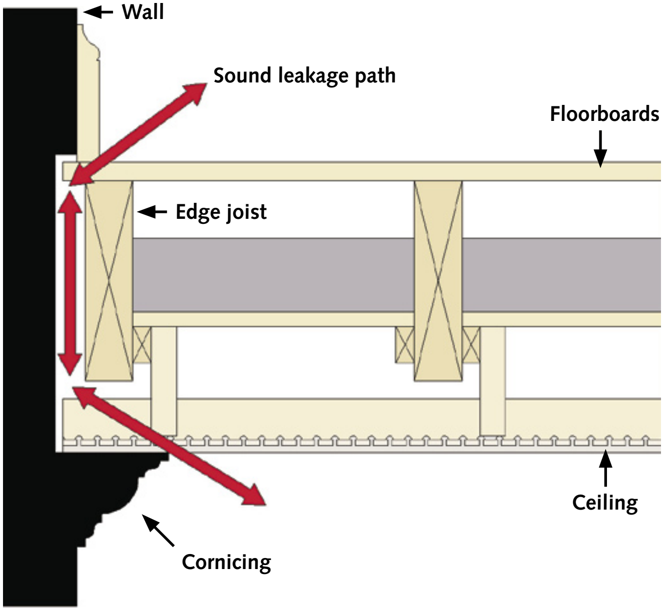


Figure 5.3f

Typical performance range recorded for traditional ash-deafened floors built pre-1919

CORE FLOOR	FLOOR CAVITY MATERIALS	Airborne Performance (1)		FLOOR FINISH	Impact Performance (1)	
		$D_{nT,w}$ (dB)	OER		$L'_{nT,w}$ (dB)	OER
Ash-deafened floor						
With hangers lath & plaster ceiling and deafening boards	70mm ash-deafening	53–57	C,B	floorboards	54–58	B,C
	partial ash-deafening	49–52	E,D	floorboards	58–60	C,D
	no ash-deafening	46–48	F,E	floorboards	60–63	D,E
Without hangers lath & plaster ceiling and deafening boards	70mm ash-deafening	51–54	D–C	floorboards	57–62	C-E
	partial ash-deafening	46–50	F,D	floorboards	60–63	D,E
	no ash-deafening	44–47	F,E	floorboards	61–67	D–F
	no ash-deafening			laminate(2)	59–64	D,E
	no ash-deafening			lino	65–68	F,G
	no ash-deafening			hard vinyl	67–69	F,G
Two layers gypsum-based board ceiling and deafening boards	70mm ash-deafening	47–52	E,D	floorboards	61–65	D-F
	partial ash-deafening	43–46	G,F	floorboards	63–66	E,F
				lino	64–66	E,F
Two layers gypsum-based board ceiling – no deafening boards	50mm quilt	42–46	G,F	floorboards	67–71	F,G
	no quilt insulation	38–43	G	floorboards	70–73	G
				laminate(2)	66–70	F,G

Note: *flanking transmission via perimeter spine walls can sometimes be a dominant path for sound transmission*
(1) *Performance values shown are typical mean range values*
(2) *Laminate installed with no underlay*
OER *refer to Section 3.4*

In the case of pre-1919 dwellings and the range of architectural interior period features, it is preferable that remedial measures chosen for improving sound insulation should not adversely affect these features.

Chapter 4 provides various floor surface solutions and ceiling solutions for improving impact and airborne sound insulation performance. Only some of the potential remedial treatments do not involve changing the overall floor-to-ceiling heights. Shallow platform floors and soft floor coverings will enhance impact sound insulation against footstep noise with relatively little change to existing features. The use of insertion treatments, e.g. within the floor cavity, will increase sound insulation performance and retain original ceilings and floor finishes (refer to Figure 5.3g).

Figure 5.3g

Potential cavity insertion treatments

Insertion material	Comments	Density kg/m³	Depth mm
Heavy treatments			
Ash-deafening*	Often original floor cavity material	1100	70
Pulverised fuel ash* (pfa)	Best mixed with stone chips	768	100
Dry sand*	Should be installed on polythene sheet	1590	50
Limestone chips*	Best used in mixed chip size and with 25mm mineral wool quilt or with 'pfa' mix	1390	60
Whin scalpings*	Preferable mixed size	1240	60
Crushed shells*	Can give off strong marine odour	1095	75
Foamed slag*	Best mixed with stone chips	985	80
Recycled waste gypsum*	Insert bags and then cut open	700	100
Light treatments			
Mineral wool batt	Will only assist mid and high frequencies	140–200	150
Mineral wool quilt	Will only assist mid and high frequencies	10–33	150
Blown fibre	Will only assist mid and high frequencies	<10	

Notes

** requires deafening boards, do not lay these materials directly on the ceilings.*

1) *Avoid electrical wires being covered by insulation materials, as overheating may occur, refer to BS 7671.*
2) *Undertaking patch repairs may not always provide suitable improvements.*
3) *Where a mixture of materials are used recalculate depth and mass.*
4) *Depth and mass of heavy treatments are designed for 70 – 80kg per square metre, similar to former ash-deafening loads.*
5) *When applying additional loads to existing timber floors expert advice should be sought from structural engineers to identify load limitations of floor.*

The use of ceiling treatments such as secondary ceilings (as outlined in Chapter 4) can provide increased performance for both airborne and impact sound insulation. These will, however, influence interior floor to ceiling heights and period features such as ornate cornicing.

Special attention should be given to loading implications of secondary ceilings. In some cases it is best to use an independent ceiling to avoid deflecting the floor joists any further. One of the limiting factors of using secondary or independent ceilings is the height limit from existing ceiling to window and door architraves.

For impact noise it is always preferable to reduce impact or footstep noise at source by use of floating floor treatments, such as platform or resilient batten systems or soft floor coverings. Insertion resilient floor systems are available that can be placed between the joist and floorboards, as shown in Figure 5.3h. Although the floor height change is small (20–40mm), this would still require lifting of floorboards.

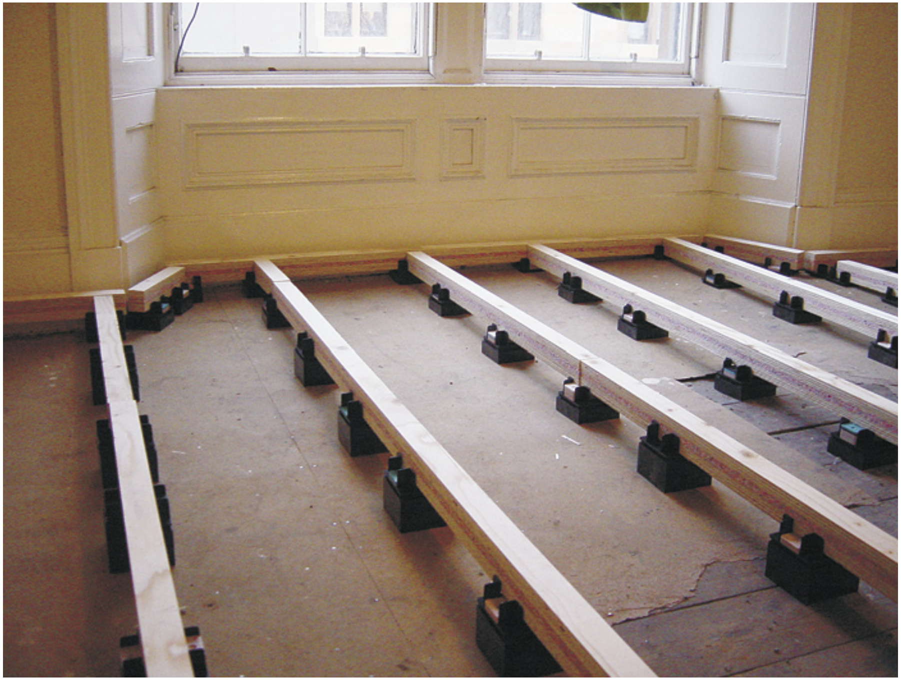
Figure 5.3h

Insertion of resilient treatment between flooring boards and joists

Cradle systems are useful for re-levelling of the floor. More recently, new batten systems have been devised for use on timber floor structures. As with other floating floor treatments, however, these increase the overall floor depth and reduce floor to ceiling heights.

Figure 5.3i

Example of re-levelling highly deflected timber floor using a cradle system



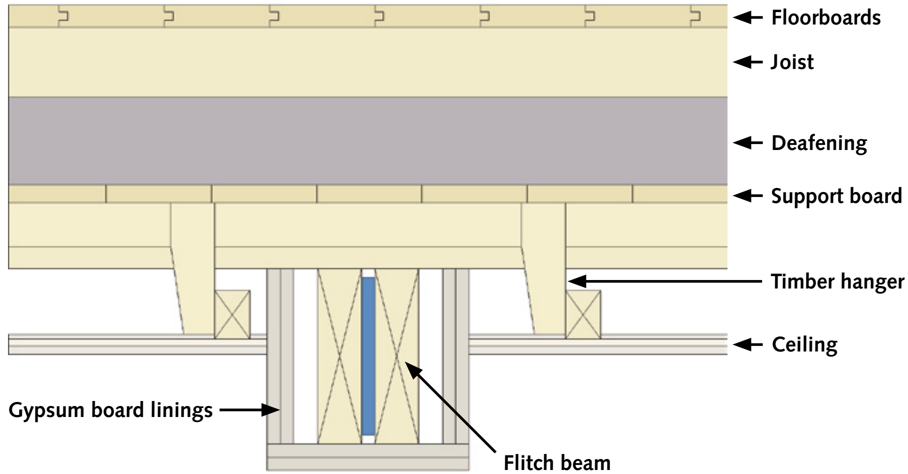
Where there is low floor stiffness and/or significant deflections by the floor joists, the use of flitch beams can provide substantial improvements in stiffness and reduce airborne and, more particularly, impact sound transmission.

Flitch beams are composed of a steel web with timber joists on both sides. This reduces the overall weight of the beam on the existing structure (as opposed to a normal steel beam) while still providing adequate support. The flitch beam does require to be boxed with two layers of gypsum-based board to maintain the floor's integrity for fire resistance. Figure 5.3j shows an example of a flitch beam and cross section through its construction.

5.3.4 Remedial measures

Figure 5.3j

Flitch beam insertion to prevent further deflection, increase floor stiffness and improve sound insulation



(Typically built 1930–44)

Lightweight timber floors supported by masonry walls were commonly used forms of separating floor construction during the 1930s and early 1940s. The replacement of ash-deafening with quilt materials together with the use of gypsum-based board ceilings instead of heavy lath and plaster resulted in a poorer performing separating

floor. Figure 5.4a provides a cross section of the typical floor build-up, which is often associated with four-in-a-block type dwellings.

In addition to the reduction in mass of the floor the use of thin masonry supporting walls both internally and on the inner leaf of the cavity external wall results in high levels of vertical flanking transmission via the perimeter walls.

These factors lead to a number of issues when trying to improve sound insulation and not only will the separating floor require upgrading but additional linings may also be required for the flanking walls. Figure 5.4b lists the factors influencing sound insulation performance of masonry supported lightweight timber floors.

Similar to ash-deafened floors, post-build service work and alterations such as notching of joists, damaged floorboards and replacement of carpets with laminate or wood flooring leads to poorer levels of sound insulation.

Figure 5.4c shows the typical sound insulation performance of masonry supported lightweight timber floors built between 1920–44.

Figure 5.4a

Typical examples of lightweight timber floors supported by masonry walls.

(1) **(2)** **(3)**

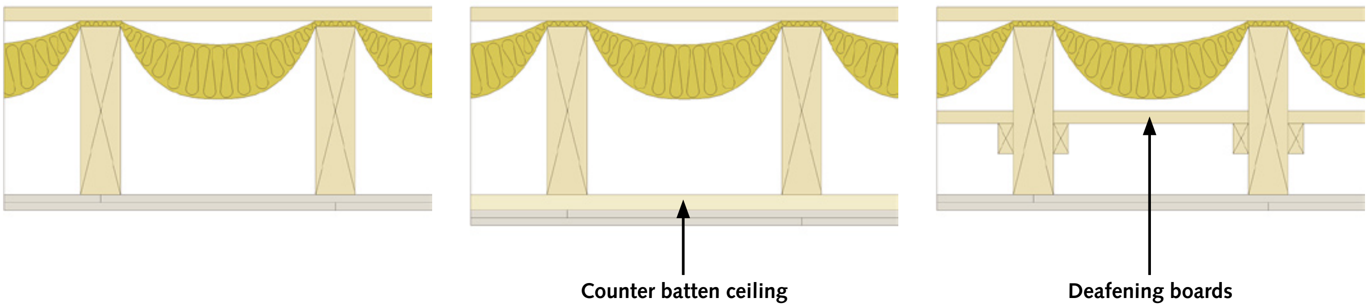


Figure 5.4b

Factors influencing sound insulation performance of masonry supported lightweight timber floors.

Factors influencing sound insulation performance of masonry supported lightweight timber floors

- Poor original design and inadequate construction materials
- Flanking sound via thin walls
- Disintegration of mineral wool between floorboards and joists
- Damage to quilt or ceiling by water leaks
- Joists notched for services, pipes and cables leading to reduced stiffness of floor
- Damaged floorboards may result in squeaking boards and introduce sound paths
- Lack of absorption in floor cavity
- Direct fix of ceiling to joists rather than suspended ceilings
- Service pipe penetrations through separating floor
- Removal of carpets and change to sanded floorboard finish
- Replacement of carpet by laminate, wood flooring, vinyl, lino or tiles.

Figure 5.4c

Typical performance of masonry supported lightweight timber separating floors

CORE FLOOR	FLOOR CAVITY MATERIALS	Airborne Performance **		FLOOR FINISH	Impact Performance **	
		$D_{nT,w}$ (dB)	OER		$L'_{nT,w}$ (dB)	OER
Masonry supported* timber floor						
Floorboards + thin quilt + *200mm joists + 2 layers of gypsum-based boards*	Disintegrated 30mm quilt between joists and floorboards	35–39	G	floorboards	71–75	G
Additional cross ceiling batten or brander 50 x 50mm	Disintegrated 30mm quilt between joists and floorboards	38–42	G	floorboards	68–72	G

* *strong flanking transmission via perimeter half brick thick walls*
** *performance values shown are typical mean range values.*
OER *refer to Section 3.4*

5.4.1 Remedial measures

To raise the level of sound insulation performance for this type of floor, treatments need to be applied to the floor surface, ceiling and flanking walls. Unlike pre-1919 dwellings, however, the smaller room sizes and floor to ceiling heights results in limited options for improvement.

The use of floating floor treatments (as outlined in Section 4.6) such as shallow platform floors, normal platform floors or resilient battens increases impact performance significantly and provides a positive contribution to airborne sound insulation. Using these systems avoids having to lift floorboards but does increase the floor depth. Soft floor coverings improve impact performance but, depending on the type chosen, may not improve airborne sound insulation.

Figure 5.4d provides examples of possible remedial treatments for floor surface and ceilings without lifting the existing floorboards.

Insertion treatments such as previously shown in Figure 5.3h also increase impact performance but will require floorboards to be removed and replaced.

Use of mineral wool or absorption materials within the main floor cavity can increase sound insulation for speech, TV and general living noise. Use of blown fibre insulation avoids the need to lift floorboards.

Ceiling treatments such as secondary ceilings will improve airborne and impact performance but ceiling void depth will be very limited (typically not more than 150mm) due to the small distance between ceiling and window soffit. Where possible, increasing the secondary ceiling void depth will generally provide an improved level of sound insulation

Figure 5.4d

Floor surface and ceiling treatments for masonry supported lightweight timber floors.

Treatments		Change in Depth	Airborne improvement	Impact improvement
Floor treatments*	Soft floor coverings (with flooring board finish)	22–38mm	0–3dB	5–10dB
	Shallow platform floor	13–32mm	3–4dB	10–14dB
	normal platform floor	40–60mm	5–7dB	11–15dB
	resilient battens	50–65mm	8–12dB	12–18dB
Ceiling treatments* applied to existing ceiling	50x50mm brander + resilient bar + quilt	70mm	5–9dB	5–10dB
	50x50mm brander + counter brander + quilt	115mm	4–8dB	5–9 dB
	suspended metal frame + quilt	115mm	8–12dB	8–14dB

Notes

** Performance of floor and ceiling treatments may be restricted by flanking*

1) *Values shown are estimated based on lower dwelling flanking walls being lined with 42mm mineral wool backed board.*

2) *Performance improvements using both floor and ceiling treatments cannot be calculated by adding values together.*

3) *For optimum improvements both floor surface and ceiling treatments should be used.*

4) *'quilt' relates to 50mm mineral wool or equivalent.*

Figure 5.4e illustrates examples of improving sound insulation by using resilient shallow platform floor linings and secondary ceilings that can be attached directly to the existing ceiling.

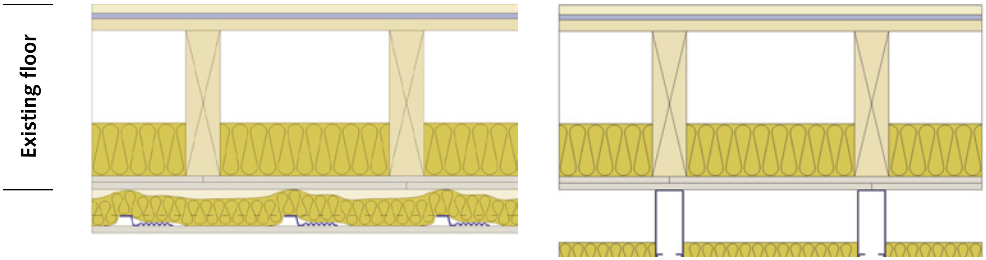
If the ceiling is going to be replaced for other reasons it is best to install resilient ceiling bars directly to the joists, and importantly, perpendicular to the joist direction (see 4.7.1). If access is possible to the floor cavity a minimum of 100mm quilt insulation should be placed in the voids between the joists, if sufficient insulation is not already present. Two layers of gypsum-based board, minimum 10kg/m^2 each layer, should then be fixed with staggered joints to the resilient bars.

Note: for masonry supported lightweight timber floors, even if the above floor and ceiling treatments are adopted, the potential improvement to sound insulation will be ineffective if the flanking walls are not treated.

As such the flanking walls should be lined with at least 42mm mineral fibre backed boards. Other potential wall linings (as discussed in Section 4.5) include resilient wall linings or independent wall linings. Suitable improvement to reduce flanking noise can be gained by lining only the lower dwelling perimeter walls below the separating floor. The choice of wall lining treatment will depend on the quantity of flanking noise.

Figure 5.4e

Secondary ceilings fixed to existing ceilings



6

Concrete construction

Also available in print from
www.arcamedia.co.uk

Examples of correctly built blockwork cavity wall with no open joints and junction with precast wide slab

Many different forms of blockwork wall, concrete floors and in-situ concrete systems (as found in high-rise dwellings) have been widely used since the 1950s. Across Scotland the diverse range of such wall and floor types leads to a number of complex issues when diagnosing sound insulation performance.

The two most common forms of separating wall are solid and cavity blockwork walls. The range of materials used for such walls includes:

- aircrete;
- lightweight aggregate;
- dense aggregate;
- no-fines concrete.

The two principal floor types found are precast wide slabs and in-situ concrete slabs. Beam and block floors are widely used in other parts of the UK but less so in Scotland.

These walls and floors can provide good levels of sound insulation when designed using the appropriate materials. Incorrect design of walls and floors, use of wrong materials and bad workmanship can, however, result in increased sound transmission and complaints from occupants.

The performance of solid and cavity walls and a range of concrete floor types is considered here in relation to:

- the core construction;
- key structural junctions;
- surface finishes or linings;
- common errors during construction;
- methods of improving sound insulation performance.

6.2.1 Core construction

The core construction of solid block walls is normally composed of dense aggregate concrete blocks, typically 215 x 100 x 440mm. Blocks are laid full width 215mm, as shown in Figure 6.2a. Such block laying, also known as "laid on its side", increases the wall's stiffness and acoustic performance.

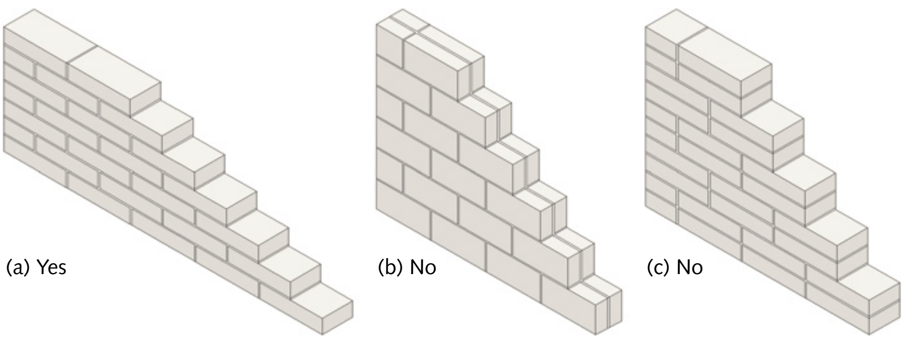


Figure 6.2a

Examples of correct and incorrect laying of 215mm dense blocks for existing solid walls:

(a) Correctly built with blockwork laid full width in single course stretcher bond;

(b) Incorrectly built as not laid on side (not full width) and using mortar infill;

(c) Incorrectly built with double coursing.

Dense block solid walls do not have an isolating layer, such as a cavity, but depend on their mass and stiffness for sound insulation performance. They can often provide effective insulation for normal living noise and some low frequency "bass" and electrical appliance noise. Other materials such as lightweight aggregate or aircrete, due to their lower mass, are not as effective for sound insulation when used in solid walls.

Figure 6.2b

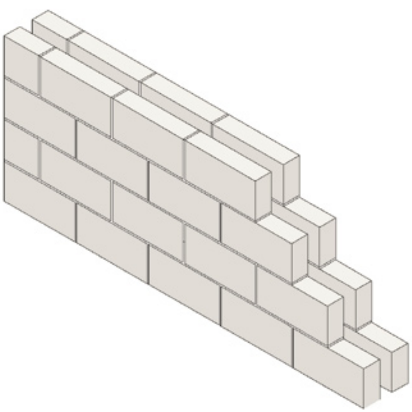
Potential errors in core construction of solid walls

Potential errors in core construction of solid walls:

- Not laying blocks on their side and full width (see Figure 6.2a)
- Using double coursing of blockwork (see Figure 6.2a)
- Incorrect block density
- Mortar beds not sufficiently filled with mortar and/or open joints.

Figure 6.2c

Cavity wall construction found in many existing dwellings



6.2.1 Core construction

For cavity walls the core construction is two leafs of 100mm (4″) blockwork separated by a cavity. The cavity creates an isolation (or decoupling) layer. Whilst the overall mass of solid and cavity walls may be similar, this isolation means that the sound insulation performance of cavity walls is often better than solid walls.

Isolation is the most effective ingredient towards good sound insulation performance. Masonry cavity walls regularly outperform solid walls. In addition mass is not always so important for cavity walls. This is demonstrated by the higher sound insulation performance of aircrete cavity walls than dense block cavity walls.

Wall ties are inserted in cavity walls to brace and stiffen the wall leafs for structural reasons. However, the structural connection formed by the ties can lead to a reduction in sound insulation performance. As well as transmitting sounds like speech, wall ties create a bridge for mortar droppings to collect on, which can further reduce performance. Separating wall cavities of less than 75mm are more likely to lead to the collection of mortar on wall ties.

Figure 6.2d

Examples of defects in existing cavity wall core construction

Examples of defects in existing cavity wall core construction

- Cavity too narrow
- Collection of mortar on wall ties
- Use of incorrect wall ties
- Mortar beds not sufficiently filled with mortar and open joints
- Cavity bridged by floor slabs or steel beams.

Figure 6.2e

Examples of *cavity bridging* due to wrong wall ties (being too stiff) and mortar that has collected on wall ties

6.2.2 Blockwork walls: key structural junctions

As for all types of separating walls, connection to other walls and floors provides routes for flanking sound transmission. This can reduce the separating wall's potential performance. It is important that the junction with the inner leaf of the external wall is correctly built. The two most common methods of connecting the inner leaf to the separating wall are:

- toothed;
- butted and tied.

Figure 6.2f shows both forms of junction for solid and cavity walls. For solid walls, the inner leaf (225mm coursings) is often *toothed* into the separating wall at every third and fourth course of the separating wall. Alternatively, the inner leaf is *butted and tied* to the face of the separating wall with ties fixed at no more than 300mm centres. The *butted and tied* method for solid walls generally results in a higher performance than *toothed*.

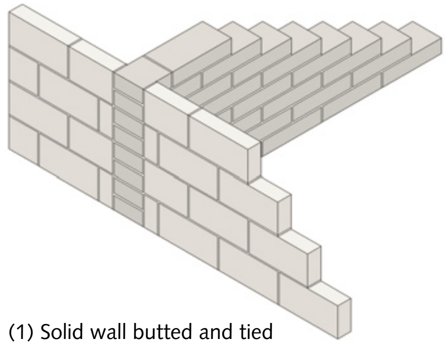
For cavity walls, there is little difference between *toothed* and *butted and tied* junctions because the cavity already provides effective isolation.

GO TO MAIN INDEX

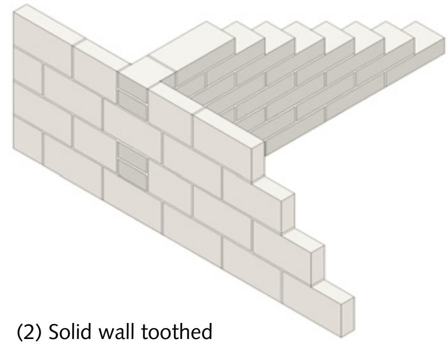
6.2.2 Blockwork walls: key structural junctions

Figure 6.2f

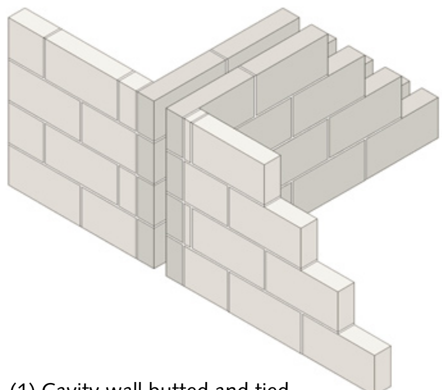
Correctly built junctions of separating walls with inner leafs (1) butted and tied (2) toothed



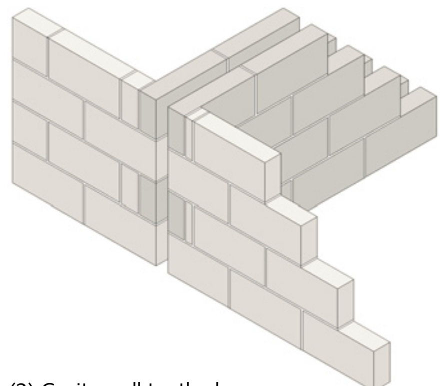
(1) Solid wall butted and tied



(2) Solid wall toothed



(1) Cavity wall butted and tied



(2) Cavity wall toothed

At higher frequencies of sound, such as for speech and general living noise, a blockwork wall's sound insulation performance is highly dependent on the surface treatments used. The three most common methods of finishing a wall, as shown in Figure 6.2g, are:

- 13mm plaster;
- gypsum board dry lining (on dabs or timber straps / battens);
- 6–13mm internal render or parge coat with gypsum board dry lining on dabs.

Plaster

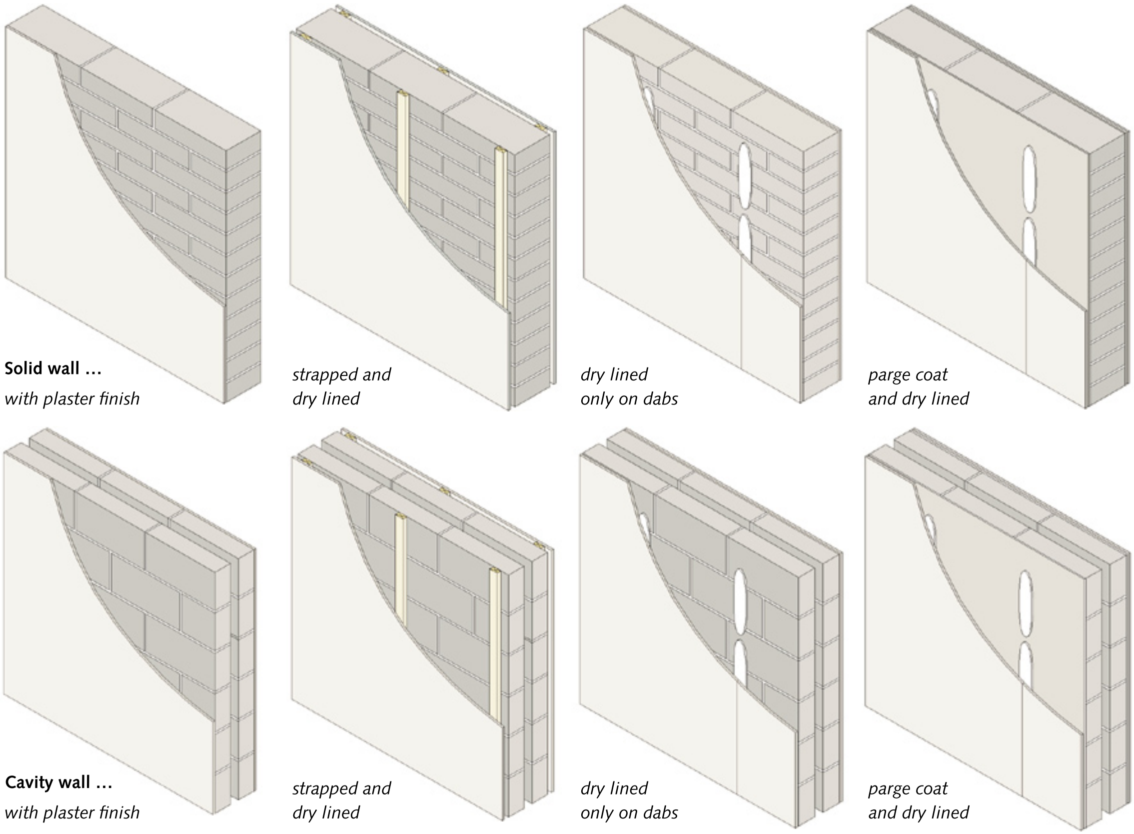
Plaster finishes were commonly used prior to the emergence of gypsum-based boards. A plaster finish to blockwork is typically 13mm thick and assists in sealing the block face and any open mortar joints.

There are three potential issues with plaster-finished walls that may reduce their performance:

- 'chasing' (i.e. channels cut into blockwork) is required for electrical wiring and sockets, this reduces the overall mass of the wall leafs and if cut too deep into the blockwork can reduce performance markedly;
- plaster can 'boss' (as described in Chapter 5), reducing sound insulation performance; and
- lightweight plasters with poor sound insulation properties were used in some dwellings.

Figure 6.2g

Type of wall finish for solid and cavity separating walls



Gypsum board dry linings

With the demand for increased housing development in the 1960s, reduced site costs, faster build times and shortages in skilled labour, dry lining board finishes often replaced the use of plaster on walls.

Dry lining was also attractive to housebuilders because the cavity formed by the dab or strap allowed easier installation of electrical wiring and sockets. This cavity was increasingly important with the growth in household electrical appliances during this period.

Originally, gypsum-based boards were attached to the blockwork by timber straps. However, straps create continuous contact between the dry lining and the wall, which allows sound to transfer between core blockwork and dry lining. Since the late 80s it has been common practice to use adhesive plaster dabs, which acoustically perform better than timber straps.

Figure 6.2h outlines the key factors that reduce dry-lined block wall performance and which led to a failure rate of nearly 50% in airborne sound insulation tests for 1990s blockwork walls where only dry lined finishes were used.

Figure 6.2h

Key factors reducing dry lined block wall performance

Factors that reduce the sound insulation performance of blockwork walls with only dry-lined finishes:

- Poor workmanship and open block joints
- The 'drum effect' (as discussed in Section 4.5)
- Variations in gypsum board weight.

6.2.3 Blockwork walls: surface finishes

Parging (internal render) and gypsum board dry linings

In the late 1970s and early 1980s, pilot sound tests were undertaken involving parge coats or internal renders. Parge coats, using a sand:cement mix could improve the sound insulation performance of blockwork walls, specifically for speech frequencies. A parge coat is also termed internal render and is the application of a sand and cement coating (8–13mm thick) to the room side of the block face. (See Chapter 4: Section 4.4, for further information)

Finishes for "no-fines" concrete walls

No-fines concrete was used quite widely between the 1930s and 1970s. No fines concrete consisted of cement and whinstone aggregate (usually 19mm) but no sand. Proportions of cement varied from 1:8 to 1:10 parts stone. This created a porous block, in relation to sound, and without the correct surface treatment could lead to complaints about sound transmission between dwellings, particularly when using only gypsum board finishes.

There are approximately 22,000 no-fines dwellings across Scotland. Methods used to treat the surface of no-fines concrete included sealing the face with either:

- a double wet treatment of 17mm render and 13mm plaster; or
- a wet and dry solution of 13mm render and dry lining board (min. 10kg/m^2).

6.2.4 Blockwork walls: areas of weakness

When built correctly, blockwork walls (with a range of finishes) can perform very well. Areas of weakness, however, can include:

- core construction;
- junction designs;
- incorrect specification of materials;
- inappropriate use of block types or wall ties; and
- finish treatments.

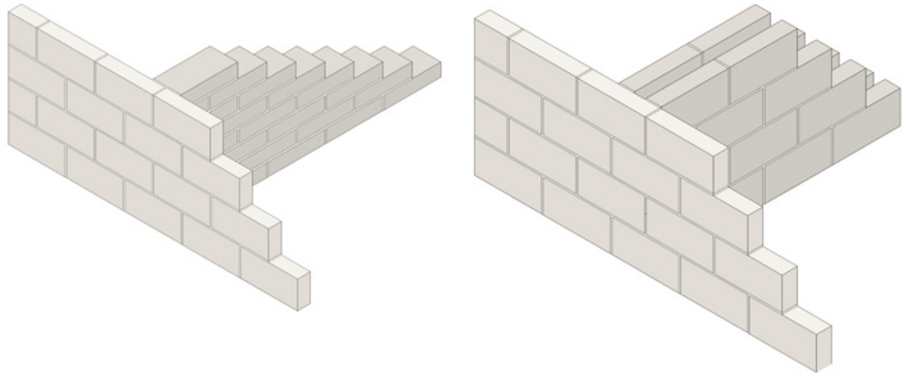
The combination of two or more of these areas of weakness in the same wall may result in complaints.

For instance, the noise of conversation, TV, and general living can be heard by neighbours as a result of:

- insufficiently filled mortar beds;
- wall ties that are too stiff or too thick leading to strong acoustic bridging;
- mortar collection on wall ties – this can be worsened if the wall is only drylined;
- running the inner leaf of the external wall, dwelling to dwelling, past the separating wall (see Figure 6.2i).

Figure 6.2i

Examples of incorrectly continuing the inner wall leaf (dwelling to dwelling) past the separating wall leading to excessive flanking transmission.



6.2.4 Blockwork walls: areas of weakness

For solid walls, poor sound insulation performance over a wide range of frequencies results from:

- blocks not laid full width or double symmetric coursing of blockwork (as shown in Figure 6.2a);
- not using dense blocks (min. 1850kg/m^3).

Most blockwork walls perform well with render and gypsum board finish and there are very few complaints from occupants. When wall ties are not used and mortar joints are made thinner (as with some aircrete thin joint systems), isolation stiffness and performance improved. Figure 6.2j shows typical ranges of performances for various blockwork walls and finishes.

Figure 6.2j

Typical airborne sound insulation performance for blockwork separating walls.

CORE WALL	FINISH	Performance**	
		$D_{nT,w}$ (dB)	OER
Solid* **			
215mm Dense block (laid flat)	13mm plaster	54–58	C,B
	12.5mm dry lining	49–54	E–C
	13mm parge coat + dry lining	53–58	C,B
Aircrete block	13mm plaster	50–54	D,C
	12.5mm dry lining	48–52	E,D
Cavity			
2 x 100mm leafs Dense block (50mm cavity)	13mm plaster	54–60	C–A
	12.5mm dry lining	51–57	D–B
	13mm parge coat + dry lining	54–59	C–A
2 x 100mm leafs Aircrete block (75mm cavity)	13mm plaster	55–62	C–A
	12.5mm dry lining	51–57	D–B
	8mm parge coat + dry lining	55–61	C–A
No-fines concrete cavity wall	12.5mm dry lining	46–50	F–D
	parge coat and 13mm plaster	50–55	D,C

Notes.

* *aircrete blockwork uses weaker mix for parge coat than aggregate blockwork*

** *performance values shown are typical mean range values.*

*** *performance values of solid walls are more influenced by flanking via inner leaf blockwork*

OER *refer to Section 3.4*

6.2.5 Blockwork walls: remedial treatments

Figure 6.2k shows a range of noise complaint issues and build errors associated with solid and cavity blockwork walls and a range of remedial treatments. Further information on the construction details of the remedial wall and flanking wall treatments can be found in Chapter 4.

Figure 6.2k

Suggested remedial treatments for noise complaint issues and build errors associated with solid and cavity blockwork walls

Wall type Noise issues and Build errors		Separating wall **Remedial Treatments and Typical Performance Improvement(2)**					Inner leaf flanking wall **Remedial treatments**		
		Blown fibre cavity fill	13mm render & drylining or plaster	8mm render + 42mm mineral fibre backed gypsum board	Resilient wall lining treatment	Independent wall lining	42mm mineral fibre backed gypsum board	Resilient wall lining treatment	Independent wall lining
SOLID WALLS (1)		**n/a**	**+3–6dB**	**+5–8dB**	**+6–10dB**	**+7–12dB**			
Noise issues	Speech, TV		■	■	■		□		
	General living noise		■	■	■		□		
	Doors/drawers closing				■	■	□		
	Low freq. music bass				■	■	□	□	□
	Appliance noise				■	■	□	□	□
Build errors	Blocks not laid flat				■	■			
	Block density too low					■			
	Open perpends		■	■					
	Dry lining only		■	■	■				
	Inner leaf run through				■		■	■	■
CAVITY WALLS		**+3–8dB**	**+5–8dB**	**+7–10dB**	**+7–12dB**	**+8–15dB**			
Noise complaint issues	Speech, TV	■	■	■	■				
	General living noise	■	■	■	■				
	Doors/drawers closing				■	■			
	Low freq. music bass				■	■	□	□	Note (3)
	Appliance noise				■	■	□	□	Note (3)
Build errors	Cavity too narrow				■	■			
	Wall ties too stiff			■	■	■			
	Open perpends		■	■					
	Dry lining only		■	■	■				
	Mortar build-up on wall ties causing strong bridging				■	■	□	□	□
	Inner leaf run through			■	■	■	■ b/s	■ b/s	■ b/s
Change in wall thickness one side compared to only dry lined (23mm)		0mm	13mm	40mm	40-65 mm	70–90 mm	32mm	40–65 mm	70–90 mm
Key:	■	recommended							
	□	dependent on extent of flanking contribution							
	b/s	both sides							

Notes:

(1) Improvements to solid walls are more restricted due to flanking influences than cavity walls.

(2) It is recommended to seek expert acoustic advice as each wall or floor system may have different influences on performance improvements.

(3) As cavity already provides isolation lining may not be required.

Refer to Chapter 4 for further information on fixing and installing remedial wall treatments.

6.3 CONCRETE FLOORS

6.3.1 Construction

The construction of concrete floors varies quite markedly and may involve:

- poured in-situ on temporary or permanent shuttering;
- pretensioned or post tensioned slabs;
- combined precast and in-situ floors;
- beam and block floors;
- precast floors with screeds;
- precast slabs with timber floating floors.

Precast floor slabs used during the 1970s, 1980s and early 1990s were typically 150mm thick, using either solid or hollow cored sections. Voids or hollow cores reduced the weight of slabs and increased spans. Many slabs had weights below 300kg/m^2, resulting in noise transfer between dwellings.

This factor together with the move away from screed to floating floor finishes led to the overall mass being increased to a minimum of 300kg/m^2. More commonly, since the early 1990s the thickness of hollow core slabs has increased to 200mm. This is due to demand for longer spans, structural requirements and the marginal sound insulation performance of 150mm slabs.

The difference in thickness between 150mm and 200mm slabs is important for sound insulation because it increases overall stiffness. Higher stiffness results in less vibration within the slab and less chance for the slab to transmit sound to the rooms above and below.

Beam and block floors have been less used in Scotland than in other parts of the UK. Composed of reinforced inverted T-shape beams, at set centres, concrete blocks are laid between the beams.

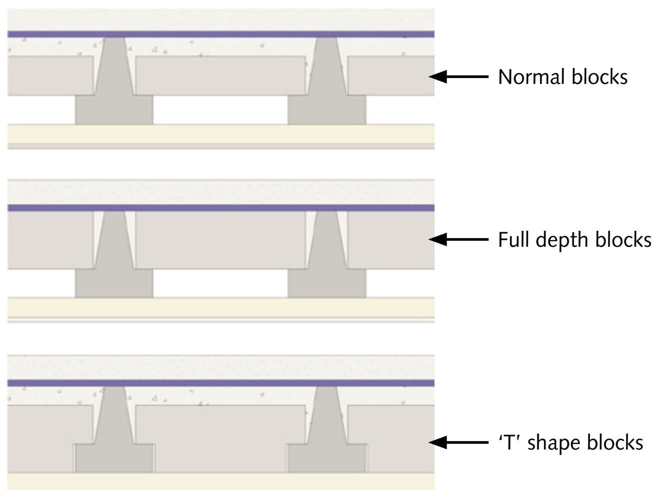
Beam depth can vary from 150–250mm and the blocks may be laid between the beams such that they are flush with the top of the beam.

In some cases the top of the beams protrude above the blocks and the resulting recesses can be filled in with a screed or grout, prior to topping with another screed layer or other surface finish.

Although a beam and block floor may have a similar mass as a precast wide slab floor, the number of components, high flanking transmission and potential poor workmanship may lead to some existing dwellings having poorer acoustic performance. Recent developments in beam and block floor design, as highlighted in the following section, have reduced some of these negative effects.

Figure 6.3a

Section details of beam and block floor types



The detailing of junctions of floors with surrounding walls is very important. Building the floor slabs into masonry walls helps reduce flanking sound transmission between dwellings by 8–12dB (see Case Study 6E). The floors act like a resistance or impedance to the flanking sound travelling via the inner leaf of the external wall. Thicker slabs perform better as they reduce flanking sound transmission at the perimeter walls.

Older beam and block floor systems were notorious for the level of flanking sound transmission at their perimeter walls. This was caused by sound travelling between flats, via the wall, where the beams were supported and also where the walls were parallel to the beams.

More recently the designs of some beam and block floors have been changed and improved in relation to the floor junctions with the perimeter walls. Use of precast and in-situ "edge beam" elements (see Figure 6.3c) have reduced the flanking transmission via the walls and increased their sound insulation performance.

A summary of potential faults in concrete floor construction and junctions is provided in Figure 6.3d.

Figure 6.3b

Floor slab:

(1) correctly built-in to wall leaf

(2) incorrectly abutting wall leading to high levels of flanking sound transmission

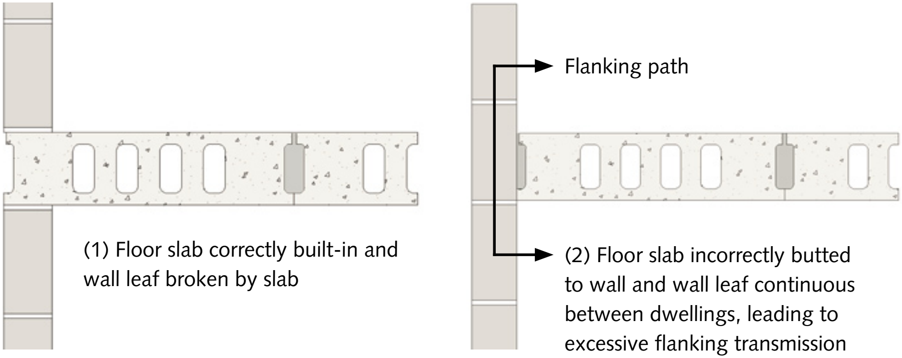


Figure 6.3c

Concrete edge beam detail now being used widely by the beam and block industry

Figure 6.3d

Faults in core construction and junctions of concrete floors that may have occurred in existing dwellings

Faults in concrete floors that may have occurred in existing dwellings

Precast wide slabs

- Slab joints not fully grouted and sealed
- Not building into the perimeter walls (see Figure 6.3b)
- Using a slab with too low a mass (i.e. less than 300kg/m^2)
- Not sealing the small void created by the camber at slab & wall head junction.

Beam and block

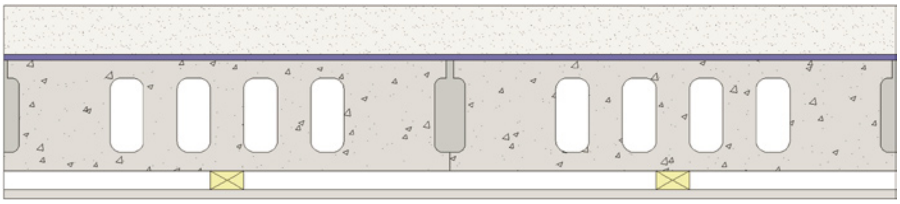
- Not fully filling between beams and over blocks with grout / screed
- Gaps left between blocks as blocks not laid tightly enough
- Perimeter walls continuous between dwellings
- Junction of beam and perimeter wall not sealed well with mortar or grout.

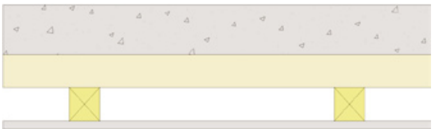
6.3.3 Concrete floors: surface finishes

Existing dwellings using concrete separating floors have involved a variety of floor and ceiling linings as outlined in Figure 6.3e.

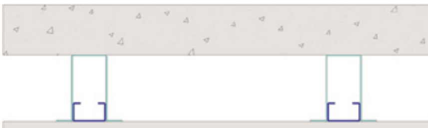
Figure 6.3e

Types of floor and ceiling linings in existing flats in Scotland built using concrete separating floors

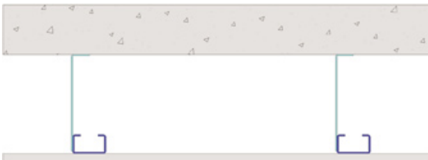

(1)

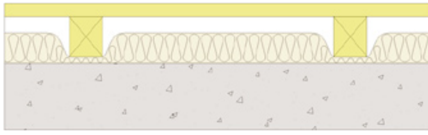

(C1)

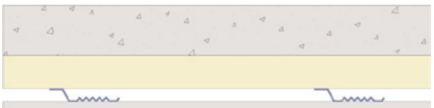

(F1)

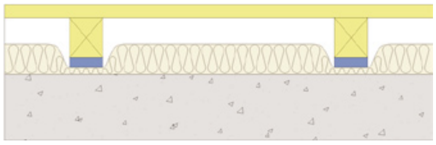

(C2)


(F2)


(C2)


(F3)


(C3)


(F4)

(1)	Screed finish floor, single isolating layer, precast slab, brander ceiling.
C1	counter batten ceiling
C2	metal frame ceilings
C3	batten + resilient bar ceiling
F1	screed on mineral wool layer
F2	bonded soft floor covering on screed
F3	batten on mineral wool
F4	resilient batten on mineral wool
F5	resilient batten (two or more densities)
F6	cradle or saddle systems


(F5)


(F6)

Screed floor finishes

Concrete floors often have screed finishes. This increases the mass and provides good levels of airborne sound insulation for speech, TV, general living noise and low 'bass frequency' music. Screeds are typically a mix of 65mm sand:cement or 40mm proprietary flow screeds. However, with some screed floors there is a risk of poor impact (footstep noise) performance. The cause of poor impact performance is not the screed itself, but the type of material used for the isolating layer and associated workmanship issues. Figure 6.3f lists typical construction faults associated with screed finish floors.

For many years it was common practice to isolate the screed with either 25mm mineral wool or 5mm foamed polyethylene. To be fully effective, the screed must not come into contact with the floor slab, perimeter walls or skirtings. When such contact does occur, (bridging) sound – such as impact noise from footsteps – passes through the screed and into the rooms of the dwelling below. As a result of the poor performance of screed resilient layers and Local Authority Building Control departments requesting sound insulation tests since the early 1980s, the Scottish house building industry has primarily adopted timber floating floor systems.

Figure 6.3f

Common construction faults found in existing dwellings for flooring screeds with isolating layers

Common construction faults found in existing dwellings for flooring screeds with isolating layers

- Single isolating layers were commonly used and could be easily torn or damaged on site
- Isolating layers were often poorly installed and did not fully cover the surface of the floor
- Joints in isolating layers often did not overlap
- Gaps remained where isolating layers were turned-up at the perimeter walls, allowing the screed to come into contact with the walls
- Penetration of the isolation layer by pipes and fixings for underfloor heating, allowing bridging of the isolating layer.

Timber floating floor systems

Timber floor surface systems comprise a variety of materials and components to support the floor deck or floorboards, including:

- mineral wool only (batt type);
- mineral wool (quilt) and resilient batten (i.e. resilient layer pre-bonded to timber batten); and
- high performance resilient batten (where no mineral wool is needed to obtain high performance).

Many concrete masonry flats built in Scotland between the 1950s and mid-1980s used mineral wool underneath the battens. Over time, repeated dynamic loading from footsteps may cause deterioration of mineral wool under battens (See Chapter 4).

Current floating floors perform very well in reducing footstep noise entering the flat below. They also permit the easy incorporation of services, conduits and underfloor heating. It is important to follow the manufacturer's instructions during installation. Figure 6.3g lists some of the typical errors with floating floor installations. Further information on timber floating floor surface treatments can be found in Section 4.6.

Bonded soft floor coverings

For concrete floors resilient layers such as bonded soft floor coverings have been used in the past and can significantly reduce impact noise transmitting to the dwelling below. However, the application of hard floor surfaces (e.g laminate) over the resilient layer reduces the insulation performance.

Figure 6.3g

Typical errors in design or installation of floating floor treatments in existing dwellings.

Typical errors in design or installation of floating floor treatments in existing dwellings

- Mineral wool placed underneath battens that has deteriorated over time
- Floating floors incorrectly installed
- Omission of flanking strips at floor edge and wall perimeters allowing impact sound (footstep noise) to flank into dwelling below
- Use of over-long nails or screws causing the resilient layer to be bridged and creating direct contact between batten and core floor structure
- Services installed under battens, reducing resilient layer thickness and bridging of batten to core floor
- Confusing high load bearer battens with normal resilient battens.

The predominant ceiling treatment in dwellings constructed of concrete blockwork was gypsum-based board connected to the core floor by either timber branders or a suspended metal grid. Most floors have one of three types of ceiling treatment suspension system:

- single timber branders (also known as ceiling battens);
- timber branders with crossed timber branders (also known as counter battens);
- metal frame.

Generally, suspended metal frame ceilings provide better acoustic performance than timber brander ceilings.

6.3.5 Concrete floors: remedial treatments

The mixture of concrete core floors, their structural junctions and diverse floor surface and ceiling treatments can result in more than one remedial treatment being applied. For example, combinations of floor and ceiling treatments or floor surface and flanking wall treatments may be required. Figure 6.3h provides suggestions for remedial treatments for a range of issues.

For impact noise (from footsteps) the best solution is to use a resilient floor surface treatment. An existing floor that already has a poorly performing floating floor can be removed and a new higher performance floating floor incorporated within the existing floor depth.

Where floor to ceiling heights are restrictive and complaints relate to speech, TV and general living noise it is recommended that a mineral wool or absorption layer (e.g. blown fibre) be installed within the ceiling void. Care should be taken to avoid existing electrical service cables or downlighters overheating. Guidance on electrical wiring in dwelling can be found in BS 7671 (2001). Where minor changes to ceiling height are permissible, the application of secondary higher density gypsum-based board mounted on 50 x 50mm timber branders with a metal resilient bar can also improve performance and reduce noise transfer between dwellings.

The ceiling treatments shown in Figure 6.3h offer increasing levels of performance gain but also have an increasing influence on floor to ceiling heights. The most effective ceiling treatment is an independent ceiling that is supported by the perimeter walls.

If major refurbishment works are being undertaken and access can be gained to dwellings above and below the separating floor then combined floor and ceiling treatments provide the best outcome for reducing noise transmission.

If the inner leaf wall has been run through vertically, dwelling to dwelling, past the edge of the floor slab then *flanking treatments* should be used (see Section 4.5). These treatments may also provide solutions to flanking noise in perimeter walls in older beam and block floor designs.

Figure 6.3h

Suggested remedial measures for noise complaint issues and build errors associated with concrete floors in dwellings

CONCRETE FLOORS, NOISE ISSUES AND BUILD ERRORS		Separating floor				Inner leaf flanking wall			Separating floor				
		Surface Remedial Treatments and Typical Performance Improvements*				**Remedial Type Measures**			**Ceiling Remedial Treatments and Typical Performance Improvements ***				
Airborne Improvement		0–3dB	2–5dB	3–7dB	4–9dB				3–6dB	4–9dB	7–12dB	varies	10–14dB
Remedial Treatment		Bonded soft floor covering with floorboard finish	Platform floor systems	Resilient batten systems	Cradle or saddle systems	42mm mineral fibre backed gypsum board	Resilient wall lining treatment	Independent wall lining	50mm mineral wool or equivalent placed in existing ceiling void	secondary ceiling with 50mm timber branders and resilient bar + quilt	secondary ceiling with 100mm suspended metal frame + quilt	secondary ceiling with spring hangers + quilt	Independent ceiling with 125mm void + 100mm quilt
Impact Improvement		5–22dB	14–22dB	14–28dB	20–28dB				3–8dB	5–10dB	8–12dB	varies	8–14dB
Noise issues	General living noise, TV		◆	◆	◆	□	□	□	■	■	■	■	■
	Low freq. music bass		◆	◆	◆	□	□	□				■	■
	Footfall impact noise	■	■	■	■					●	●	●	●
	Perimeter wall density too low					■	■	□					
Build errors	Floor joints not sealed		◆	◆	◆				■	■			
	Uneven core floor				■								
	Bridged resilient layer	■	■	■	■	□	□	□	■	■	■	■	■
	Inner leaf run through					■	■	■					
Change in floor height when adding to existing screed floor surface		4–22mm	18–60mm	50–75mm	70–90mm								
Height change – replacing existing floor (60–80mm)			none	0–15mm	0–30mm								
Change in wall thickness one side compared to only dry lined (23mm)						32mm	40–65mm	70–90mm					
Change in floor to ceiling height									■				

KEY:		
	■	Recommended
	□	(Optional) Dependent on extent of flanking contribution
	*	Improvement values are dependent on flanking transmission present
	●	May be used either with floor surface treatments or as another option if floor treatments not possible
	◆	Floor surface treatments can also reduce these types of noise but ceiling treatment may be more effective

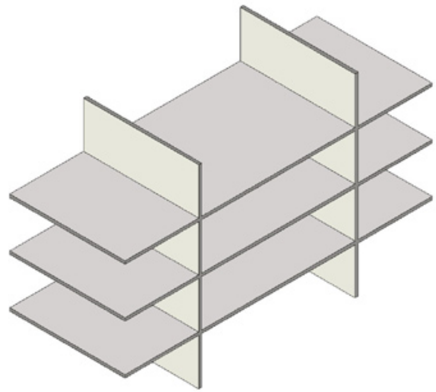
With the significant increases demanded in housing numbers during the post-war period and the rise in population in the 1950s and 1960s, public sector authorities required a major shift in housing provision. The solution was to build high-density multi-storey housing commonly known as 'High-Rise'. Figure 6.4a provides examples of high-rise construction formats.

The development of high-rise was primarily centred around the use of concrete and the high load capabilities, span factors and new junction mechanisms possible for cladding systems.

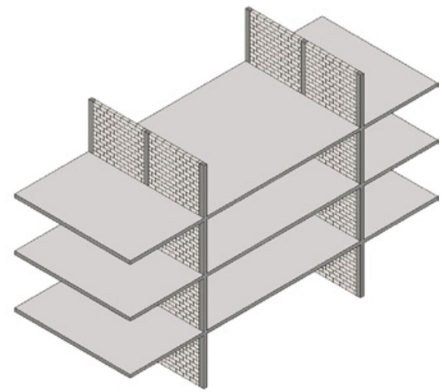
System building using slipform concrete, jack systems and large precast elements provided engineered solutions that could cater for multiple different services and habitable provision as well as faster build times.

Figure 6.4a

Examples of high-rise construction formats



(1) In-situ or precast concrete



(2) Columns with block infill

6.4.1 High-rise: core structure

The design of high-rise not only incorporated large floor and wall panels or continuous in-situ elements but also concrete frames, such as columns interconnected to floor slabs. Separating walls were sometimes formed by blockwork being used for infill sections between columns. To reduce the overall weight, and therefore dead loads, lightweight blockwork was sometimes used. In addition, cavity walls were sometimes built directly off continuous slabs, creating strong *bridging* (leaf to leaf).

Whilst concrete columns, floors and walls have high mass and stiffness they also have strongly coupled joints or continuous intersections. Figure 6.4b shows examples of strongly coupled elements, such as:

- 'cross' joints (junction of separating walls and floors); and
- 'T' joints (junctions of separating and external walls and separating floor and external wall).

Strong connections between wall and floor elements at these junctions provide greater opportunities for sound and vibration to travel from one element to another.

A further complication arises if the wall and floor components that junction at these interconnections, have similar material properties. This can lead to:

- similar acoustic resonances;
- easier transfer of sound or vibration energy between components.

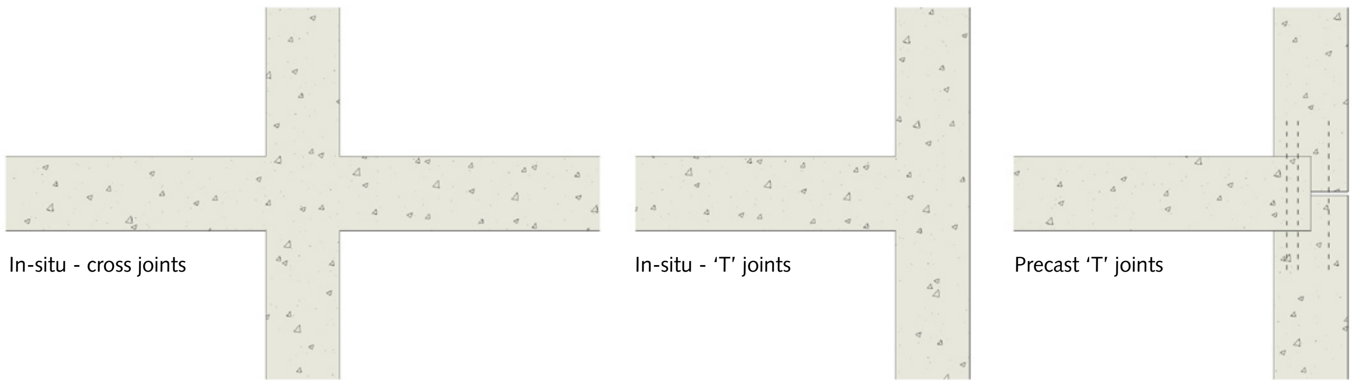
In some high-rise dwellings the junctions between floor and wall elements (particularly precast external walls) used grouted joints with reinforcement. However, due to poor workmanship the joints were sometimes not fully filled and sealed, providing a potential source of sound leakage.

As a result of material differences between lightweight infill blocks (for walls) and in-situ concrete columns, there is generally less sound transmission from the walls into the columns. These blocks are, however, lightweight and similar to in-situ concrete walls and the choice of linings is important to obtain good sound insulation.

6.4.2 High-rise: key structural junctions

Figure 6.4b

Examples of strongly coupled wall and floor elements



The majority of the high-rise or tower flats built in the 1950s, 1960s and 1970s used either wet plaster (e.g. in stairwells and hallways) or gypsum board dry linings on straps (e.g. within the dwellings).

Without suitable linings to absorb sound or vibration, high levels of sound transmission can occur. In such situations, sound and noise can quite easily transfer over several storeys through the wall and floor elements with very limited potential for isolation, absorption or resilience.

In-situ concrete's high mass and stiffness can generally provide good levels of sound insulation at low frequencies. However, the separating walls and floors built between 1950s and 70s often led to poor insulation for mid and high frequency sounds, such as speech, TV and general living noise.

Ceilings in these buildings are often composed of gypsum-based board with small timber straps. There is rarely any quilt within the ceiling void as it was the primary service zone for cables and wires. Figure 6.4c provides example sound insulation levels for high-rise dwellings (eight storeys or more) using in-situ concrete and in-situ concrete frames with block infill.

Figure 6.4c

Example of sound insulation levels of high-rise dwellings for separating wall and floor.

STRUCTURE	Airborne Performance * *		Impact Performance * *	
	$D_{nT,w}$ (dB)	OER	$L'_{nT,w}$ (dB)	OER
60s Concrete frame				
Lightweight block walls infill between columns *gypsum-based board on straps*	49–51	E,D		
60s In-situ concrete floor* *gypsum-based board on straps for ceiling thin floor screed*	47–54	E–C	64–69	E–G

* *flanking transmission via perimeter walls*
* * *performance values shown are typical mean range values.*
OER *refer to Section 3.4*

Other noise sources in high-rise dwellings

Interconnecting wall and floor elements also provide transmission pathways for other noise sources. It is common for the lifts in high-rise dwellings to have track systems mounted on the shaft walls. In addition to the general noise of the lift, these track systems also act as a source of vibration that travels through the vertical core of the building to surrounding walls and floors.

Rubbish chutes are also commonly situated in the vertical core of the high-rise blocks. The hard surface finishes of the chutes and the discarding of rubbish often creates random and annoying sources of noise.

Communal areas such as corridors, stairs and landings are primarily all hard surface finishes with little sound absorption. As a result, the reverberation time (or echo) of noise can be quite long. Sound is therefore more able to transfer with ease through the stairwells and along corridors. Impact noise such as doors closing sharply or being slammed shut is easily transferable between apartments.

Soil and vent pipes (SVPs) are commonly situated within the main core and not on the outside of the blocks. The boxed linings to pipes within the dwellings may only comprise single layer boarding. The flow and pressure of water within these pipe stacks can lead to noise being generated along the pipe's full length.

The primary areas of weakness for high-rise dwellings are:

- core structure and strong rigid junctions between wall and floor elements;
- poor junctioning of precast elements were grouts had not been properly filled;
- lift noise transmitting into dwellings;
- noise from rubbish chutes;
- hard surfaces in communal areas with almost no absorption;
- insufficient linings which result in easy transmission of sounds at certain frequencies.

High-rise dwellings often have reduced floor to ceiling heights that present difficulties for the insertion of remedial treatments both on the floor surface and ceiling. Door jambs and windows built very near to the separating walls also limit the space available for remedial treatments.

The use of absorbent linings will significantly improve sound insulation. Furthermore, the levels of flanking sound transmission will also be reduced for both airborne and impact sound and it is recommended that either 42mm mineral fibre backed boards or resilient wall linings (see Section 4.5) be installed. If such treatments are to be applied to the inner leaf of the external wall, care should be taken to ensure that moisture, thermal performance and fire resistance are not affected.

In the case of ceilings, there is often no more than 100mm to work within, due to window soffits and door architraves. Treatments may involve either removing the existing ceiling and applying a new ceiling or applying a secondary ceiling to the existing. Figure 4.7a provides examples of possible ceiling remedial treatments.

For dwelling rooms backing onto lift shafts or refuse chutes, a resilient or independent wall lining treatment should be applied (external to the shaft or chute) as detailed in Section 4.5. Service pipes should be lined with 50mm mineral wool quilt or equivalent and boxed with two layers of gypsum-based board with a minimum mass per unit area of 10kg/m^2.

Corridors and communal areas should be treated with Class A or B acoustic ceiling tiles either direct bonded or placed on a suspended metal frame. Using a metal frame grid and inserting 25mm mineral wool or equivalent within the ceiling void will increase the potential absorption.

7

Timber frame construction

Also available in print from
www.arcamedia.co.uk

The predominant frame construction found in Scotland is timber frame, the bulk of which has been built during the last 20 years. The volume output of this has risen sharply in Scotland over the past decade and in 2005 represented over 60% of annual new build dwellings.

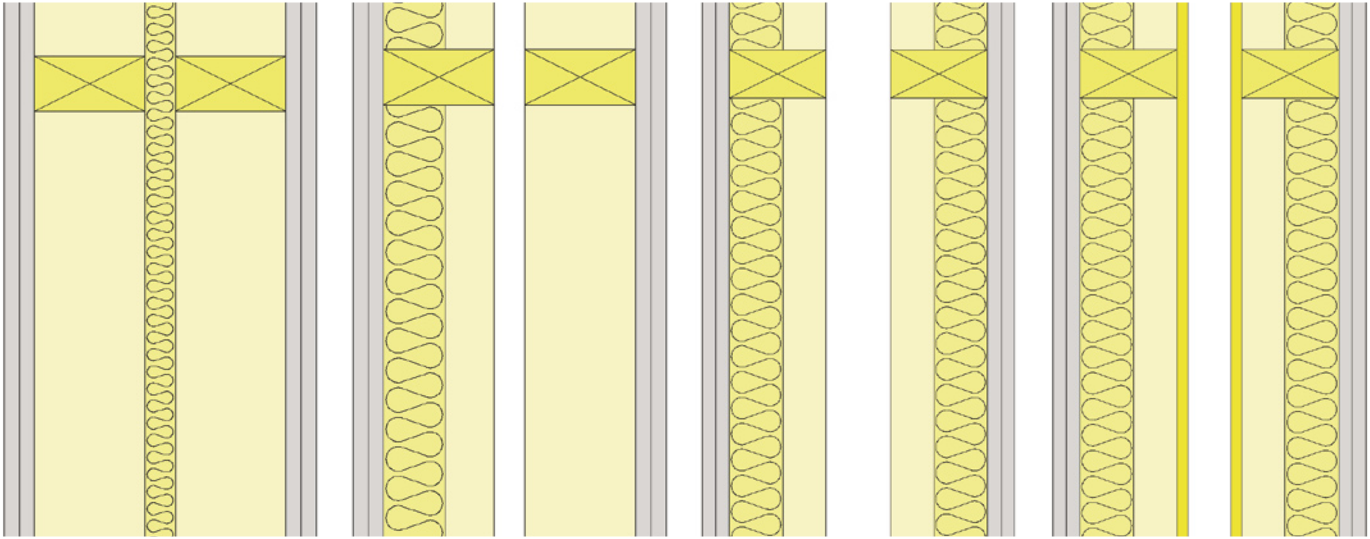
This sector of the construction industry has benefited from the information obtained from the sound insulation testing that has been common practice since the mid-1980s. The sound insulation performance of timber frame dwellings has risen significantly over the past 10 years. This is due to the emergence of some innovative timber wall and flooring systems that have reduced the transfer of sound energy between adjacent dwellings.

This chapter provides an overview of timber frame dwellings and the typical separating walls and floors that are found in Scotland.

Figure 7.2a shows four different types of timber twin frame separating walls commonly found in existing Scottish dwellings.

Figure 7.2a

Typical timber frame separating walls with quilt or batt insulation found in existing dwellings



1 insulation suspended centrally

2 insulation one side

3 insulation both sides

4 Sheathed frame on cavity side

7.2.1 Core construction

Timber frame separating walls use light materials and do not have the same mass and stiffness functions as masonry walls. They do, however, provide very effective isolation, the most significant ingredient for good sound insulation performance.

Timber frame separating walls are normally composed of two leafs of timber studs supported off timber sole plates and are closed by a head plate. The studs are typically 100mm x 50mm with the frames separated by a 30–50mm cavity. Some frames may be smaller such as 89mm x 45mm and frame separation can be as small as 20mm. The studs may be spaced at 300–600mm centres depending on loading.

Dwangs may be used to stiffen the stud frames. In addition, cross bracing is quite common with small metal ties bridging the studs. Frames are sometimes strengthened by a sheathing board, which is mounted on the cavity side.

Isolation is provided by the cavity between the frames. Sound and vibration is only structurally transferable between the frames at the metal ties (typically two per storey height).

7.2.1 Core construction

Example of insulation netting support and timber cross bracing

Unlike masonry and concrete, timber frame structures can incorporate absorption insulation materials within the core structure. During the 1970s and 1980s it was common practice to use mineral wool cavity absorption insulation as shown in Figure 7.2a, (1) and (2), either:

- 25mm layer between the twin frames; or
- 50mm layer on one side of the twin frame structure.

The insulation was often incomplete due to:

- damage during construction;
- not being inserted between every frame; or
- incorrect fixing causing a collapse of the insulation within the cavity.

Lack of absorption between the frames can reduce the sound insulation properties at key speech frequencies but most timber frame walls built during the last decade have incorporated at least 50mm quilt insulation in both frames. Figure 7.2a details (3) and (4) show current common practice. Netting is often used to support the insulation and some dwellings use batt insulation as this maintains its shape better and can be tightly fitted between the studs.

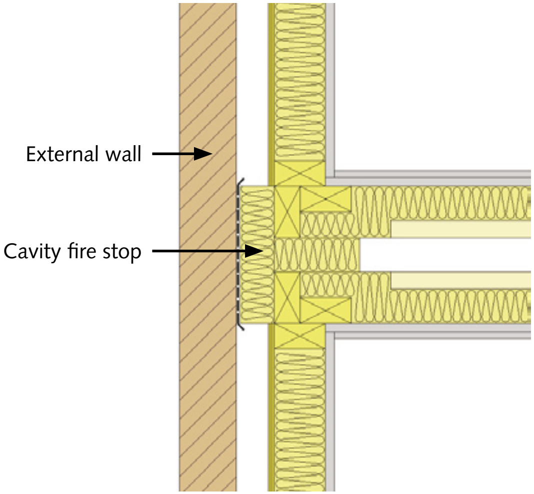
Where the separating wall twin frames adjoin the inner leaf (as shown in Figure 7.2b), the structural isolation is maintained between adjoining dwellings. This reduces the potential for flanking sound transmission to occur.

A significant proportion of the volume of timber frame walls is composed of insulation and air, which results in complex pathways for sound transmission to occur between dwellings.

Twin frames are often mounted on concrete rafts. Due to the significant difference in material properties between timber and concrete there is restricted flanking, frame to frame, via these foundations. However, if the frames are not mounted flush to the bearing surface small gaps can reduce performance due to leakage under the sole plates.

Figure 7.2b

Junction between inner leaf and twin frame separating walls (plan view)

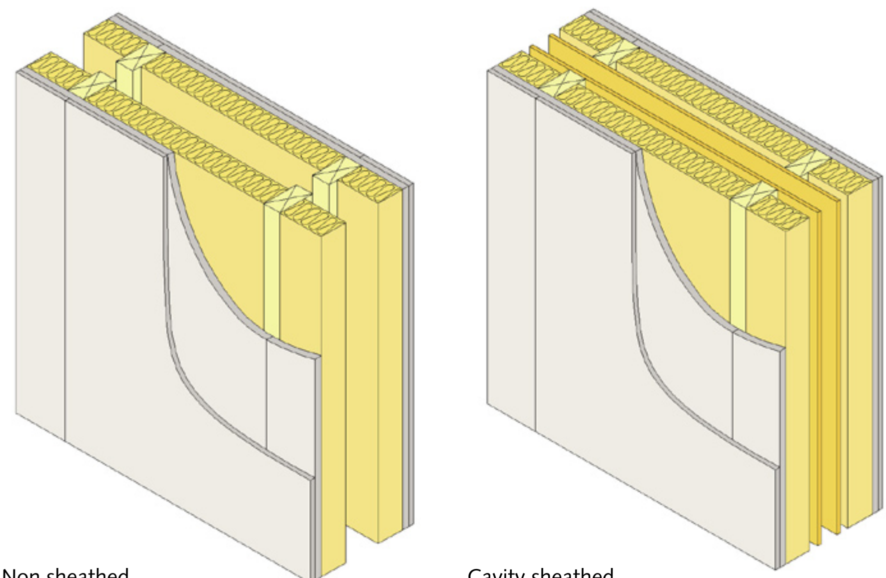


Timber frame separating walls are commonly finished with two or more layers of gypsum-based board with staggered joints. The thickness of each layer ranges from 10–19mm with typical two layer linings comprising 19mm and 12.5mm gypsum boards.

Sockets and service pipes etc. provide potential weaknesses in the separating walls for sound insulation. To reduce these effects, additional board lining on straps (termed 'sacrificial service zones') are applied where there are multiple sockets or pipes.

Figure 7.2c

Examples of non-sheathed and cavity sheathed timber frame walls



Non sheathed

Cavity sheathed

7.2.4 Potential areas of weakness for timber frame walls

It is rare for site faults to occur with timber frame separating walls due to their being manufactured offsite in more controlled conditions in kit or cassette formats. Figure 7.2d outlines points to watch should sound insulation complaints occur for separating walls and Figure 7.2e shows the typical performance for timber frame separating walls.

Figure 7.2d

Points to watch for timber frame walls

Points to watch for timber frame separating walls

- Ensure quilt insulation is still in place
- Ensure any gaps at sole plate and/or head plate are sealed
- Wall lining layers should have been staggered
- Identify if twin frames are too close together
- Identify whether there is excessive bridging between twin studs
- Ensure service points and sockets are well sealed.

Figure 7.2e

Typical sound insulation performance of timber frame walls

CORE WALL	CAVITY	Performance**	
		$D_{nT,w}$ (dB)	OER
Timber twin frame			
89mm studs 19mm + 12.5mm gypsum-based board	**200mm cavity**		
	25mm quilt suspended#	55–60	C–A
	50mm quilt/batt both sides (b/s)#	56–62	B–A
100mm studs 19mm + 12.5mm gypsum-based board	**240mm cavity**		
	50mm quilt/batt both sides (b/s)#	62–67	A*
	with cavity sheathing board + 50mm quilt/batt (b/s)	64–70	A*

Notes.

\# *diagonal bracing used*

** *performance values shown are typical mean range values.*

OER *refer to Section 3.4*

7.2.5 Remedial measures

Where there are any issues of noise transmission additional linings or increased absorption may be required. If mid and high frequency sounds such as speech are heard through the separating wall, and there are no obvious signs of sound leakage at wall and board edges, one of the following remedial measures may be used:

i) Inject blown fibre insulation into the cavity to increase absorption provided there is sheathing board mounted on the cavity side of the twin frames.

ii) Mount a metal frame and channel wall lining, suspend 50mm quilt insulation between the frames and cover with two layers of gypsum-based board, $10kg/m^2$ each layer.

If there is also low frequency noise transmission:

iii) An independent wall lining should be built 20mm from the existing wall lining and only connected at the floor and ceiling (see independent wall linings in Section 4.5).

Suitable sound insulation improvements can be made by applying the above three options to one side (one leaf) of the separating wall.

Note: Appropriate advice should be sought from a structural engineer prior to applying additional loads to lightweight frame structures.

7.3.1 Core construction

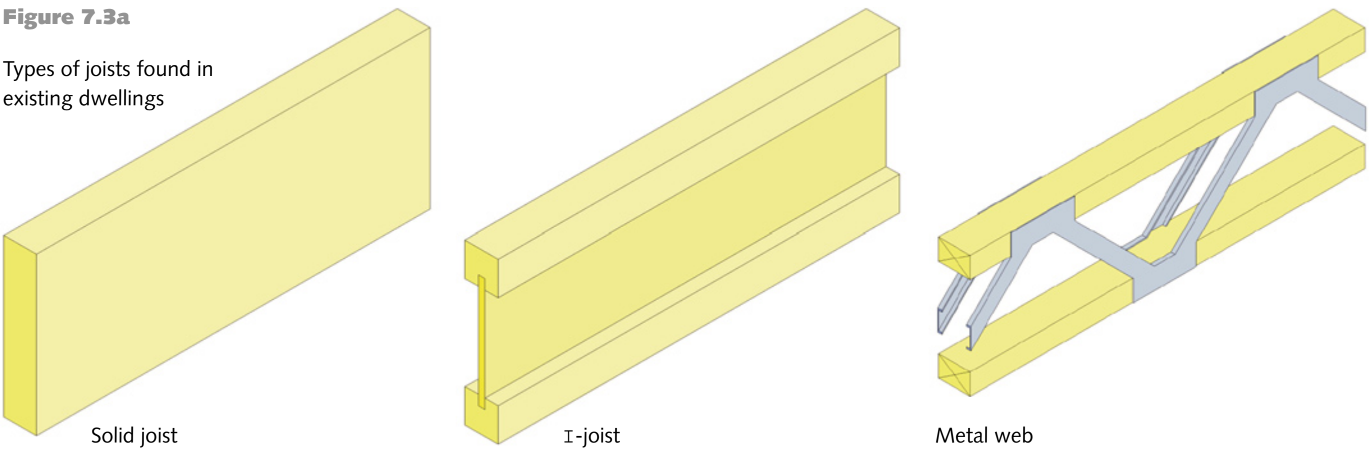
Separating floors with solid joists have been commonly used for many years. Joist depth typically varies from 220–240mm and spaced at 300–600mm centres. More recently, timber core floor design has diversified into a variety of other materials and engineered solutions, such as engineered 'I-joists' and metal web joists. Depths are typically 220–302mm for 'I-joists' and commonly 253mm for metal web joists.

Dwangs or noggings are sometimes used to brace the floor joists. Insulation quilt can be placed between the joists, typically 100mm thick mineral wool of minimum density 10kg/m^3.

Most timber frame flats built across Scotland in the last 20 years have used "single joist" systems with direct connection from the floor sub-deck to the ceiling. Some flats have used "double joist" systems of floor joists and ceiling joists. These are commonly referred to as independent ceiling joists and are discussed later in this section.

Figure 7.3a

Types of joists found in existing dwellings

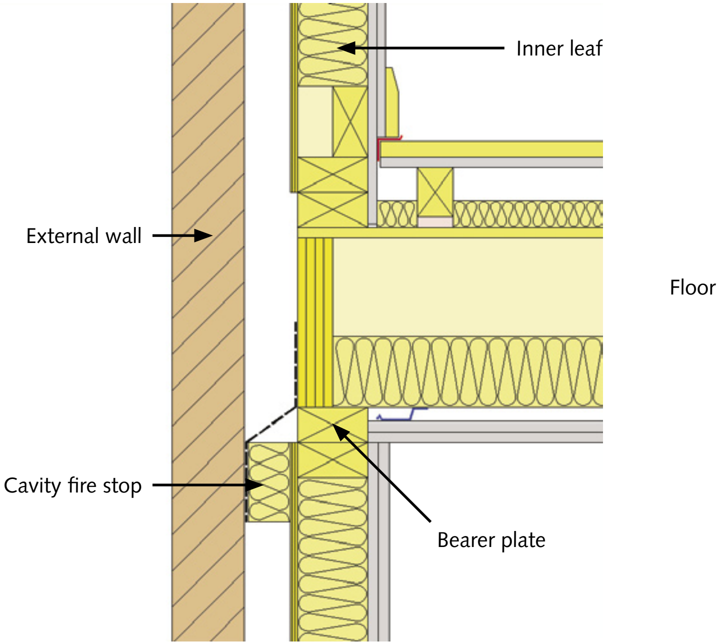


Timber joists are normally supported by bearer plates within the frame, (see Figure 7.3b), but sometimes joist hangers may have been used. In some cases the use of hangers for separating floors may lead to:

- less bracing;
- reduced overall stiffness;
- increased potential for deflection;
- higher airborne and impact sound transmission at low frequencies.

Figure 7.3b

Section showing typical junction of separating floor with inner leaf of external wall.



The variation in floor and ceiling finishes found in existing dwellings is shown by the separating floor cross sections in Figure 7.3c. Timber separating floors normally have a resilient floor surface or "timber floating floor". This not only assists impact sound insulation (against footsteps) but also airborne sound insulation.

All timber floating floors must use a flanking strip to isolate the floorboards from the perimeter walls and skirtings. If flanking strips are not fitted then footstep noise can easily enter the structure and flank into the dwelling below. In the 1980s, mineral wool was used as a flanking strip but it was difficult to turn round at the floorboard edge. It was also prone to deterioraton if the floor surface had moved or compressed under dynamic load (due to footsteps). As a result, 5–10mm polyethylene flanking strips are now used, as they are easier to install and do not degrade over time to the same extent.

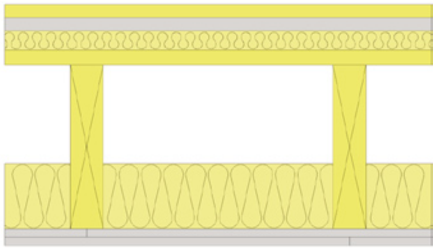
In the early 1980s timber frame separating floors involved standard construction details of:

- Floorboards (18–22mm thick)
- Gypsum-based board
- Mineral wool batt (80kg/m^3)
- Sub decking
- 220mm joists
- 100mm quilt insulation between the joists
- Two layers of gypsum-based board for the ceiling

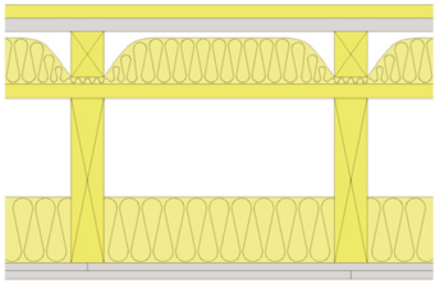
The combination of floorboard, gypsum board and mineral wool batt is termed a "platform floor". There is a wide range of batt densities. If the density is too low the floor surface is able to 'bounce' and deflect more easily. If the density is too high then the floor may be too hard and impact sound is able to transmit more easily.

Figure 7.3c

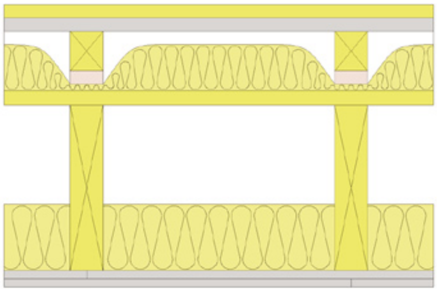
Examples of timber separating floors built since the 1980s



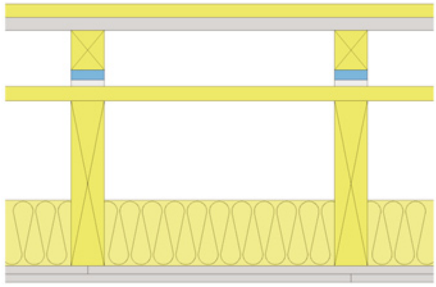
(a)



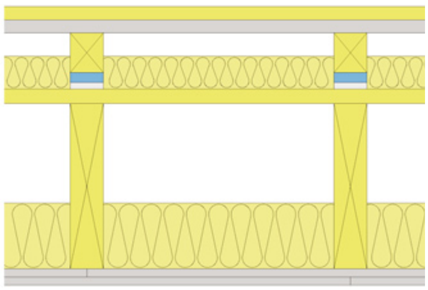
(b)



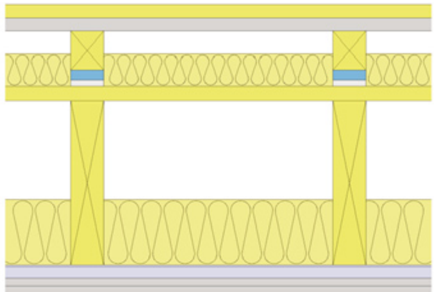
(c)



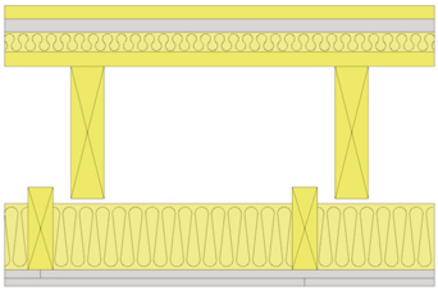
(d)



(e)



(f)

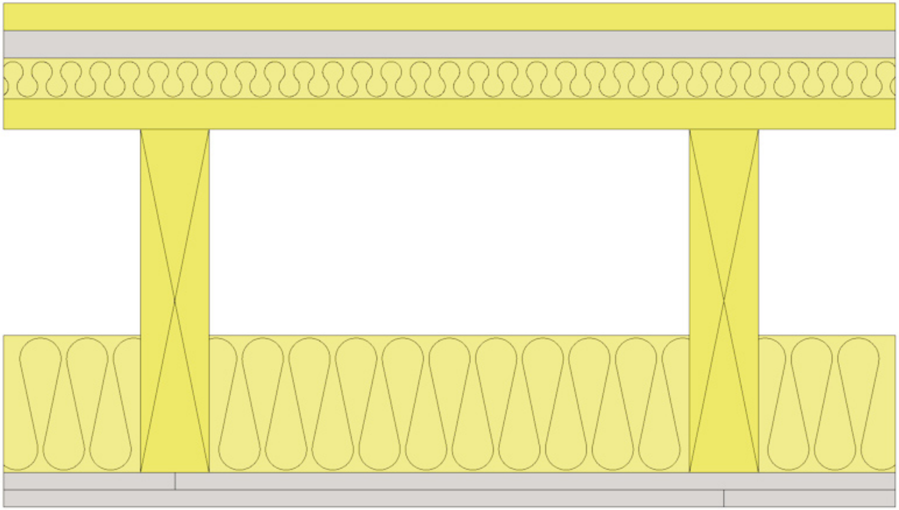


(g)

(a)	platform floor
(b)	timber battens on quilt
(c)	resilient battens with quilt
(d)	dual density resilient battens
(e)	(d) with quilt
(f)	(d) with quilt and resilient ceiling bars
(g)	platform floor with independent ceiling joists

Figure 7.3d

Typical platform floor built in the early 1980s (section view)



Another floor surface lining used was the raft, (Figure 7.3e). This uses timber battens at 300–450mm centres resting on a mineral wool layer. As the flooring surface only has contact with the sub deck through battens, and not over the whole floor area, as with platforms, more isolation is provided. However, the mineral wool may deteriorate over time as the floor flexed under loading (e.g. footsteps). The airborne performance may decrease slightly but more importantly the impact performance will significantly decrease over time.

To reduce the hard surface and corners of the timber battens repeatedly moving against the mineral wool layer, resilient battens were used (Figure 7.3f). These early resilient battens were generally formed from one homogenous (single density) compressible material.

With time the development of new, non-mineral wool-based materials provided the opportunity to:

- incorporate two or more densities,
- achieve good impact performance for a greater length of time,
- allow all resilient layers to be pre-bonded to the timber battens prior to arrival on site, thereby reducing site errors.

Figure 7.3g shows a typical raft floor using resilient battens. Further examples of resilient battens can be found in Section 4.6.

Figure 7.3e

Typical raft floor built in early 1980s with only mineral wool beneath battens (section view)

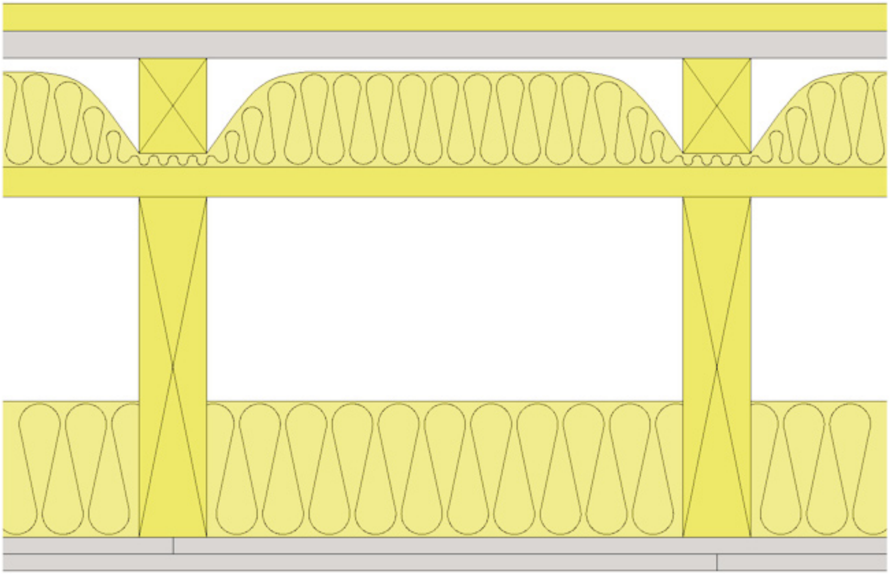


Figure 7.3f

Typical raft floors built since the late 1980s use resilient battens (of single density resilient layer) with mineral wool (section view)

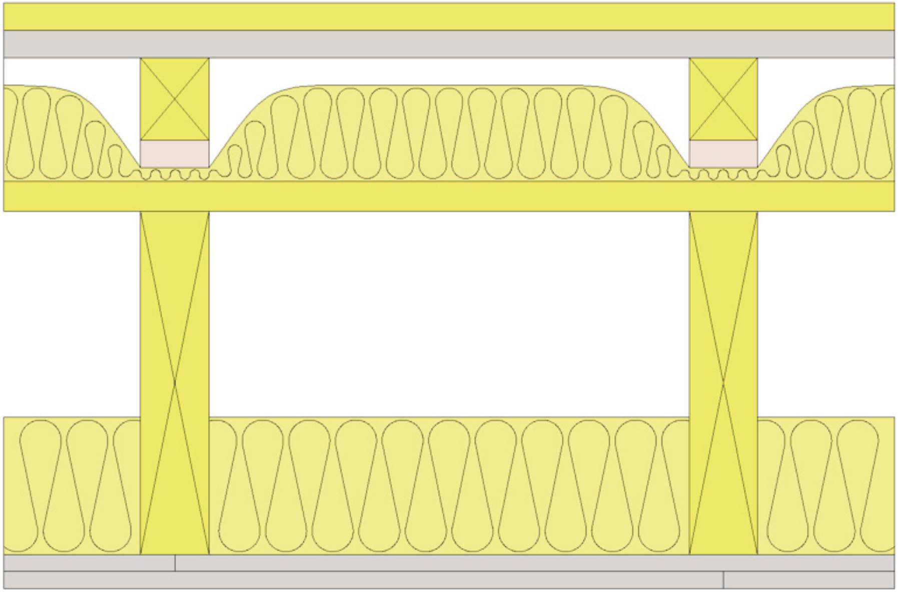
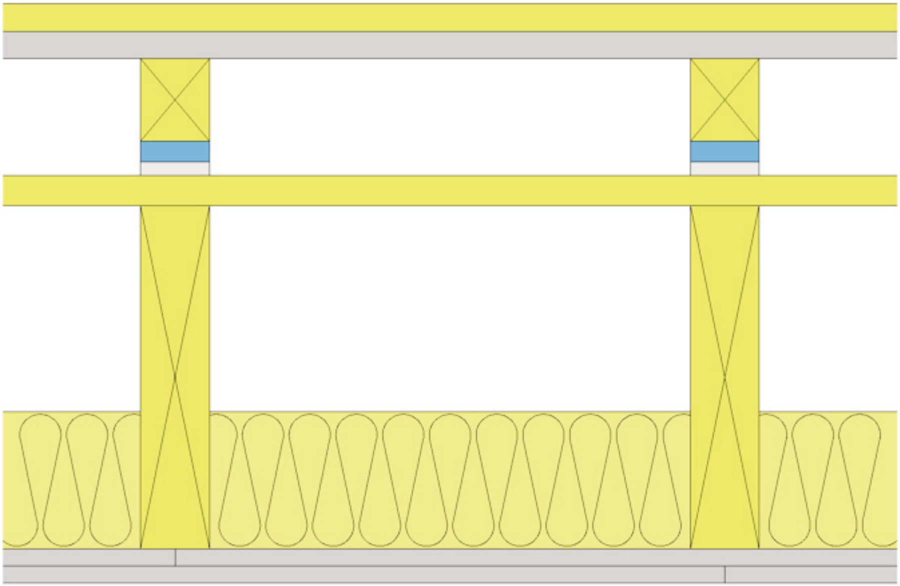


Figure 7.3g

Typical raft floor using resilient battens with two or more densities within the resilient layer



Even with resilient battens, continuous structural contact along the joist between the floor sub-deck and ceiling provides a strong path for sound transmission. If contact between the ceiling and the joists can be reduced, an increase in airborne and impact performance will be achieved.

One solution is to incorporate resilient metal bars which are connected to the underside of the joists and mounted perpendicular (90˚) to the joist direction. Examples of resilient bars can be found in Section 4.7. Figure 7.3h shows a typical section through timber floors that have been built in recent years.

The most effective method of reducing direct sound transmission through the joists is by the use of independent ceiling joists. Figure 7.3i shows a typical timber frame separating floor with independent ceiling supported by timber ceiling joists.

Note: It is not normal practice to use cradle systems on timber floors unless the sub-deck is of suitable strength to support concentrated point loading.

Figure 7.3h

Recent timber floor construction using resilient bars to decouple the ceiling

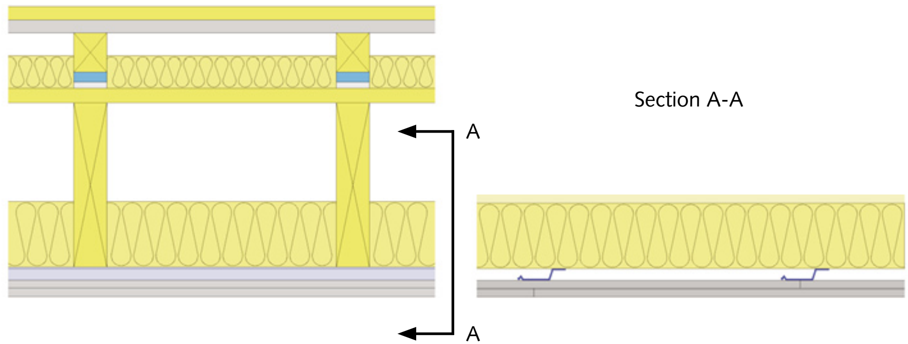
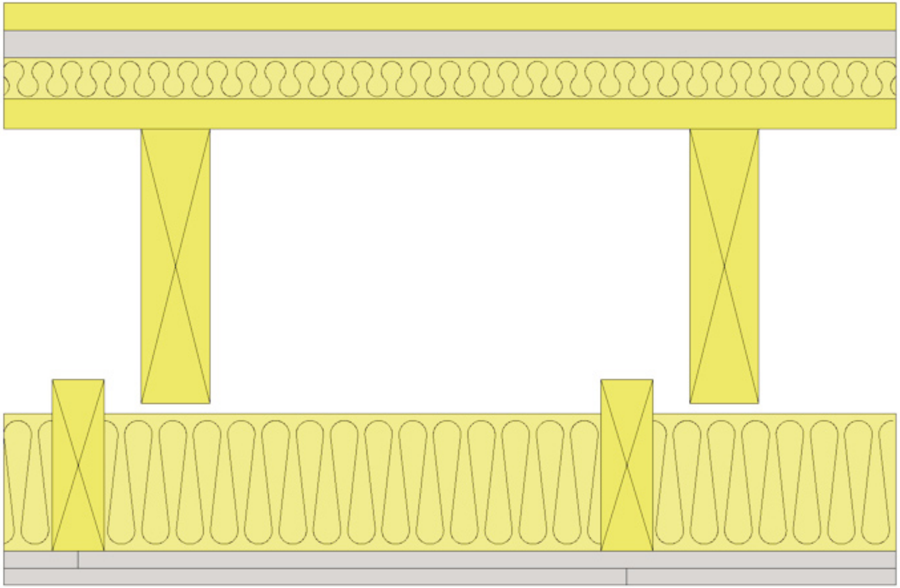


Figure 7.3i

Timber floor using independent ceiling joists with either raft or platform finishes



Joists spaced too far apart can result in a reduction in floor stiffness and complaints about footstep noise at low frequencies. Over-notching of joists can also lead to a reduction in floor stiffness and also potential squeaking.

Incorrect mechanical fixing can reduce the insulation performance provided by floating floor treatments and resilient ceiling bars. Using over-long screws will lead to bridging of the resilient layers. Inserting pipes or services within a platform floor can reduce the potential acoustic performance, whilst placing pipes or cables under resilient battens can also bridge the resilient layer.

Figure 7.3j

Points to watch for timber frame floors

Points to watch for in timber frame separating floors

- Wide joist spacing that reduces floor stiffness
- Fixings connecting ceiling boards to resilient bars should not bridge to joists
- Platform floor resilient layers damaged by inserting pipes and services within the layers
- Incorrect bridging of resilient layer by over-long screws/nails
- Reduction in stiffness due to use of joist hangers
- Ceiling boards not staggered
- Over-notching of joists for services reduces floor stiffness
- Incorrect omission of flanking strips at flooredge perimeters.

Figure 7.3k

Typical sound insulation performance for timber separating floors

CORE FLOOR	SURFACE TREATMENTS	Airborne Performance **		Impact Performance **	
		$D_{nT,w}$ (dB)	OER	$L'_{nT,w}$ (dB)	OER
220mm Timber floors					
With chipboard + gypsum-based board (flooring) OSB + 100mm quilt insulation + two layers of gypsum board (ceiling)	Platform floor	48–54	E–C	58–63	C–E
	Battens+mineral wool	51–56	D,C	55–60#	B–D
	Resilient battens, single density+mineral wool	52–56	D–B	55–59	B–D
	Resilient battens, two or more densities	52–56	D–B	56–59	C,D
Ceiling					
With resilient ceiling bar	Resilient battens two or more densities	58–62	B–A*	49–53	A*–B
With independent ceiling	Resilient battens two or more densities	60–64	A*	44–51	A*,A

\# *over time mineral wool may deteriorate after repeated compression by batten*
** *performance values shown are typical mean range values.*
OER *refer to Section 3.4*

7.3.6 Remedial measures

There are several methods to improve performance if it is felt that the level of sound insulation currently being achieved by a timber frame separating floor is insufficient.

To increase the stiffness of the floor, dwangs or noggings can be inserted between the joists as bracing. This will, however, require access to the floor cavity, either from above or below.

Alternatively, a secondary ceiling may be applied to the underside of the existing ceiling to increase both airborne and impact sound insulation. This should only be undertaken where the existing ceiling boards have direct contact with the joists (see Case Study 7A).

The secondary ceiling should comprise a minimum 100mm void formed either by timber battens and counter battens, or metal frame, with 50mm mineral wool quilt insulation laid over the whole ceiling area. The ceiling board should be one layer of gypsum-based board minimum 10kg/m^2.

Note: When remedial treatments involve increasing loads on frame structures it is recommended that advice be sought from a structural engineer prior to the commencement of remedial work.

8

Conversions

Also available in print from
www.arcamedia.co.uk

Conversions account for approximately 5% of the flatted housing stock in Scotland (as shown in Figure 8.1a) and are becoming increasingly popular among property developers and house builders. Scottish Planning Policy on Economic Development advocates sensitive re-use of old buildings as both good commercial sense and as a way to minimise the use of natural resources.

The term 'conversion' as used in this document, means new dwellings that result from the conversion of a house or other type of building and not as defined in Schedule 2 to Regulation 4 of the Building (Scotland) Regulations 2004.

Most conversions were originally houses and the difficulties of ensuring adequate sound insulation often lie in the management of the architectural impact on the interiors. Conversions of non-domestic buildings such as offices, churches, shops, schools, warehouses and hospitals tend to present a wider range of technical challenges to architects, specifiers and developers.

Figure 8.1a

Summary of Scottish House Condition Survey estimated statistics for conversions (2002)

Conversion	Conversions
Flats or houses resulting from the conversion of a house or other type of building (e.g. warehouse).	■ Approximately 38,000 ■ 5% of all flats ■ 2% of all dwellings ■ 83% of converted dwellings built before 1919 ■ 62% have 4–6 rooms ■ 80% are in 2–3 storey buildings

GO TO MAIN INDEX

Examples of buildings converted into dwellings














Separating walls and floors formed as a result of conversions must achieve the functional requirements of Scottish Building Standard 5.1, as described in 'Section 5: Noise' of the Technical Handbooks. One way to comply with the functional requirements is to achieve the required levels of sound insulation, (shown in Figure 8.1b).

Aside from providing advice on sound insulation for the conversion of non-domestic properties or large houses into smaller residential units, principally flats, general advice is provided here on sound insulation issues such as:

- use of 'pre-conversion sound tests' sometimes termed 'deterministic sound tests';
- upgrading existing structures to separating wall and floor performance requirements;
- introducing completely new separating walls within the existing building envelope; and
- common problems found in conversions.

It does not cover circumstances where only the external façade is retained, with an entirely new internal structure. Nor does it cover dwellings that are attached to commercial premises, which may be subject to specific environmental noise limits set by the local authority. Environmental noise limits use different measurement criteria and often involve higher levels of insulation than those required under Building Standards.

Figure 8.1b

Sound insulation requirements for separating walls and floors in conversions

(Building Standard Section 5: Noise).

Airborne Sound

Minimum values of weighted standardised level difference ($D_{nT,w}$) as defined in BS EN ISO 717-1:1997.

	Mean Value (dB)	Individual Value (dB)
Walls	53	49
Floors	52	48

Impact Sound

Maximum values of weighted standardised impact sound pressure level ($L'_{nT,w}$) as defined in BS EN ISO 717-2:1997

	Mean Value (dB)	Individual Value (dB)
Floors	61	65

Note: For a single wall or floor test the mean value should be achieved. If more than one wall or floor is being tested and is of the same construction, then the "mean value" must be met and individual test results must not be worse than the "individual value".

8.2 SITE SURVEYS

8.2.1 Dealing with a conversion: the starting point

In some conversions the make up of the construction is not known beyond the wall, floor and ceiling finishes and an invasive study may be needed to determine the full existing construction.

Invasive works undertaken before pre-conversion testing can result in:

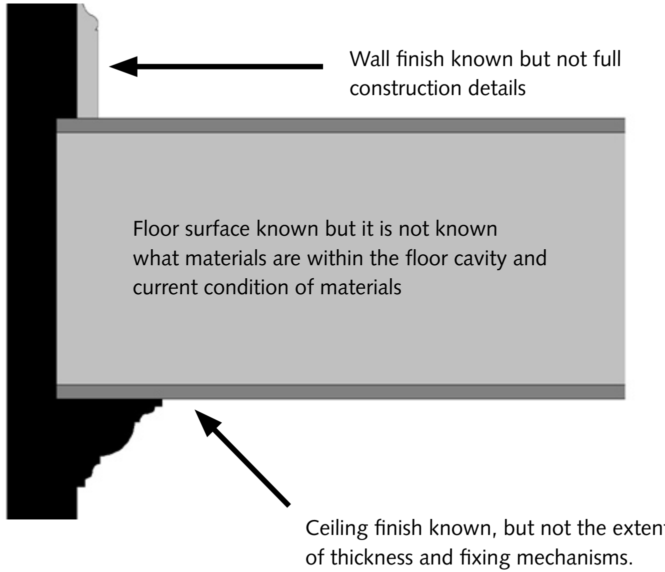
- needless damage to existing architectural interiors, period features and historic fabric;
- unwanted openings;
- creation of voids within the wall or floor;
- weaknesses in the structure that create sound paths;
- over-specification when changing existing walls or floors to separating walls or floors;
- additional works, costs and delays.

Where possible all construction work relating to historic or period feature buildings should be undertaken with a "minimum intervention approach". BEFORE carrying out ANY invasive work to existing walls and floors a **Pre-Conversion Sound Test** should be undertaken (as described in Section 8.2.2).

Figure 8.2a

Typical starting point for some conversions where little is known about the construction of the existing walls and floors.

Existing floor junctioning with perimeter walls. (Section view).



8.2.2 Pre-conversion sound tests and desktop assessments

It is normal practice to have a building surveyed for its structural condition, but often the acoustic conditions of a building are not considered until the project is well advanced. In some cases, sound insulation may not have been considered at all until the work is complete and the verifier requests a sound test to demonstrate compliance with the Building Standards. If it is found that the separating wall or floor does not comply:

- extensive remedial works may be required;
- the completion certificate may not be accepted by the verifier;
- there may be considerable delays to entry for occupants;
- the cost of non-compliance can be easily as much as replacing a roof or eradicating rot.

Pre-conversion sound tests can both avert the risk of non-compliance and avoid damage to the existing fabric. If the existing wall or floor structures already have voids and other openings present it may not be possible to undertake tests, but a desktop study may be worthwhile.

Figure 8.2b outlines the three steps for architects and developers to consider when deciding whether a conversion sound insulation assessment is required.

Figure 8.2b

Key Steps to design a conversion to comply with Building Standard 5.1.

Conversions and assesment for sound insulation:
A guide for architects, housebuilders and developers

STEP 1 Layout plans
Will the new dwellings have separating walls and/or floors?

YES / NO

NO → **Building Standards Standard 5:1 is not applicable**

YES ↓

Are the separating walls and floors to be formed from **existing** wall and floor structures?

YES / NO

NO → New separating walls and floors to be constructed. ↓

YES ↓

Are these existing walls and floors intact? (i.e. no voids or openings)

YES / NO

NO → **STEP 2 Initial design**
Propose draft design details for new separating walls and floors and infill sections for openings (such as door openings). ↓

YES ↓

STEP 2 Pre-conversion tests
Identify existing sound insulation levels prior to undertaking any works
Instruct acoustic consultant to carry out **Pre-conversion sound tests** on samples of the proposed separating walls and floors

NB: Test requirements

1. Existing walls and floors must be intact.
2. Invasive works have not been carried out.
3. No doors in test walls
4. Provide consultant with plan layouts (existing and proposed).

↓

Do Pre-conversion sound test results comply with Standard 5.1?

YES / NO

NO → **STEP 3 Desktop assessment**
Instruct acoustic consultant to carry out **Desktop assessment** to assess proposals and recommend other solutions and upgrading if required.

Desk studies

- Solutions should aim where possible to have minimum impact on existing interiors and architectural features.
- Consultant will require information on the existing construction where known.

↓

Once building works are complete, sound tests may be requested to confirm compliance with Standard 5.1.

YES ↓

If tested wall and floor construction is not altered (i.e. weakened or components removed), no further works are required. Test report may be used to confirm compliance with 5.1.

STEP 1: Establish dwelling layouts

The architect/designer prepares draft schematic plans indicating where each dwelling unit (or plot) will be located as well as the proposed separating wall and floor structures. Often existing wall and floor structures may be used but sometimes completely new walls or floors are required.

STEP 2: (a) Identify existing sound insulation performance and/or (b) identify infill materials for openings and proposed new separating wall and floor constructions.

(a) Identify existing sound insulation performance

Only once the building is accessible and dwelling plot plans have been prepared can a building acoustic consultant undertake pre-conversion sound tests. **No construction work** should be undertaken within the building until the pre-conversion sound tests have been carried out and evaluated.

Using the draft plot layouts that show the intended separating walls and floors, the acoustic consultant undertakes sample airborne sound insulation measurements of the walls and floors, as well as impact measurements of the floors to establish the current levels of sound insulation being achieved by these existing core structures.

If the existing wall or floor structures already achieve the required sound insulation standards and provided:

a) their construction remains the same; or
b) additional linings are applied (e.g. for fire requirements) that will not reduce their acoustic performance,

The test reports may be presented as evidence of compliance with Building Standard 5.1.

(b) identify infill materials for openings and proposed new separating wall and floor constructions.

If it is not be possible to undertake a pre-conversion sound test then the architect/ designer should prepare a series of working drawings showing the proposed infill materials for openings and the proposed separating wall and floor constructions (see STEP 3b).

STEP 3: Desktop assessment

The acoustic consultant can prepare desktop assessments covering situations where:

(a) the performance of the existing structure is below the required standards

(b) no pre-conversion testing is possible and thus the architect/designer provides their proposed working details to the acoustic consultant for (i) opening or void infills and/or (ii) proposed constructions of the separating walls and floors.

(c) no testing or working details have been prepared and the acoustic consultant is asked to design and recommend all the separating walls and floors.

How to find a Building Acoustic Consultant

The Association of Noise Consultants has a register of member companies:
www.association-of-noise-consultants.co.uk

The Institute of Acoustics has a members register with a search sub-category for consultancies:
www.ioa.org.uk

To limit the risk of noise transmission, conversions can be planned to take account of potential patterns of use for adjoining dwellings. Potentially noisy areas such as kitchens and living rooms should, where possible, not be adjacent to quieter areas in the neighbouring dwelling such as bedrooms. Figure 8.3a indicates those rooms that should preferably not be placed back-to-back and identifies other noise source issues.

Cupboards and wardrobes that do not have mechanisms for silent closure can lead to complaints about random and sudden noise. Sockets fixed on the separating wall may also lead to complaints about noise arising when plugs are inserted and switches are activated. The use of an additional wall lining that creates a service zone can reduce such noise complaints.

Note that aerial points on or adjacent to separating walls encourage people to place televisions and other entertainment systems against the separating wall and the resultant noise often leads to complaints.

The array of equipment and appliances used in kitchens and utility rooms present a range of noise sources. Sockets for washing machines, dishwashers and fan extract ducts should be located away from the separating wall if there are quiet rooms, e.g. bedrooms, immediately adjacent in the adjoining dwelling. If this cannot be avoided, the separating wall should be designed to provide higher levels of sound insulation.

Plant rooms and lifts can generate high levels of noise. If the lift has a track system the tracks should not be fixed to the separating wall.

It is always best to ensure that similar room uses are aligned above and below one another, for example bedrooms should be situated above or below bedrooms.

It is also important to consider floor surface finishes. Hard floor finishes such as tiles, wood laminates or bare floorboards can significantly increase the level of footstep noise in the dwelling below. (See Section 4.10).

Figure 8.3a

Suggested room use *back- to- back* (separating walls) and for *above and below* (separating floors).

Primary room use	May be adjoined to	Avoid adjoining to
Bedrooms (3,4)	Bedrooms (3,4) Store rooms Dining rooms	Living rooms (1,3) Bathrooms (1) Kitchens (1) Lifts (2) Plant rooms (2)
Living rooms (3)	Living rooms (3) Kitchens (3,4) Store rooms Dining rooms	Bathrooms Plant rooms (2) Lifts (2)
Kitchens (3,4)	Kitchens (3,4) Bathrooms (1) Dining rooms Plant rooms (2) Lifts (2)	Bedrooms (1) Studies
Dining rooms (3,4)	Kitchens (3,4) Bathrooms (1) Dining rooms	Bedrooms (3,4)
Bathrooms	Bathrooms Kitchens Lifts (2) Plant rooms (2)	Bedrooms Living rooms Dining rooms

(1) If it is impossible to avoid adjoining to these rooms, design higher performing walls and floors.
(2) Specialist insulation measures may be needed for quiet rooms adjoining plant rooms or lifts.
(3) Avoid placing TV aerial sockets and cables near the separating wall.
(4) Avoid placing cupboards or multiple sockets on the separating wall.

8.4 SEPARATING WALLS

8.4.1 Existing walls

The guidance in the Technical Handbooks represents minimum standards and is shown in Figure 8.1b. When specifying separating wall constructions in conversions it is recommended to aim for a higher performance, such as 55 dB $D_{nT,w}$ to allow for variations in workmanship. Typical insulation performance for a variety of existing wall types is presented in earlier chapters, as follows:

- Stone & rubble walls, or brick walls with plaster: Figure 5.2g;
- Blockwork walls: Figure 6.2j;
- Timber walls: Figure 7.2e.

8.4.1 Existing walls

Converting masonry internal walls to separating walls

Solid masonry walls with plaster finish 240mm thick or more, i.e. one brick thick, can sometimes meet Building Standard requirements provided that:

- there is no boss plaster;
- there are no open perpends or chases;
- finish is not only dry lining;
- there are no significant flanking issues.

Stone and rubble walls may be 400–600mm thick and can provide suitable insulation levels.

Masonry walls less than 230mm thick – typically 160mm (i.e. half brick thick with 30mm lath and plaster) – often fail to achieve adequate airborne sound insulation.

To upgrade the performance of masonry walls after “pre-conversion testing” it is recommended to use either:

- a mineral fibre backed board; or
- a resilient wall lining; or
- an independent lining.

If there is strong flanking sound transmission at adjoining walls such as the inner leaf of the external wall, these may also need to be lined. Sometimes there may be openings at the base of the wall or wall head where floor joists are supported. These openings will need to be sealed with either:

- mineral wool quilt or batt insulation; or
- solid timber dwangs inserted between the joists, above the new wall lining, and packed with mineral wool insulation.

Converting timber internal walls to separating walls

This detail is quite rare but can occur in conversions of large houses. The existing timber wall is likely to comprise a 100mm frame finished with lath and plaster or plasterboard on each side, without any insulation quilt.

It is recommended that the wall finish is stripped off on one side and the cavity filled with insulation quilt. An independent wall lining should then be constructed on one side, as shown in Figure 8.4a. Solid timber dwangs should be inserted between the floor joists above and below the new separating wall with high density batt insulation (>100kg/m^3) between.

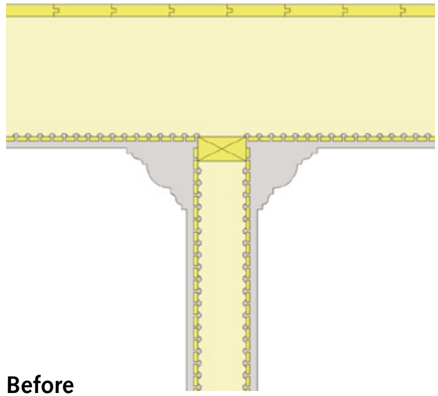
Care must be taken when sub-dividing a larger space by constructing new separating walls off an existing floor. In addition to selecting the correct partition type, it is important to prevent strong flanking paths and avoid overloading the structure.

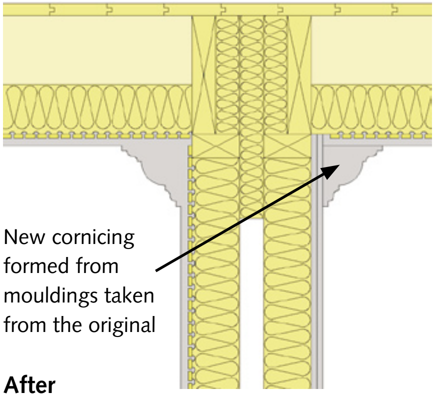
8.4 SEPARATING WALLS

8.4.1 Existing walls

Figure 8.4a

Separating wall created by adding independent linings to existing timber wall. (Note floor cavity closed with solid dwangs and batt insulation).





Existing concrete floors

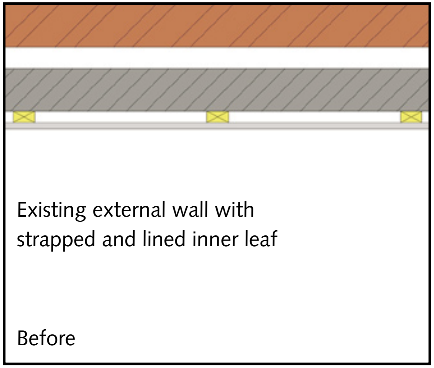
Cavity block walls should not be built off a continuous floor slab because the slab would bridge the cavity and significantly lower the insulation of the wall. For a continuous floor slab the following walls may be used:

- 215mm dense (more than 1850kg/m^3) concrete block wall, with blocks 'laid on their side', finished both sides with 13mm sand-cement render and 12.5mm gypsum-based board, minimum 10 kg/m^2. (see Figure 8.4b); or
- lightweight twin frame metal or timber studs, frames offset by a minimum of 20mm, outer face of frames at least 200mm apart, quilt insulation placed in both frames (25–50mm) and lined, in both rooms, with two layers of gypsum-based board min. 10kg/m^2 per layer. (see Figure 8.4c)

The wall must be built up to, and fully sealed against, the concrete soffit. Where the wall meets the external wall it should preferably be keyed into the external wall. If this is not possible, it may be necessary to line the external wall to reduce flanking transmission. (refer to Section 4.3 regarding types of flanking wall linings). Flanking sound transmission commonly occurs at the external wall inner leaf for thicknesses of less than 230mm and mass per unit area of less than 390kg/m^2.

Figure 8.4b

Plan view of new solid dense separating wall at junction with existing perimeter cavity wall that is continuous between dwellings



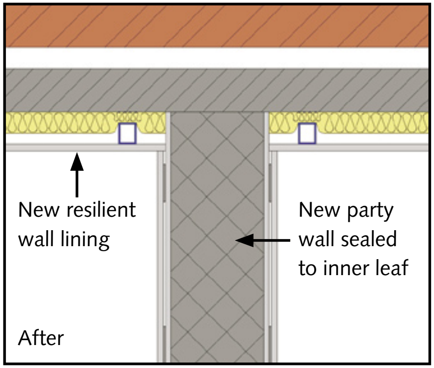
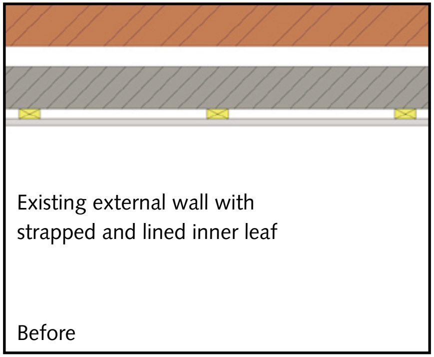
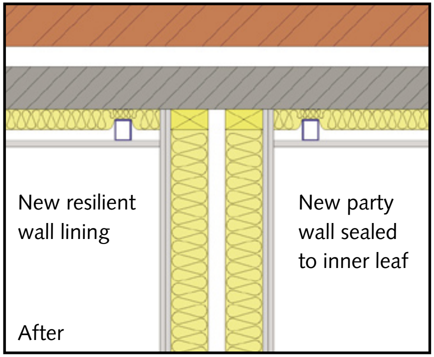


Figure 8.4c

Plan view of new lightweight twin frame separating wall junction with existing perimeter wall that is continuous between dwellings





Existing timber floors

For existing timber floors new party walls are recommended to be twin leaf partitions as described above. Again, similar measures to those discussed above must be taken at the wall junctions.

When constructed off an existing timber floor, the floorboards must never run continuously under the partition. This will create a strong flanking path. It is recommended that the boards are cut along the line of the cavity.

There is also a high risk of flanking transmission within the floor void, especially if the joists are running at right angles to the partition. It is recommended that, where possible, one of the partition leafs is built along the line of a joist. Where a partition is not built along the line of a joist, full depth timber dwangs should be inserted between every joist along the full length of the partition, see Figure 8.4a. A dense mineral fibre batt 140–200kg/m^3 should also be inserted in the cavity between the dwangs.

Existing beams passing through new party walls

There is a strong risk of flanking transmission in situations where existing beams pass through new party walls. Massive concrete beams should not present a significant problem provided that the new wall is well sealed against the beam. However, steel beams must be boxed in using two sheets of dense gypsum-based board with the cavity created around the steel, filled with mineral fibre quilt.

Service penetrations through party wall

Service penetrations through party walls should be avoided where possible. Where this is not possible, the hole created for the service penetration should be as tight as possible and be fully sealed with mortar or flexible mastic. The services should then be boxed in on both sides of the partition as described above for beams.

Roof spaces and attic voids

In some situations, sound transmission between dwellings may not be due to the existing separating wall but as a result of sound leakage via the roof space or attic voids above the wall. In a few cases, the void may be continuous or openings between roof spaces have not been resealed after work has been undertaken. Sound is able to pass from the dwelling room through the ceiling into the roof void and on into the adjacent dwelling's roof void and rooms. In addition to sound insulation these openings and sound transmission pathways also raise issues about fire resistance and smoke penetration. Where possible, a gypsum lining comprising two layers of gypsum-based board (min 10kg/m^2 per layer) should be erected to close off the opening. It is also advisable to suspend 50mm mineral wool quilt insulation across one side of the new lining. The 50mm layer is not required in situations where a minimum of 100mm mineral wool quilt insulation is already installed between the roof joists.

Figure 8.1b shows the minimum airborne sound insulation requirements and maximum impact sound transmission requirements for separating floors.

Airborne and impact performance for a variety of existing floor types is presented in earlier chapters, as follows:

- Ash-deafened timber floors: Figure 5.3f
- Masonry supported lightweight timber floors: Figure 5.4d
- In-situ concrete floors: Figure 6.4c
- Timber frame floors: Figure 7.3k

Timber floors

Existing timber floors generally fall into two categories: those with heavy deafening between the joists and those with no deafening or a lightweight insulation quilt.

Many timber floors incorporating heavy deafening should comply with the sound insulation requirements, provided the deafening material is still in good condition, is at least 70–80mm in depth and has heavy plaster ceilings still intact.

Lightweight timber floors with no deafening or only quilt insulation between the joists are more likely to fail the initial sound tests and require substantial upgrading, presuming secondary ceilings and flooring treatments have not already been fitted.

There are three options for improving timber floors that are damaged or have poor sound insulation but each involves a substantial amount of work. As outlined in Chapter 4 (Section 4.3) the three primary options, which are not exclusive and more often combined, are:

i) new flooring treatments;
ii) inserting materials within the floor void; and
iii) ceiling treatments.

Where alterations to the floor are not desirable, the alternative option is a ceiling treatment, such as:

i) additional lining boards;
ii) suspended secondary ceiling; or
iii) independent ceiling.

The factors affecting, and methods of improving, the sound insulation performance of ash-deafened timber floors and masonry-supported lightweight timber floors are discussed in Chapter 5. Key points to observe during conversion works for timber separating floors are shown in Figure 8.5.

Figure 8.5

Key points to watch in conversions involving masonry or stone supported timber floors.

Key points to watch with conversions involving masonry or stone supported timber floors.

- Ensure adequate deafening or insertion treatments are applied
- Ensure the voids between the room perimeter joists and walls are well sealed
- Avoid notching of joists for services as this will weaken the stiffness of the floors
- If installing floating floor treatments to achieve the required impact performance ensure flanking strips are installed and take account of the rise in floor heights
- Investigate whether a soft bonded floor covering may be more appropriate than a timber floating floor, (saves on cost and avoids height issues and alterations to existing rooms above the floor)
- If existing floorboards can be retained investigate if resilient insertion treatments can be used between joist and floorboards
- Avoid using downlighters unless a secondary ceiling or acoustic/fire covers or shields are applied
- Check influence of additional loads with a structural engineer
- Check implications for fire when specifying new ceiling boards for sound insulation.

Concrete floors

Conversions of buildings with concrete floors have become more common in recent years, especially former city centre office buildings. (see also Section 8.6, Façades)

Due to the high mass of the concrete floors the airborne sound insulation is normally sufficient, provided the vertical continuity of the external wall inner leaf is broken by the floor slab. However, pre-conversion testing is recommended prior to work commencing, due to potential flanking and localised weakness of pipe penetrations and types of façades used (e.g. curtain walling).

In general, where the floor slab has a mass per unit area greater than 350kg/m^2, it is likely that the airborne sound insulation will achieve the Building Standards' requirements, provided there is limited flanking sound transmission.

No matter how heavy the slab, it is likely that the impact insulation will be poor. There are a number of options that can be used to improve impact performance. Where maximising floor-to-ceiling height is important, a resilient overlay board, as described above for timber floors, can be installed. Where height is not an issue, the preferred method is to install a chipboard floating floor on resilient battens or cradles, as discussed in Chapters 4 and 6. Cradle floating floors have the advantages of providing:

- a void for service runs;
- an opportunity to level the floor; and
- greater impact sound insulation improvement than shallow treatments.

The various ceiling options for concrete floors are also described in Chapter 6.

Services within floors

One of the principal causes of failures found during completion testing is the inadequate sealing of new service penetrations. There is also often a failure to spot old weaknesses. Pre-conversion sound testing can be of great assistance in identifying the location of hidden voids and/or damage to the existing floor structure that will require remedial measures.

Service routes under timber floors are sometimes marked onto the floorboards or are identifiable from damage to the floorboards. If deafening has been damaged, it should be made good as discussed above (see Chapter 4).

Where old pipes or ducts that previously passed through the floor have been removed, the remaining voids should be made good to the original specification of the floor. These must also comply with fire regulations.

All new penetrations for services such as waste water pipes must not only be sealed with an appropriate fire collar but also be acoustically sealed. This generally involves fully packing the void around the pipe with deafening material or dense mineral wool. The floor and ceiling should then be made good to minimise the void around the pipe/duct.

The whole service run should be enclosed on both sides of the floor by wrapping the pipe with 50mm mineral fibre quilt and boxing around with a freestanding frame that must not touch the services. The frame should then be sheeted with two layers of gypsum-based board with a minimum density of 10kg/m^2 per layer.

Note that cast iron pipes generally provide more sound insulation than clay or plastic pipes, and provided they are in good condition, should not be replaced.

It is common to run electricity cables as well as water and gas pipes within the floor void. This is acceptable and should not require any additional acoustic attenuation measures. However, care should be taken to ensure that their installation does not damage the deafening material (in timber floors) or bridge the resilient layers where floating floor treatments are used.

It is strongly recommended not to run waste or rainwater pipes horizontally within a party floor. Where this detail cannot be avoided, it will be necessary to take additional measures to increase the insulation and isolation of the pipe. The pipes can be boxed as described above or they can be wrapped using proprietary acoustic multi-layer ‘jacket type’ products.

Columns and beams

Columns can be a source of flanking transmission, in particular hollow steel columns. They can also provide a strong path for structural impact transmission. Pre-conversion sound tests should be able to identify whether any columns act as a significant transmission path and whether any treatment is required. It may not be necessary to treat the column in all dwellings if flanking is limited.

A typical treatment for columns would be to construct a free standing metal stud partition around the column, incorporating 50mm insulation quilt and sheeted with two layers of gypsum-based board. Where columns pass through separating floors, as in old bonded warehouses, the junction between column and floor should be well sealed not only for sound insulation but also for fire. Where it is doubtful how well these voids can be sealed, the column linings should be double lined with gypsum-based board (minimum mass per unit area 10kg/m^2).

Beams do not significantly affect the sound insulation performance of a separating floor. However, if a beam has been installed for strengthening, the boxing around the beam may be a single sheet of lightweight board and this results in a weak area for airborne sound insulation. This can be resolved by stripping off the boxing, packing any voids with dense mineral wool batt and re-sheeting with two layers of dense gypsum-based board.

If new wall linings are being applied in period feature buildings, it may be possible to remove the existing skirtings and refit them onto the new wall lining treatment to retain some of the original interior detail. Furthermore the use of mouldings can allow new plaster cornices to be of the same design when taken from the original cornice details.

Retaining the existing structure but replacing the external façade has recently become popular in conversions of 1950s and 1960s office blocks. Acoustic flanking problems can, however, occur when new, lightweight curtain walling (or curtain glazing) is fixed onto the outside of the building and tied back to the floors. Due to the individual nature of each curtain wall system and the connections with proposed party floors and party walls, expert acoustic advice should be sought.

A major issue is the gap created between the slab edge and the façade wall. This can sometimes be quite wide and will give rise to substantial flanking sound transmission. It is recommended that the void between the slab edge and the glazing/walling is packed with dense mineral fibre batt 140–200 kg/m^3. Immediately above and below the batt the void should be closed off with a horizontal closer material of 10 kg/m^2. While this would typically be a plasterboard or sheet metal closer, a number of proprietary lead and polymeric barrier layers are also available.

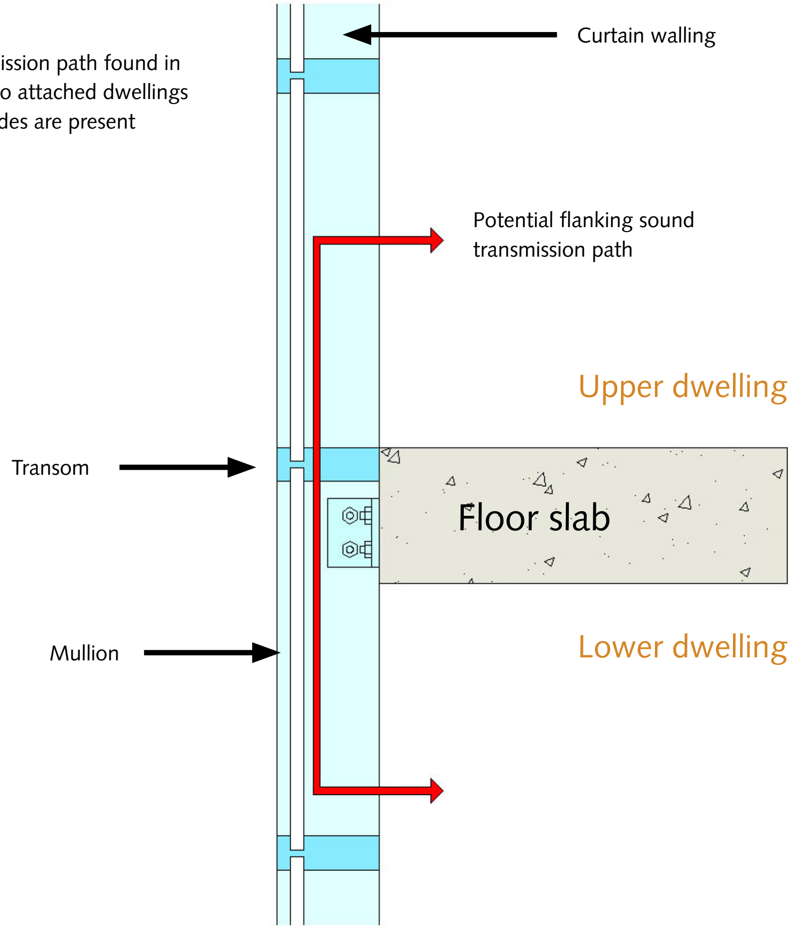
The flooring and ceiling should then be installed in the normal way ensuring that these are acoustically sealed against the wall or glazing mullions. It is prudent to insert insulation quilt in either the ceiling or floor cavity adjacent to the external façade to provide additional protection. It should be noted that this issue also exists at party walls/external wall junctions and care should be taken to introduce a similar barrier to transmission as described above for floors.

The less obvious issue is sound passing along the hollow mullions and transoms if they are continuous dwelling to dwelling, as shown in Figure 8.6.

It is recommended that this situation be avoided by ensuring that the mullions or transoms do not run continuously past a separating floor or wall. The mullion line should be broken with the introduction of a dead panel along the line of the party wall/floor. The panel should be inserted in such a way as to ensure that it makes the hollow mullions discontinuous. Suitable absorption materials are also required at these junctions and all openings must be well sealed and voids filled.

Figure 8.6

Typical flanking transmission path found in conversions of offices to attached dwellings where continuous façades are present



Conversions often require infills to doorways and openings in existing walls. These walls may need to serve as separating walls between dwellings or between dwellings and common areas. The following example shows how an existing doorway can be sealed between a new dwelling and a communal stairwell/hallway for a large family house being converted into flats (apartments).

Original construction

In the example illustrated here, the original construction has very ornate ceilings and cornice work. The proposed design required existing walls and door openings to become new party walls between the new common hallways and the dwelling living room. The infill had to be able to meet the performance requirements for airborne sound insulation of walls without additional wall linings affecting the existing walls. The client also required the original features to be retained or reproduced to provide balance within the new drawing room.

Deterministic test and/or desk study

As the original door openings would result in sound leakage, a deterministic test was not possible. A desk study assessment was therefore undertaken of the potential sound insulation of the existing structure. The specification of the infill thickness had to be no greater than (230mm).

A plan view of the doorway infill is shown in Figure 8.7. On completion of the work, a sound test demonstrated to the Verifier that the new separating wall between hallway and dwelling drawing room fully complied with the requirements of the Building Standards.

Figure 8.7

Infill of doorway for party wall, where wall is composed of stone and lath and plaster

Specification of door opening infill (plan view)

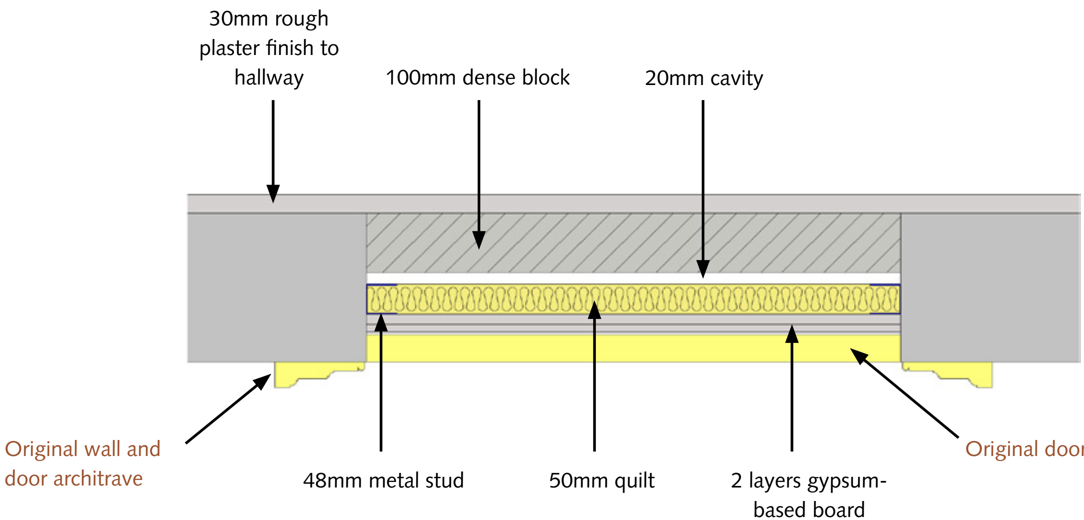


Figure 8.8

The finished construction viewed from:

a) the hallway and stairwell, where the original doorway has been infilled and lined (x) to blend in with the existing wall finish; and

b) as viewed from the new dwelling side (drawing room) showing how using the original door as part of the finish has retained balance and interior design.

9

Case studies

Also available in print from
www.arcamedia.co.uk

The case studies included here provide examples of different types of noise complaints and errors in construction. Each case study provides information on:

- building form and original construction;
- issue to be addressed: type of complaint or error in construction;
- other issues relevant to potential remedial work;
- remedial work undertaken;
- sound insulation test results and Occupant Equivalent Rating (OER) before and after remedial work.

Refer to Chapter 4 for further construction details and information relating to some of the remedial treatments. For purposes of clarity, wall ties and cavity fire stops are not shown in the case studies. These case studies address sound insulation issues only and not other Building Standards.

> **List of case studies**

List of Case Studies		Note: The case study number corresponds to relevant Chapter.
3A	Investigating noise complaints	
5A	Ash-deafened separating floor	Improvement to ash-deafened tenement floor undertaken at the same time as other work
5B	Non-deafened tenement separating floor	Improvement to tenement floor using new secondary lowered ceiling
6A	Solid block separating wall	Complaints about being able to hear speech, TV and general living noise from neighbours through a solid party wall in a block of flats
6B	Inner leaf flanking at separating wall	Complaints about hearing all types of noise from neighbouring dwellings as a result of inner leaf being continuous between dwellings
6C	Cavity block separating wall	Complaints about hearing speech, TV and general living noise from neighbouring dwellings through a cavity wall
6D	Concrete separating floor	Complaints about impact (footstep) noise transmission to lower dwellings through concrete floor with existing timber floor
6E	Flanking at concrete separating floor	Complaints about hearing all types of dwelling noise in lower flat due to inner leaf run past floor slab
6F	In-situ concrete frame with blockwork infill	Complaints about speech, TV and general living noise
6G	In-situ concrete floor	In-situ concrete floor and complaints about footstep noise
7A	Timber separating floor	Complaints about sound transmission from upper dwelling through timber frame separating floor

3A INVESTIGATING NOISE COMPLAINTS

The following case study gives an example of where (1) undertaking interviews with occupants and (2) carrying out sound insulation tests can together provide a more detailed set of information when investigating noise complaints.

Two neighbouring flats, A and B, share a separating wall on the top floor of a tenement block of flats. The flats are located next to a city centre road, which does not have high levels of traffic. Figure 1 shows a plan of the case study dwellings. The separating wall is half brick thick with 20–30mm plaster both sides. The wall is acting as a spine wall throughout the apartment block.

All dwellings within the block are managed by a housing association. No records have been found to suggest any previous invasive building work to the separating wall. The first complaint regarding sound transmission was made to the housing association by neighbour A two months after neighbour B moved in.

The noise complaint related to hearing a wide range of normal living noise (e.g. speech, television and music). Two other complaints had been recorded from other flats below Flat B, relating to hearing music noise. Initial assumptions were that the occupant of Flat B was possibly behaving anti-socially and that this was affecting a number of other flats.

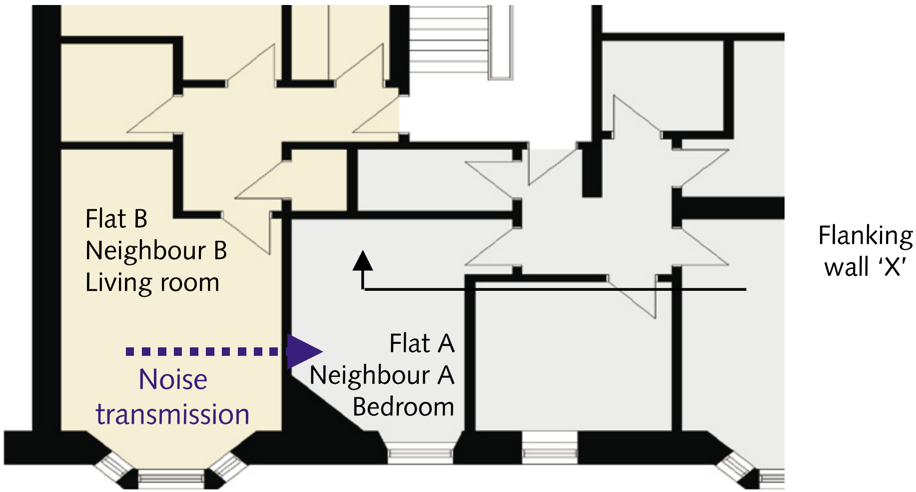
The housing association was concerned that neighbour A could hear a wide range of normal living noise. It was decided that prior to issuing a “warning letter” to neighbour B an acoustic consultant should investigate and undertake measurements of the separating wall.

Figure 2 lists a brief summary of factors from separate interviews with occupants on either side of the separating wall.

3A INVESTIGATING NOISE COMPLAINTS

Figure 1

Plan view of case study Flats A and B



3A INVESTIGATING NOISE COMPLAINTS

Figure 2

Details and summary of comments given by occupants on either side of the separating wall

	Flat A	Flat B
Occupant evaluation of sound insulation	very poor	excellent
Types of sound/noise heard	speech, TV, hi-fi	none
Room function	bedroom	living room
Screening in front of wall (e.g. wardrobes, cupboards)	none	none
Number of occupants	one	one
Occupant's hearing	good	good
Period of habitation	10 years	six months
Occupant's age	65–70	35–40
Gender of occupant	female	male

3A INVESTIGATING NOISE COMPLAINTS

FLAT A
(source of primary complaint)

The occupant described the sound insulation of the separating wall as **very poor** and that they can hear almost all sounds from Flat B. The room in Flat A adjacent to the separating wall is a "bedroom" with no wardrobes or cupboards screening the wall and there is no noise generating equipment within the bedroom. Due to the noise transmission problem this bedroom became used as a store and guests slept in the living room.

It was initially thought neighbour B was being anti-social as neighbour A could hear music. But since neighbour B's conversations involving normal voice levels could also be heard, the problem may be poor sound insulation. Neighbour A stated that, living in a flat, she would expect to hear some noise but not as much as currently heard.

FLAT B
(source of noise)

The occupant described the sound insulation of the same separating wall as **excellent** and did not hear his neighbours. In Flat B the room immediately adjacent to the separating wall is a living room. Stereo loud speakers were directly mounted on the separating wall and there were no cupboards or wardrobes screening the wall. When listening to music or TV the volume levels are never high and no neighbours had mentioned noise issues since he moved in.

3A INVESTIGATING NOISE COMPLAINTS

On completion of the interviews, an airborne sound insulation test was carried out. The sound insulation of the separating wall was found to be 45dB $D_{nT,w}$ and this would typically relate to occupants describing the sound insulation as 'F' on the OER scale (see section 3.4).

With this level of sound insulation and poor performance at mid frequencies it is quite typical that conversation and speech could be heard in the neighbouring dwelling.

3A INVESTIGATING NOISE COMPLAINTS

There were several differences between the flats and neighbours that could have contributed towards the problem, for example: room function; potential noise sources; time of room use; age of dwellers; lifestyles and expectations.

Neighbour B could not hear any noise from Flat A due to the bedroom in Flat A no longer being used. The issue for lower flats of only hearing music noise indicated that the wall-mounted speakers were directly placing sound energy into the wall (construction spine wall), causing it to be distributed throughout the block of flats. The adjoining wall (wall 'X') also provided a flanking sound transmission path into Flat A.

3A INVESTIGATING NOISE COMPLAINTS

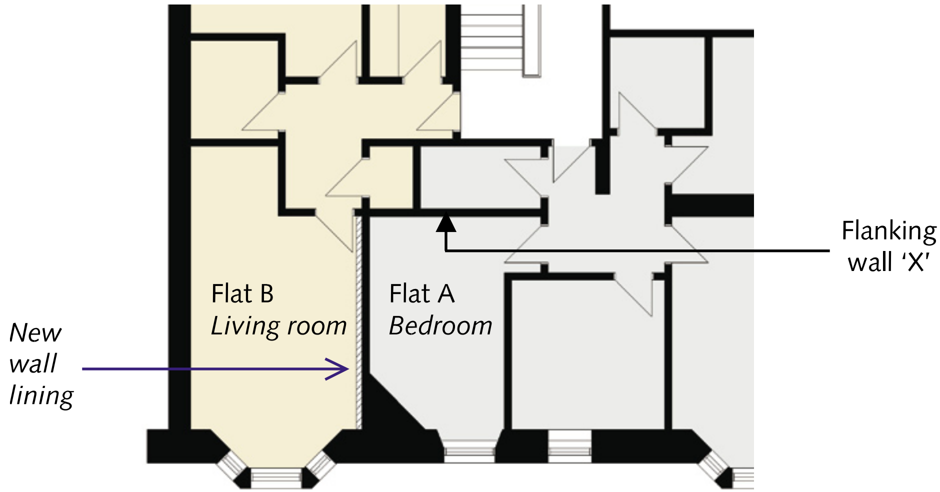
To address the direct transmission of sound between dwellings through the separating wall a new wall lining was proposed for the living room of Flat B (see Figure 3). The wall lining consisted of two layers of 12.5mm plasterboard with staggered joints mounted on a free-standing 48mm metal frame with 50mm mineral wool quilt placed between the metal studs. A 20mm offset gap was required between frame and original wall. This construction raised the sound insulation performance of the wall by at least 10dB, to 55dB $D_{nT,w}$.

Flat B was chosen for the wall lining due to the uneven thickness of the separating wall in Flat A caused by the fireplace, and because lining Flat A's bedroom would also involve the additional cost of lining flanking wall 'X'. Lining only Flat B's side of the separating wall prevents sound transmission through the separating wall and also restricts flanking transmission into wall 'X' and other lower flats.

3A INVESTIGATING NOISE COMPLAINTS

Figure 3

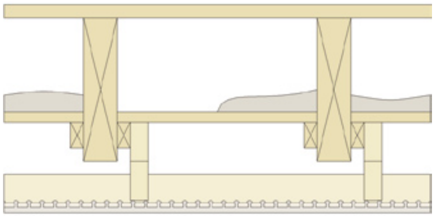
New wall lining applied to Flat B



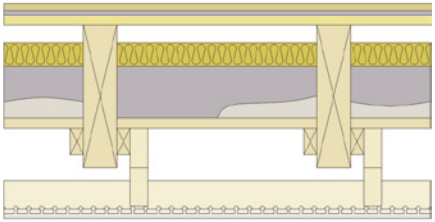
5A (SEPARATING FLOOR) IMPROVEMENT TO ASH-DEAFENED TENEMENT FLOOR UNDERTAKEN AT THE SAME TIME AS OTHER WORKS

BUILDING	Block of tenement flats built pre-1919.
ISSUES	Work was undertaken to install central heating and property managers decided to upgrade the sound insulation following complaints about airborne sound from the dwellings below. The client also wanted to install laminate flooring.
CONSTRUCTION OF ORIGINAL FLOOR	Ash-deafened traditional tenement floor with lath & plaster ceiling on timber hangers. Stone and rubble walls supported timber floor. Ash-deafening was missing between some of the floor joists or was limited. Existing 28mm floorboards were badly damaged due to previous work.
SOUND INSULATION TEST	Airborne sound insulation was rated by occupants as 'E' and impact sound insulation rated as 'D'.
REMEDIAL SOLUTION	To lift existing floor and install 70mm granular chips with mineral wool layer. Soft floor covering 8mm thick bonded to new 22mm chipboard layer prior to laminate being installed.
FLOOR RETESTED POST-REMEDIAL WORKS	Both airborne and impact performance were improved by 8dB and now have an Occupant Equivalent Rating of 'B'. **Note: impact tested directly on laminate flooring.**

5A (SEPARATING FLOOR) IMPROVEMENT TO ASH-DEAFENED TENEMENT FLOOR UNDERTAKEN AT THE SAME TIME AS OTHER WORKS



Inspected Construction



Remedial floor linings applied

	Airborne Performance		Impact Performance	
	$D_{nT,w}$ (dB)	OER	$L'_{nT,w}$ (dB)	OER
Original floor	48	(Before) E	61	(Before) D
Post remedial works	56	(After) B	53	(After) B
Improvement	8		8	

Occupant Equivalent Ratings (OER)

8 point scale A = excellent, G = intolerable*
(A, A, B, C, D, E, F, G)*

5B (SEPARATING FLOOR) IMPROVEMENT TO TENEMENT FLOOR USING NEW SECONDARY LOWERED CEILING

BUILDING

Block of tenement flats built pre-1919.

ISSUES

Occupants complained of impact and airborne sound transmission from upper flat. Both airborne and impact sound transmission were described by the occupants as particularly bad in the bedroom located below the upper flat living room.

CONSTRUCTION OF ORIGINAL FLOOR

Ash-deafened traditional tenement floor with previously installed plasterboard ceiling. It was assumed the ash-deafening had been removed when the prior work was ongoing. A thin mineral wool layer had been placed above ceiling.

SOUND INSULATION TEST

Airborne and impact sound insulation were rated by occupants as ‘F’ for OER.

REMEDIAL SOLUTION

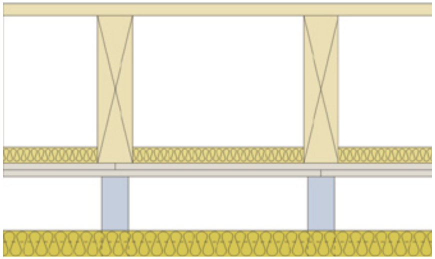
To install new secondary lowered ceiling using metal frame ceiling with 100mm void and gypsum-based board 12kg/m^2. Metal frame connected directly to joists. 50mm mineral wool laid over the entire new ceiling area.

FLOOR RETESTED POST-REMEDIAL WORKS

Both airborne and impact performance were improved by 10dB and 9dB respectively.

5B (SEPARATING FLOOR) IMPROVEMENT TO TENEMENT FLOOR USING NEW SECONDARY LOWERED CEILING

Inspected Construction



Remedial floor linings applied

	Airborne Performance		Impact Performance	
	$D_{nT,w}$ (dB)	OER	$L'_{nT,w}$ (dB)	OER
Original floor	45	(Before) F	65	(Before) F
Post remedial works	55	(After) C	56	(After) C
Improvement	10		9	

Occupant Equivalent Ratings (OER)

8 point scale A = excellent, G = intolerable*
(A, A, B, C, D, E, F, G)*

6A (SEPARATING WALL) COMPLAINTS ABOUT BEING ABLE TO HEAR SPEECH, TV AND GENERAL LIVING NOISE FROM NEIGHBOURS THROUGH A SOLID PARTY WALL IN A BLOCK OF FLATS

BUILDING

Three-storey block of flats with 215mm dense blockwork solid walls between flats A and B.

Precast concrete separating floor with resilient batten floating floor and metal frame ceiling and single layer gypsum board. Inner leaf of dense block.

ISSUES

Occupants complained that they could hear general living noise, TV and conversations quite easily through the separating wall into living rooms on each side.

CONSTRUCTION OF ORIGINAL WALL

Solid dense block party wall with only 12.5mm dry lining board on dabs each side. Inspection showed some mortar joints not well filled and poorly sealed. Inner leaf junctioned correctly.

OTHER FEATURES

Televisions on each side adjacent to party wall. Side ‘a’ had radiators and several sockets on party wall. Side ‘b’ had only one ‘double’ electrical socket. No architectural, historic, services or other restrictions apply.

ANALYSIS

Existing wall design already performed poorly and was amplified by bad workmanship at mortar joints.

REMEDIAL SOLUTION

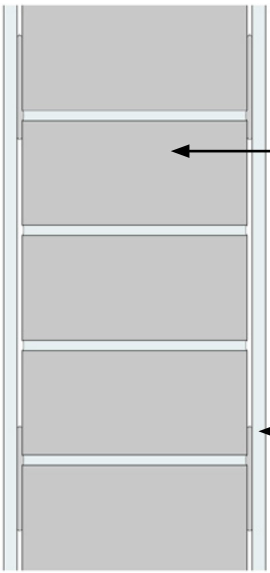
Strip back wall lining on side ‘b’ only. 13mm parge coat to wall face and mount resilient wall lining.

(See Chapter 4 for further information on remedial wall treatments.)

6A (SEPARATING WALL) COMPLAINTS ABOUT BEING ABLE TO HEAR SPEECH, TV AND GENERAL LIVING NOISE FROM NEIGHBOURS THROUGH A SOLID PARTY WALL IN A BLOCK OF FLATS

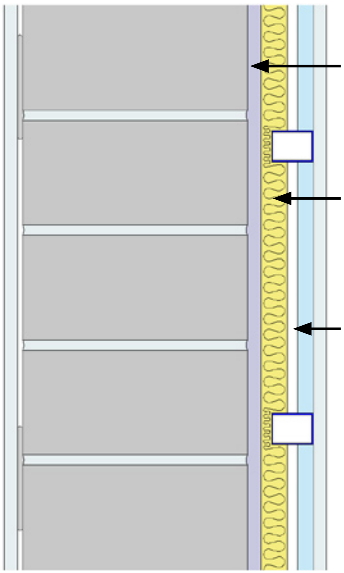
Original Construction (section view)

(a)



Remedial wall linings applied

(b)



	Airborne Performance	
	$D_{nT,w}$ (dB)	OER
Original wall	51	(Before) D
Post remedial works	59	(After) A
Improvement	8	

Occupant Equivalent Ratings (OER)

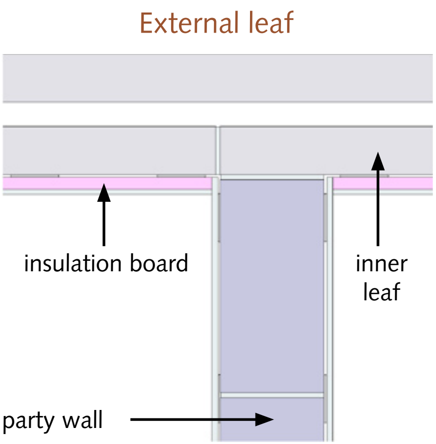
8 point scale
A = excellent, G = intolerable*
(A, A, B, C, D, E, F, G)*

6B (SEPARATING WALL) COMPLAINTS ABOUT HEARING ALL TYPES OF NOISE FROM NEIGHBOURING DWELLINGS AS A RESULT OF INNER LEAF BEING CONTINUOUS BETWEEN DWELLINGS

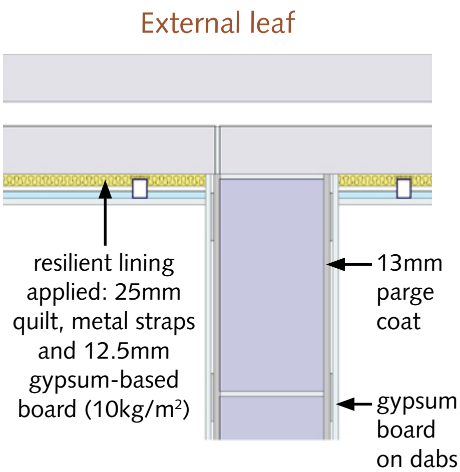
BUILDING	Four-storey block of flats. Dense blockwork solid walls and precast concrete floor.
ISSUES	Occupants complained that sound insulation was very poor at the separating walls between bedrooms.
CONSTRUCTION OF ORIGINAL WALL	Solid dense block party wall with 12.5mm dry lining board on dabs each side. Inspection showed inner leaf had been run through between dwellings and mortar joints were not fully filled at wall junction.
ANALYSIS	Poorly mortared joints and inner leaf were run through, leading to high levels of direct sound transmission and flanking sound.
OTHER FEATURES	Only electrical sockets on separating wall. No architectural, historic, services or other restrictions apply.
REMEDIAL SOLUTION	Party wall face parged (13mm) and dry lined on dabs. Open mortar joints on inner leaf sealed. Resilient wall lining applied to inner leaf of external wall. *For further information on remedial wall treatments, see Chapter 4.*
IMPORTANT NOTE	**If an insulated lining is being applied to external wall, check Building Standards for Fire (Section 2) and Energy (Section 6).**

6B (SEPARATING WALL) COMPLAINTS ABOUT HEARING ALL TYPES OF NOISE FROM NEIGHBOURING DWELLINGS AS A RESULT OF INNER LEAF BEING CONTINUOUS BETWEEN DWELLINGS

Original Construction (plan view)



Remedial wall linings applied



	Airborne Performance	
	$D_{nT,w}$ (dB)	OER
Original wall	44	(Before) F
Post remedial works	56	(After) B
Improvement	12	

Occupant Equivalent Ratings (OER)

8 point scale
A = excellent, G = intolerable*
(A, A, B, C, D, E, F, G)*

6C (SEPARATING WALL) COMPLAINTS ABOUT HEARING SPEECH, TV AND GENERAL LIVING NOISE FROM NEIGHBOURING DWELLINGS THROUGH A CAVITY WALL

BUILDING

Three-storey block of flats using dense blockwork cavity wall and concrete floor.

ISSUES

Occupants complained that sound insulation was poor and general conversations, TV and other living noise could be heard.

CONSTRUCTION OF ORIGINAL WALL

Cavity dense block party wall with only 12.5mm dry lining board on dabs each side.

ANALYSIS

Mortar joints appeared to be sealed but joints may not have been fully filled. Party wall face requires parge coat.

OTHER FEATURES

Rooms were small on both sides and radiators also located on separating wall so minimal amount of additional linings were required.

REMEDIAL SOLUTION

- Dry lining cut back
- Party wall face parged (rendered) 13mm
- Party wall dry lined using higher mass cement based 10mm boards.

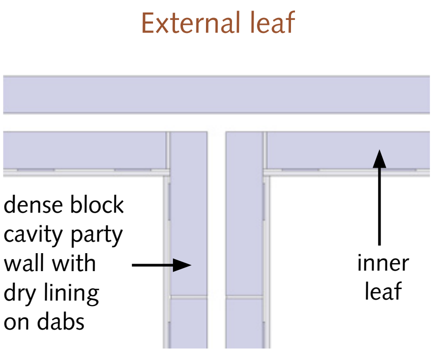
For further information on remedial wall types, see Chapter 4.

IMPORTANT NOTE

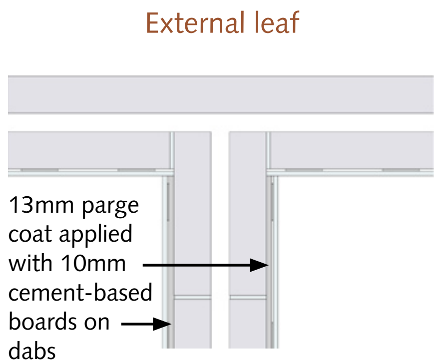
Dependent upon original installation sequence of boards, it may be possible to remove original separating wall lining without damage to the inner leaf lining. If the inner leaf is being removed for works the parge coat should be taken up to corner junctions.

6C (SEPARATING WALL) COMPLAINTS ABOUT HEARING SPEECH, TV AND GENERAL LIVING NOISE FROM NEIGHBOURING DWELLINGS THROUGH A CAVITY WALL

Original Construction
(plan view)



Remedial wall
linings applied



	Airborne Performance	
	$D_{nT,w}$ (dB)	OER
Original wall	51	(Before) D
Post remedial works	60	(After) A
Improvement	9	

Occupant Equivalent Ratings (OER)

8 point scale
A = excellent, G = intolerable*
(A, A, B, C, D, E, F, G)*

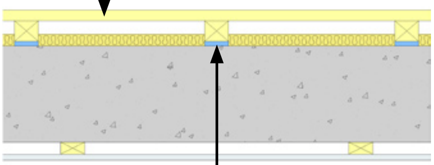
6D (SEPARATING FLOOR) COMPLAINTS ABOUT IMPACT (FOOTFALL) NOISE TRANSMISSION TO LOWER DWELLINGS FOR CONCRETE FLOOR WITH EXISTING TIMBER FLOOR

BUILDING	Block of flats built in 1960s, all under control of single housing association. In-situ concrete floors with timber floating floor on mineral wool insulation and timber brander dry lined ceilings.
ISSUES	Multiple complaints about impact noise for some years. Other modernisation works due to be carried out for central heating etc. with cables and pipes to be run within floor void
CONSTRUCTION OF ORIGINAL FLOOR	Original mineral wool resilient layer had deteriorated under battens, but is still intact between battens. Battens now resting directly on floor slab with no resilience. Total depth of floor board and battens 75mm.
SOUND INSULATION TEST	Okay for airborne sounds but impact performance was very poor.
REMEDIAL SOLUTION	Lift existing floor and install resilient batten system at 400mm centres within depth of original floor using 22mm chipboard. Insert flanking strips throughout perimeter of floorboard junction with wall and skirtings.

6D (SEPARATING FLOOR) COMPLAINTS ABOUT IMPACT (FOOTFALL) NOISE TRANSMISSION TO LOWER DWELLINGS FOR CONCRETE FLOOR WITH EXISTING TIMBER FLOOR

Original Construction (section view)

Remedial floor linings applied



	Impact Performance	
	$L'_{nT,w}$ (dB)	OER
Original floor	67	(Before) F
Post remedial works	49	(After) A*
Improvement	18	

Occupant Equivalent Ratings (OER)

8 point scale
A = excellent, G = intolerable*
(A, A, B, C, D, E, F, G)*

6E (SEPARATING FLOOR) COMPLAINTS ABOUT HEARING ALL TYPES OF DWELLING NOISE IN LOWER FLAT DUE TO INNER LEAF RUN PAST FLOOR SLAB

BUILDING

Block of flats using precast slab with screed finish resting on isolating polyethylene layer. Ceiling suspended on metal frame. Inner leaf of lightweight aggregate blocks.

ISSUES

Complaints related to hearing all types of noise in bedroom from living room in dwelling above. No complaints about impact sound.

ORIGINAL CONSTRUCTION

Precast wide slab not built into wall. Inner leaf continuous vertically between flats. Voids found at junction of slab and wall head.

FLOOR TESTED FOR SOUND INSULATION

Airborne insulation was very poor. Impact performance tested on screed was also poor.

ANALYSIS

Inner leaf running through created strong flanking paths for sound over a wide range of frequencies. Impact performance appeared acceptable to occupants as carpets were hiding this issue.

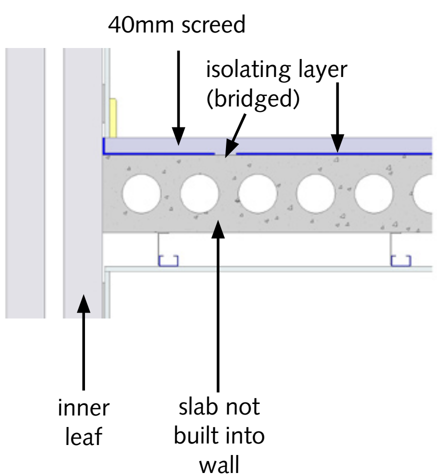
REMEDIAL SOLUTION

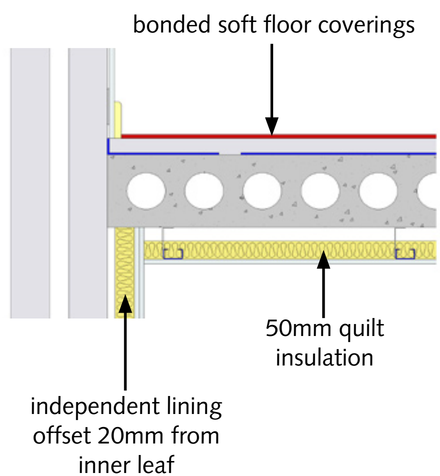
- Independent lining applied to lower room only. 48m metal frame offset by 20mm from wall. 50mm quilt insulation and two layers of gypsum-based board (staggered joints).
- Ceiling lined with 50mm quilt
- 4mm bonded soft floor covering applied to upper floor surface.

6E (SEPARATING FLOOR) COMPLAINTS ABOUT HEARING ALL TYPES OF DWELLING NOISE IN LOWER FLAT DUE TO INNER LEAF RUN PAST FLOOR SLAB

Original Construction (section view)

Remedial wall and ceiling linings applied





6E (SEPARATING FLOOR) COMPLAINTS ABOUT HEARING ALL TYPES OF DWELLING NOISE IN LOWER FLAT DUE TO INNER LEAF RUN PAST FLOOR SLAB

	Airborne Performance		Impact Performance	
	$D_{nT,w}$ (dB)	OER	$L'_{nT,w}$ (dB)	OER
Original floor	42	(Before) G	67	(Before) F
Post remedial works	55	(After) C	44	(After) A*
Improvement	13		23	

Occupant Equivalent Ratings (OER)

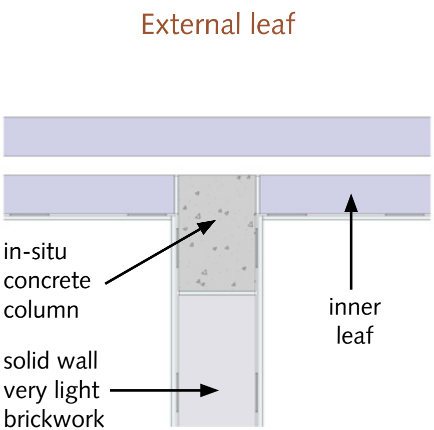
8 point scale A = excellent, G = intolerable*
(A, A, B, C, D, E, F, G)*

6F (HIGH-RISE WALL) COMPLAINTS ABOUT SPEECH, TV AND GENERAL LIVING NOISE

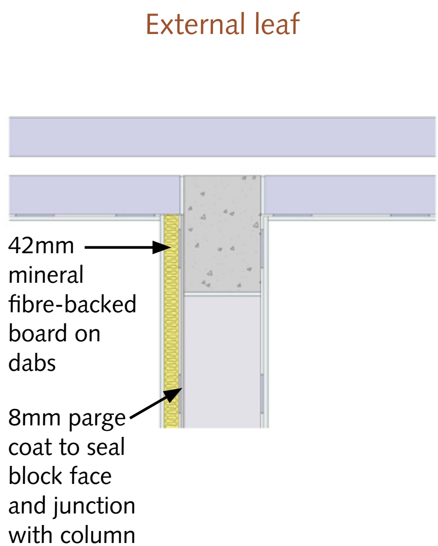
BUILDING	1960s high-rise block of flats of 10+ storeys. Complaints received by local authority from a number of dwellings.
ISSUES	Complaints related to speech, TV and general living noise. Remedial treatment required to be less than 60mm due to door and window jambs.
CONSTRUCTION OF ORIGINAL WALL	In-situ concrete frame with very lightweight block in-fill with gypsum-based board on straps. Potential weakness at junction of blockwork and columns.
WALL TESTED FOR SOUND INSULATION	Walls generally poor at mid and high frequencies. This supported complaints being made about certain sounds being heard. Almost no flanking at external wall inner leaf due to mass of column.
ANALYSIS	Treatment with absorbent lining to one side likely to markedly improve performance.
REMEDIAL SOLUTION	Strip back existing lining to party wall. Apply 8mm parge coat to seal any open joints between blocks, junction with column and block face. Apply 42mm mineral fibre backed board on dabs one side.

6F (HIGH-RISE WALL) COMPLAINTS ABOUT SPEECH, TV AND GENERAL LIVING NOISE

Original Construction



Remedial wall lining applied



	Airborne Performance	
	$D_{nT,w}$ (dB)	OER
Original wall	51	(Before) D
Post remedial works	60	(After) A
Improvement	9	

Occupant Equivalent Ratings (OER)

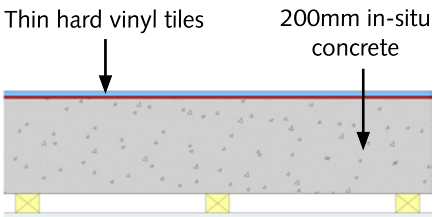
8 point scale
A = excellent, G = intolerable*
(A, A, B, C, D, E, F, G)*

6G (HIGH-RISE FLOOR) IN-SITU CONCRETE FLOOR AND COMPLAINTS ABOUT FOOTFALL NOISE

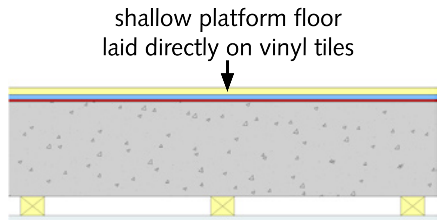
BUILDING	1960s high-rise of 10+ storeys. In-situ concrete floors and walls.
ISSUES	Complaints related to footstep noise being heard in dwellings below. Upstairs occupants worked shift patterns and so noise was heard by occupants below during the night and early morning. No complaints about hearing airborne noise. Very restricted ceiling heights so no opportunity to use ceiling treatments. Maximum permissible alteration to floor height is 35mm.
CONSTRUCTION OF ORIGINAL FLOOR	In-situ concrete with thin vinyl covering bonded to floor. All perimeter walls are also in-situ concrete.
FLOORS TESTED FOR SOUND INSULATION	Impact results were 64dB and 66dB for floors tested. **(Note: tested on bonded thin vinyl)**
ANALYSIS	Due to ceiling and flanking issues and lack of complaints about airborne noise only impact sound needed to be addressed. Due to high levels of flanking noise via perimeter walls, the installation of a ceiling system likely to only partially help.
REMEDIAL SOLUTION	Install shallow platform floor involving floorboard with prebonded resilient layer (t&g joints). Flanking strips installed at junction with room walls and skirting.

6G (HIGH-RISE FLOOR) IN-SITU CONCRETE FLOOR AND COMPLAINTS ABOUT FOOTFALL NOISE

Original Construction (section view)



Remedial ceiling linings applied



	Impact Performance	
	$L'_{nT,w}$ (dB)	OER
Original floor	66	(Before) F
Post remedial works	45	(After) A*
Improvement	21	

Occupant Equivalent Ratings (OER)

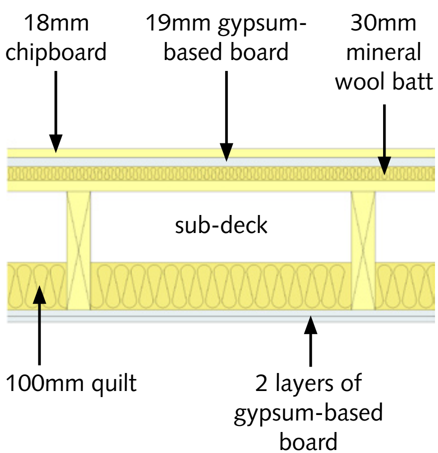
8 point scale
A = excellent, G = intolerable*
(A, A, B, C, D, E, F, G)*

7A (SEPARATING FLOOR) COMPLAINTS ABOUT SOUND TRANSMISSION FROM UPPER DWELLING THROUGH TIMBER FRAME SEPARATING FLOOR

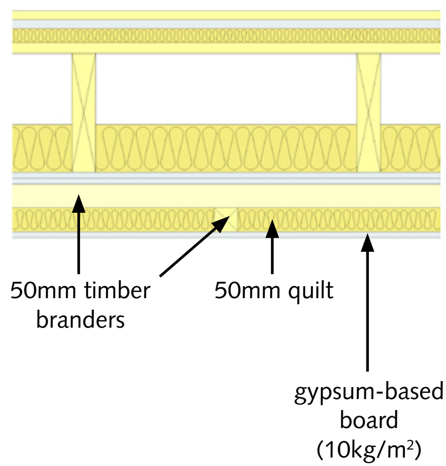
BUILDING	Block of two-storey timber frame flats, built during early 1990s using solid timber joists.
ISSUES	Complaints related primarily to airborne sound transmission through floor, although occupants also complained slightly about impact noise.
ORIGINAL CONSTRUCTION	Solid joist with ceiling boards fixed direct to joist, 100mm quilt insulation between joists and platform floors (continuous mineral wool batt)
FLOOR TESTED FOR SOUND INSULATION	See test results.
ANALYSIS	This floor construction is normally marginal in achieving the Building Standards' requirements. Results correlated with occupants' comments.
REMEDIAL SOLUTION	Secondary ceiling installed on metal frame hangers or cross brandered 50 x 50mm timbers with single layer of gypsum-based board 10kg/m^2 supporting 50mm quilt insulation. **Note: metal frame hangers provide better insulation than cross brandered timbers.**

7A (SEPARATING FLOOR) COMPLAINTS ABOUT SOUND TRANSMISSION FROM UPPER DWELLING THROUGH TIMBER FRAME SEPARATING FLOOR

Original Construction (section view)



Remedial ceiling linings applied



7A (SEPARATING FLOOR) COMPLAINTS ABOUT SOUND TRANSMISSION FROM UPPER DWELLING THROUGH TIMBER FRAME SEPARATING FLOOR

	Airborne Performance		Impact Performance	
	$D_{nT,w}$ (dB)	OER	$L'_{nT,w}$ (dB)	OER
Original floor	49	(Before) E	62	(Before) E
Post remedial works	56	(After) B	54	(After) B
Improvement	7		8	

Occupant Equivalent Ratings (OER)

8 point scale A = excellent, G = intolerable*
(A, A, B, C, D, E, F, G)*

Annexes

Also available in print from
www.arcamedia.co.uk

The following section presents examples of frequently asked questions from occupants and property managers in relation to sound insulation between attached dwellings and methods of improvement. It is important to note that whilst the responses given below are of a generic nature each noise complaint or problem may have individual issues. It is advised that prior to undertaking work, appropriate expert acoustic advice should be sought, such as from a member of the Association of Noise Consultants.

Methods of improvement

Q What methods are there for improving insulation of a separating wall against speech and general living noise?

A Prior to undertaking any work, it is important to determine if the sound is transmitting directly through the wall or via other structures, such as the external wall, floor or ceiling. There are a variety of wall lining treatments, presented in Section 4.5.

Blockwork walls

Q Our bedroom backs onto our neighbours' kitchen and we can hear their cupboard doors closing. The house construction is brick or blockwork. Can we insulate the wall on our side and will it make much difference?

A The best method of reducing this impact noise is to line the bedroom side of the wall with a resilient wall lining or independent wall lining, see Section 4.5. Possible improvement levels are shown in Figures 5.2h and 6.2k. Masonry brick wall construction is discussed in Chapter 5 and blockwork walls in Chapter 6.

Low frequency noise

Q We can hear low frequency "bass" music through our separating wall with the adjoining house. The volume is not loud and our neighbours are not being anti-social. We think it may be due to poor sound insulation or bad construction. What system would be best to try and reduce this noise?

A The primary method of reducing this noise is to use an independent lining. The greater the cavity the better the insulation and normally you should not use less than two layers of gypsum-based board for the linings (min 12kg/m^2) each layer. Refer to Section 4.5.

High-rise and hearing conversations

Q We can hear conversations through the separating wall. The building is high-rise concrete flats. Can we reduce this noise without making too many changes to the size of our room?

A If it is primarily conversations being heard, you may be able to use a mineral fibre backed board. Refer to Section 4.5 and Case Study 6F for further information.

Preparing for a sound test

Q I want a sound test carried out for the wall between my house and my neighbour as we want to improve the sound insulation. Where can I get information on what I need to do? Does the person doing the test need to get access to my neighbour's house?

A Access into the adjoining dwelling will be required. Chapter 3 describes what is involved for a sound insulation test and Figure 3.2a provides a guide for occupants preparing for a sound test.

Testing and assessing multiple dwellings

Q We manage a wide range of dwelling types. Some of these dwellings seem to repeatedly be associated with noise complaints. How can we assess these for sound insulation? Do we need to measure all of the houses and walls?

A Providing the dwelling types to be tested are similar in construction you do not need to test all of the dwellings. Only a sample of tests will be required. Section 3.1 provides information on dealing with multiple dwellings and Figure 3.1a outlines the key stages and functions involved. Figure 3.3a details factors that may influence subjective assessments by occupants.

Impact noise in multiple apartments

Q Our organisation manages several blocks of flats and we have received a number of complaints about footstep noise. How can we best reduce this without having to lower ceilings or disturb the occupants too much?

A The best way to reduce footstep noise (or impact noise) is to install a resilient layer directly onto the existing floor hard surface. If there is only thin carpet or vinyl tiles then installing a high performing bonded soft floor covering, typically 15mm thick will make a significant difference. Alternatively using a very shallow platform floor with a pre-bonded resilient layer will also improve performance markedly without raising floor levels significantly. Both of these systems are described in Section 4.6 (refer also to Case Studies 6D, 6E and 6G).

Upper flat has hard floor finishes and improvements can only be applied to ceilings in lower flat

Q The flat above ours has hard floor finishes that may be laminate. Previously we could sometimes hear their television and conversations (airborne noise) but now we constantly hear them walking across the floor. The apartment block is a traditional tenement style. We can only provide remedial treatments to our ceiling or walls. Can we install ceilings that will reduce both the airborne and impact noise?

A Secondary ceilings can provide improved insulation for both airborne and impact sounds. Chapter 5 provides details on types of secondary ceilings for tenements, case studies and details of potential improvements. Check to see if any sound is flanking down via the perimeter walls, and if so, these may also need treatment. Secondary ceilings will increase insulation but it may still be possible to hear some footstep noise.

Airborne flanking noise via perimeter walls

Q We can hear noise from the upstairs dwelling but only at the perimeter walls. The construction is blockwork walls and concrete floors. Can we insulate the perimeter walls?

A There is a choice of different wall linings that can be applied. See Chapter 6 Sections 6.2 and 6.3.

Noise from service pipes

Q We have communal service pipes passing through the separating floor. We can clearly hear noise from the pipes when other flats are draining water. The pipes currently have thin box linings. Is it possible to reduce this noise without damaging the existing walls?

A There are two methods of approaching this issue: **1)** to leave the existing boxing and encase the box with mineral wool batt and apply a secondary boxing of two layers of gypsum-based board, minimum 10kg/m^2; or **2)** cut back the boxing to expose the pipes, without damaging the existing wall linings, wrap the pipes in 50mm mineral wool quilt and box with two layers of gypsum-based board minimum 12kg/m^2 each layer. Details relating to these linings are also given in Chapter 4, Section 4.8.

Proposing impact tests and carpets present in apartments

Q We manage an apartment block and are considering upgrading the separating floors due to the number of complaints about footstep noise. Carpets are laid throughout the flats. For a test, do we need to test all floors and do we need to pull back the carpet?

A Only part of the floor decking under the carpet requires to be exposed. It is best to pull the carpet back (and any underlay) at a corner to allow easy refitting. Chapter 3 Section 3.5.2 discusses impact tests and Figure 3.2a lists helpful points for occupants before and during the test.

Building Regulations and Standards

Current

The Building (Scotland) Act 2003.

Building Standards Section 5: Noise. Technical Handbook (Domestic), Building (Scotland) Regulations 2004.

Previous

The Building Standards (Scotland) Regulations 1990	London, HMSO, 1990
The Building Standards (Scotland) Amendment Regulations 1987	London, HMSO, 1987
The Building Standards (Scotland) Regulations 1981	London, HMSO, 1981
The Building Standards Scotland (Consolidation) Regulations 1971	London, HMSO, 1971
Technical Memorandum 3: “Sound insulation in houses”. Department of Health for Scotland	Edinburgh. HMSO. 1957

British Standards		
BS EN ISO 140:1998	**Acoustics – Measurement of sound insulation in buildings and of building elements.**	BSI 1998
BS EN ISO 717:1997	**Acoustics – Ratings of sound insulation in buildings and of building elements.**	BSI 1997
BS 7671:2001	**Requirements for electrical installations**	BSI 2001

BRE/CIRIA Papers

BRE CP 20/78	**"Sound insulation performance between dwellings built in the early 1970s."** E.C. Sewell, W.E. Scholes. Building Research Establishment, 1978.
BRE CP 28/78	**"Party wall insulation and noise from neighbours".** F.J. Langdon, I.B. Buller. Building Research Establishment. 1978.
BRE IP 6/80	**"Field measurements of the sound insulation of plastered cavity masonry walls".** E.C. Sewell, R.S. Alphey, J.E. Savage, S.J. Flynn. Building Research Establishment, 1980.
BRE IP 7/80	**"Field measurements of the sound insulation of plastered solid blockwork walls".** E.C. Sewell, R.S. Alphey, J.E. Savage, S.J. Flynn. Building Research Establishment, 1980.
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CIRIA Report 114	**"Sound control for homes" (1986).**
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Books and Reports

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Sound insulation – the implications of the new performance standards.
Royal Institute of Environmental Health of Scotland. Spring, 1993.

M.S.Adams.

"The relationship between post-construction testing and sound insulation performance." Applied Acoustics 57 (1999) 79-87.

R.J.M. Craik, A. MacPherson, A.W.M. Somerville.

"On the influence of low frequencies on the annoyance of noise from neighbours." Inter-noise 2003, Seogwipo, Korea, 2003.

J.H. Rindel.

Acoustic and Testing Organisations	
Association of Noise Consultants	www.association-of-noise-consultants.co.uk
Institute of Acoustics	www.ioa.org.uk
United Kingdom Accreditation Service	www.ukas.com
Architectural Organisations	
Royal Institute of British Architects	www.riba.org
Royal Incorporation of Architects in Scotland	www.rias.org.uk
Chartered Institute of Architectural Technologists	www.ciat.org.uk
Standards and Building Regulations	
Scottish Building Standards Agency	www.sbsa.gov.uk
International Standards Organisation	www.iso.org
National House Building Council	www.nhbc.co.uk
Office of the Deputy Prime Minister	www.odpm.gov.uk (England and Wales regulations)
Historic Buildings	
Historic Scotland	www.historic-scotland.gov.uk
Edinburgh World Heritage	www.ewht.org.uk
Scottish Lime Centre	www.scotlime.org
Housing, Regeneration and Management	
Communities Scotland	www.communitiesscotland.gov.uk
Scottish Executive – Housing & Regeneration	www.scotland.gov.uk
Scottish Federation of Housing Associations	www.sfha.co.uk
Scottish House Condition Survey	www.shcs.gov.uk

Noise Statistic Sources	
Royal Environmental Health Institute of Scotland	www.rehis.org
Chartered Institute of Environmental Health (CIEH)	www.cieh.org
Department of the Environment, Food and Rural Affairs	www.defra.org.uk
UK National Statistics	www.statistics.gov.uk
UK Noise Association	www.ukna.net
Construction Materials Products Associations	
Aircrete Bureau	www.aircrete.co.uk
British Precast Concrete Federation	www.britishprecast.org
Concrete Block Association	www.cba-blocks.org.uk
Construction Industry Research and Information Association	www.ciria.org
Construction Products Association	www.constprod.org.uk
Federation of Plastering & Drywall Contractors	www.fpdc.org
Gypsum Products Development Association	www.gpda.org.uk
Proprietary Acoustic System Manufacturers	www.pasm.org.uk
Steel Construction Institute	www.steel-sci.org
UK Mineral Wool Association	www.eurisol.com
UK Timber Frame Association	www.timber-frame.org

Absorption	Conversion of sound energy into heat, often by the use of a soft porous material.
Absorptive material	Material that absorbs sound energy.
Airborne sound	Sound propagating through the air, often linked to noise sources such as speech and television.
Airborne sound insulation	Sound insulation that reduces the transmission of airborne sound between buildings or parts of buildings.
Brander	A section of timber of set size used to support ceiling boards.
Boss plaster	Plaster that has lost adhesion to the wall face and when tapped 'sounds' hollow.
Cradle (saddle)	An intermediate support system (with a resilient layer base) for batten supported floors which isolates the batten from the floor base and can allow services to travel in any direction.
Dabs	A plaster or gypsum-based bonding compound to fix gypsum-based boards to masonry walls.
Deafening (pugging)	Infill material to provide increased mass and absorption for timber floors. Originally ash was used but can be an aggregate material or sand.
Decibel (dB)	The unit used for different acoustic quantities to indicate the level with respect to a reference level.
Density	Mass per unit volume, expressed in kilograms per cubic metre (kg/m^3).

Direct transmission	Sound which is transmitted only through the main separating element and involves no other flanking element.
D_{nT}	The difference in sound level between a pair of rooms (source and receiving rooms), for a stated frequency, which is corrected (normalised) for the reverberation time (in the receiving room). See BS EN ISO 140-4: 1998.
$D_{nT,w}$	A single-number quantity (weighted and standardised) which characterises the airborne sound insulation between two rooms. See BS EN ISO 717-1:1997.
Dwangs	Struts, normally timber based, fixed between joists or studs to increase stiffness and strength properties.
Flanking element	Any building element that contributes to the airborne sound or impact transmission between rooms in a building which is not the direct separating element (i.e. not the separating wall or separating floor)
Flanking transmission	Airborne sound or impact transmission between rooms that is transmitted via flanking elements and/or flanking elements in conjunction with the main separating elements.
Floating floor treatment	A floor system which may use battens, cradles or platform base all of which use a resilient layer with flanking strips to provide isolation from the base floor and perimeter wall elements.
Floating screed	A screed floor which is isolated from the base floor and adjacent wall elements using a resilient layer.
Frame wall	A partition consisting of a structural timber or metal frame
Frequency	The number of pressure variations per second that dictates a sounds distinctive tone.

Gypsum-based board	Dry lining board using either a plaster or cement gypsum base
Hertz (Hz)	The unit of the frequency of a sound (formerly called cycles per second).
Impact sound	Sound resulting from direct impact on a building element (e.g. footsteps on a floor surface)
Impact sound insulation	Insulation that reduces (attenuates) the impact sound transmission from direct impacts (e.g. footstep noise).
Internal wall	A wall or partition which divides the dwelling space into different rooms but which does not provide the separation between different dwellings
$L'_{nT,w}$	A single-number quantity (weighted and standardised) to characterise the impact sound insulation of floors. See BS EN ISO 140-7:1998.
$L_{n,w}$	A single-number quantity (weighted and normalised) which characterises the impact sound insulation of a building element from measurements undertaken in a laboratory. See BS EN ISO 717-1:1997.
Mass per unit area (or surface density)	Mass per unit area is expressed in terms of kilograms per square metre (kg/m^2).
Mineral fibre or mineral wool	A rock or glass-based material that can be manufactured in a quilt form or batt (more rigid) form.
Noise	Noise is defined as unwanted sound.
Perpends	Joints between block or brick walls that are normally filled and sealed with mortar.

R_w	A single-number quantity (weighted) which characterises the airborne sound reduction index of a building element from measurements undertaken in a laboratory. See BS EN ISO 717-1:1997.
Resilient batten	A timber batten with a pre-bonded resilient layer for placing under the floor surface to reduce impact sound.
Resilient layer	A layer that isolates an element (e.g. screed, floating floor) from another element (e.g. base floor)
Reverberation	The persistence of sound in a space after a sound source has been terminated.
Reverberation time	The time, in seconds, taken for a sound source to decay by 60dB after the sound source has been terminated.
Separating floor	A floor that separates attached dwellings
Separating wall	A wall that separates attached dwellings