Sound transmission and insulation in buildings

Handbook

The Australian Building Codes Board

The Australian Building Codes Board (ABCB) is a standards writing body responsible for the National Construction Code (NCC), WaterMark and CodeMark Certification Schemes.

The ABCB is a joint initiative of all levels of government in Australia, together with the building and plumbing industry. Its mission is to oversee issues relating to health, safety, amenity, accessibility and sustainability in building.

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Version history

Original

Publish date: May 2004
Print version: 1.0

This version

Publish date: Jun 2024
Print version: 4.3
Details of amendments: Minor editorial corrections

Preface

This handbook is one of a series by the ABCB. Handbooks expand on areas of existing regulation or relate to topics that are not regulated by the NCC. They provide advice and guidance.

The Sound Transmission and Insulation in Buildings Handbook assists in understanding the sound transmission and insulation requirements in the NCC Volume One and Volume Two.

It addresses issues in generic terms and is not a document that sets out specific compliance advice for developing solutions to comply with the requirements in the NCC. It is expected that this handbook guides readers to develop solutions relevant to specific situations in accordance with the generic principles and criteria contained herein.

Contents

Reminder

This handbook is not mandatory or regulatory in nature. Compliance with it will not necessarily discharge a user's legal obligations. The handbook should only be read and used subject to, and in conjunction with, the general disclaimer at page i.

The handbook also needs to be read in conjunction with the NCC and the relevant legislation of the appropriate state or territory. It is written in generic terms and it is not intended that the content of the handbook counteract or conflict with the legislative requirements, any references in legal documents, any handbooks issued by the administration or any directives by the appropriate authority.

1 Background

The NCC is a performance-based code containing all Performance Requirements for the construction of buildings. To comply with the NCC, a solution must achieve compliance with the Governing Requirements and the Performance Requirements.

The Governing Requirements contain requirements about how the Performance Requirements must be met. A building, plumbing or drainage solution will comply with the NCC if it satisfies the Performance Requirements, which are the mandatory requirements of the NCC.

This handbook reflects the latest updates and modifications introduced in NCC 2022.

When compared to NCC 2019 there are 2 main changes to the NCC sound transmission and insulation requirements. These are:

(1) Changes to the clause numbering due to the introduction of a consistent volume structure (CVS) across all 3 volumes of the NCC.

(2) The Performance Requirements for sound transmission and insulation are now quantified in NCC Volume One and Two. This means the Performance Requirements now primarily include numerical targets that clarify the level of performance required, rather than qualitative (non-numerical) statements.

This handbook is not intended to replace or supersede the NCC but rather provide additional information to aid the user in the application of the sound insulation requirements of the NCC 2022.

The objectives of this handbook are to:

- outline the minimum NCC requirements
- provide guidance on compliance options that can be used to meet the NCC requirements
- provide guidance on the installation of acoustic elements
- help achieve acceptable acoustic outcomes for buildings.

It is expected that this handbook provides links between the NCC sound transmission and insulation requirements and the needs of various types of practitioners.

The NCC requires a level of sound insulation that represents the minimum acceptable building standard. This was determined through wide consultation with the community and industry. An owner or designer can always go beyond the minimum requirements in the NCC if they choose in which case, the information provided in this handbook may need to be supplemented to suit the specific project.

1.1 Scope

Chapter 2 provides an overview of the NCC Performance Requirements, Verification Methods and the Deemed-to-Satisfy Provisions.

Chapters 3 to 5 provide guidance on design practice for practitioners to consider when implementing solutions for sound transmission.

To specify particular requirements, the NCC uses a building classification system. Building classifications are labelled 'Class 1' through to 'Class 10'. Some classifications also have sub-classifications, referred to by a letter after the number (e.g., Class 1a).

The scope of this document is limited to Class 1, 2, 3 and Class 9c buildings. It focuses only on the sound transmission and insulation requirements of NCC Volume One Part F7 and NCC Volume Two Part H4. It does not cover the excess noise requirements of NCC Volume Three.

Any acoustic design should be conducted in conjunction with the design of all other building requirements including, but not limited to, structural loading, wind loading, fire safety, earthquake design, energy efficiency, ventilation requirements and buildability.

Access to the NCC is available from the ABCB website.

1.2 Using this document

This document contains 5 appendices, which are as follows.

- Appendix A contains a list of abbreviations and symbols used in this document.
- Appendix B is a glossary of key terms used in this document.
- Appendix C provides general information about complying with the NCC and responsibilities for building and plumbing regulations.
- Appendix D provides more information about laboratory and field testing.
- Appendix E provides a list of additional resources.

Different styles are used in this document. Examples of these are provided below:

NCC extracts[1]

Examples

Alerts or Reminders

[1] NCC extracts italicise defined terms as per the NCC. See Schedule 1 of the NCC for further information.

2 Sound transmission and insulation in the NCC

This chapter aims to provide an understanding of the sound transmission and insulation requirements outlined in the NCC 2022. It explores the objectives, scope, and various compliance options available and outlines effective strategies for meeting the NCC requirements.

The NCC has sound insulation requirements for residential buildings in the following parts.

- Part F7 Sound transmission and insulation in Volume One.
- Part H4 Health and amenity in Volume Two.
- Part 10.7 of the ABCB Housing Provisions (Housing Provisions).

2.1 Objective

The NCC Objective of the sound transmission and insulation requirements in Volumes One (F7O1) and Two (H4O6) is to safeguard occupants from illness or loss of amenity as a result of undue sound being transmitted:

- between adjoining dwellings or units containing sleeping facilities
- from common spaces into adjoining units
- from parts of the building with a different classification into adjoining units.

2.2 Scope

The NCC only deals with sound insulation between dwellings or units. It does not address the following:

- noise entering the building from outside, for example from industrial processes, vehicle traffic, trains, aircraft or animals
- environmental noise emission from the building to surrounding areas
- air conditioning or other plant noise within a unit
- domestic appliance noise within a unit
- room acoustic design for home entertainment systems
- noise transfer within a unit.

Reminder

Sound and noise are terms often used interchangeably. Both terms are used in the NCC. They relate to wave energy that causes vibrations in the air (or other media). The vibrations of a sound wave decrease with distance from the source as they spread over a larger area or are absorbed by objects. Hearing is the perception of sound. The term noise is typically used to describe unwanted sound.

2.3 Overview of NCC compliance

The NCC Performance Requirements prescribe the minimum necessary technical requirements for buildings, building elements, and plumbing and drainage systems.

Compliance with the NCC is achieved by complying with the NCC Governing Requirements and relevant Performance Requirements. There are 3 options available to demonstrate compliance with the Performance Requirements:

- a Performance Solution
- a Deemed-to-Satisfy (DTS) Solution, or
- a combination of a Performance Solution and a DTS Solution.

General information on compliance with the NCC is contained in Appendix C.

For sound insulation requirements, the mandatory Performance Requirements are F7P1 to F7P4 in Volume One and H4P6 in Volume Two for building Classes 1, 2, 3 and 9c. See Figure 2.1.

Figure 2.1 NCC Performance Requirements for sound insulation Volumes One and Two

Performance Requirements Sound transmission and insulation		
Volume One		**Volume Two**
Class 2 & 3 F7P1 & F7P2	**Class 9c** F7P3 & F7P4	**Class 1** H4P6

The Performance Requirements for sound insulation in Volume One and Volume Two are discussed further in this chapter.

2.4 Volume One

To meet the objective outlined in section 2.1, the NCC has detailed sound insulation provisions in Part F7 of Volume One sound transmission and insulation. The types of buildings these clauses relate to is summarised below:

- Class 2 building
- Class 3 building
- Class 9c building.

Refer to the NCC for exact definitions of the different building classifications.

2.4.1 Performance Requirements

F7P1 to F7P4 are the Performance Requirements for sound transmission in NCC Volume One 2022. The Performance Requirements in F7P1 to F7P4 are separated between Class 2 & 3 buildings (apartments and hotels) and Class 9c buildings (residential care buildings).

2.4.1.1 Apartments and hotels

F7P1 Sound transmission through floors

F7P1 Sound transmission through floors applies to Class 2 and 3 buildings (apartments and hotels) and relates to the floor separating sole-occupancy units (SOUs) or an SOU from specified spaces or parts of a different classification. It covers both airborne and impact generated sound. F7P1 tends to minimise the transmission of sound, through separating floors from a number of specified spaces. A list is included with the additional words ‘or the like’. An example of a floor separating SOUs from parts of a different classification, would be a floor separating ground floor shops (Class 6) from an apartment (Class 2) level above.

F7P2 Sound transmission through walls

F7P2 Sound transmission through walls applies to Class 2 and 3 buildings and relates to the walls between SOUs, an SOU and specified spaces or parts of a different classification. A list is included with the additional words ‘or the like’.

Any door assembly located in a wall that separates an SOU from a stairway, public corridor, public lobby or the like should meet the requirements of F7P2. F7P2 covers both airborne and impact generated sound and tends to minimise the transmission of sound through walls including services and their penetrations from a number of specified spaces.

An example of a wall separating SOUs from parts of a different classification, would be a wall in a building between shops (Class 6) and hotel rooms (Class 3).

Unlike F7P1 impact generated sound is only a consideration for walls separating a bathroom, sanitary compartment, laundry or kitchen in an SOU from a habitable room (other than a kitchen) in adjoining SOUs or walls separating an SOU from a plant room or lift shaft.

Reminder

A habitable room is a room used for normal activities. It includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom.

Rooms such as a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes-drying room are excluded and are considered non habitable.

Note that other spaces of a specialised nature occupied neither frequently nor for extended periods are also considered non habitable.

2.4.1.2 Residential care buildings

F7P3 Sound transmission through floors

F7P3 Sound transmission through floors in a residential care building relates to floors between SOUs in class 9c buildings. It covers airborne and impact generated sounds between units located above one another. It does not cover sound transmission through floors from common spaces such as a common corridor, laundry, or entertainment area.

F7P4 Sound transmission through walls

F7P4 Sound transmission through walls in a residential care building relates to the walls separating SOUs, or an SOU from a kitchen, bathroom, sanitary compartment (not being an associated ensuite), laundry, plant room or utilities room. The requirements for impact generated sound only applies to the walls separating an SOU from a kitchen or laundry.

Reminder

The requirements for the sound insulation of walls and floors as specified in F7P1 to F7P4 must not be compromised because of services that penetrate the elements.

The Performance Requirements relevant to Part F7 are reproduced below.

F7P1 Sound transmission through floors

A floor separating sole-occupancy units or a sole-occupancy unit from a plant room, lift shaft, stairway, public corridor, public lobby, or the like, or parts of a different classification, must minimise the transmission of airborne and impact generated sound such that the separating floor, including the effect of services and their penetrations, has—

(a) weighted standardised level difference with spectrum adaptation term ($D_{nT,w} + C_{tr}$) not less than 45 for airborne sound; and

(b) a weighted standardised impact sound pressure level ($L_{nT,w}$) not more than 62 for impact generated sound.

Applications

F7P1 only applies to a Class 2 or 3 building.

F7P2 Sound transmission through walls

A wall, including services and their penetrations, must minimise the transmission of sound such that—

(a) for airborne sound—

  (i) a wall separating sole-occupancy units has a weighted standardised level difference with spectrum adaptation term ($D_{nT,w} + C_{tr}$) not less than 45; and

  (ii) a wall separating a sole-occupancy unit from a plant room, lift shaft, stairway, public corridor, public lobby, or the like, or parts of a different classification, has a weighted standardised level difference ($D_{nT,w}$) not less than 45; and

  (iii) any door assembly located in a wall that separates a sole-occupancy unit from a stairway, public corridor, public lobby, or the like, has a weighted standardised level difference ($D_{nT,w}$) not less than 25; and

(b) for impact generated sound, a wall must have sufficient sound insulation to prevent illness or loss of amenity to the occupants if the wall separates—

  (i) a bathroom, sanitary compartment, laundry or kitchen in one sole-occupancy unit from a habitable room (other than a kitchen) in an adjoining sole-occupancy unit; or

  (ii) a sole-occupancy unit from a plant room or lift shaft.

Applications

F7P2 only applies to a Class 2 or 3 building.

F7P3 Sound transmission through floors in a residential care building

A floor separating sole-occupancy units must minimise the transmission of airborne and impact generated sound such that the separating floor, including the effect of services and their penetrations, has—

(a) a weighted standardised level difference with spectrum adaptation term ($D_{nT,w}$) not less than 40 for airborne sound; and

(b) a weighted standardised impact sound pressure level ($L_{nT,w}$) not more than 62 for impact generated sound.

Applications

F7P3 only applies to a Class 9c building.

F7P4 Sound transmission through walls in a residential care building

(1) A wall separating sole-occupancy units, or a sole-occupancy unit from a kitchen, bathroom, sanitary compartment (not being an associated ensuite), laundry, plant room or utilities room, including the effect of services and their penetrations, must minimise the transmission of—

(a) airborne sound such that the wall has a weighted standardised level difference ($D_{nT,w}$) not less than 40; and

(b) impact generated sound, if the wall separates a sole-occupancy unit from a kitchen or laundry.

(2) Sound insulation required by (1) must be sufficient to prevent illness or loss of amenity to the occupants

Applications

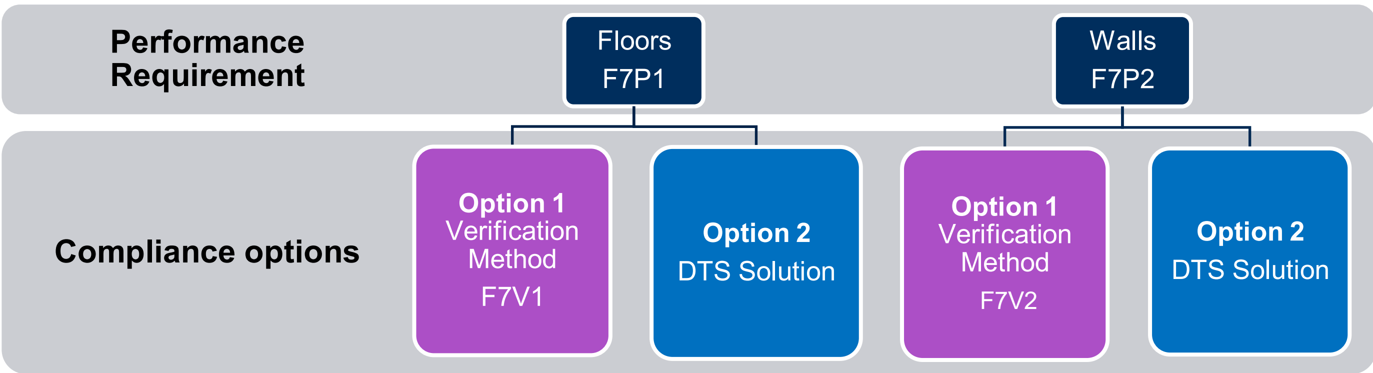
F7P4 only applies to a Class 9c building.

2.4.2 Compliance options

2.4.2.1 Apartments and hotels

There are several compliance options available to meet the Performance Requirements for apartments and hotels. A simplified overview of the available options is in Figure 2.2.

Figure 2.2 Sound insulation compliance options for walls and floors in apartments and hotels

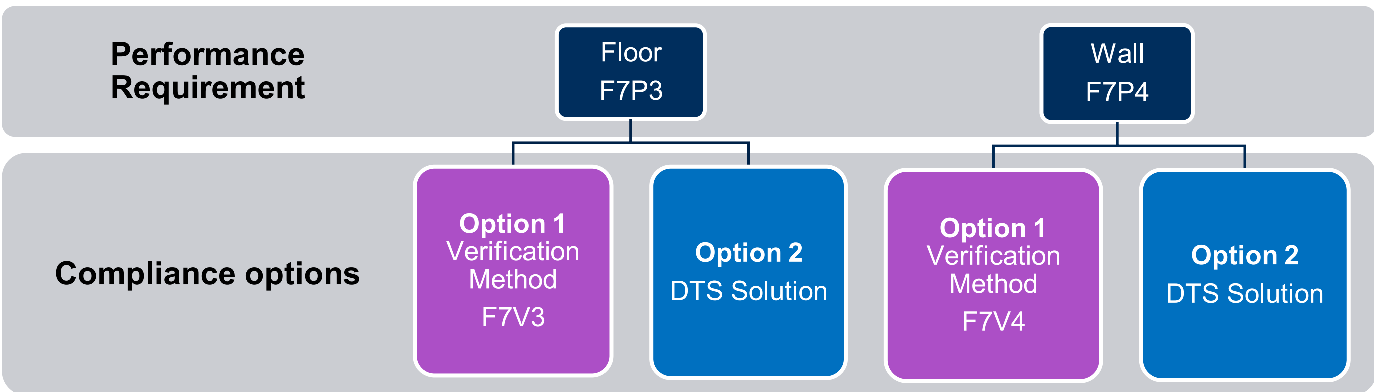


Note to Figure 2.2: Blue shading indicates a DTS Solution, purple shading indicates a Performance Solution.

2.4.2.2 Residential care buildings

There are several compliance options available to meet the Performance Requirements for residential care buildings. A simplified overview of the available options is in Figure 2.3.

Figure 2.3 Sound insulation compliance options for walls and floors in residential care buildings



Note to Figure 2.3: Blue shading indicates a DTS Solution, purple shading indicates a Performance Solution.

2.4.3 Verification Methods

Verification Methods F7V1, F7V2, F7V3 and F7V4 provide designers with a Performance Solution pathway to demonstrate compliance. Figure 2.4 and Figure 2.5 below matches the Verification Method to the relevant Performance Requirement for apartments and hotels (Class 2 & 3) and residential care buildings (Class 9c).

Figure 2.4 Sound insulation Verification Methods for apartments and hotels

Verification Method		Performance Requirement
Sound transmitted through floors Verification Method: F7V1	→	Performance Requirement F7P1
Sound transmitted through walls Verification Method: F7V2	→	Performance Requirement F7P2(a)

Figure 2.5 Sound insulation Verification Methods for residential care buildings

Verification Method		Performance Requirement
Sound transmitted through floors Verification Method: F7V3	→	Performance Requirement F7P3
Sound transmitted through walls Verification Method: F7V4	→	Performance Requirement F7P4(1)(a) and (2)

There is no Verification Method for determining compliance with F7P2(b) and F7P4(1)(b). Both requirements outline the impact generated sound insulation requirements for walls. Therefore, in this instance the option for compliance is a DTS Solution or another means of verifying that the requirements are achieved (refer to section 2.4.5 of this document).

It is not compulsory to use a Verification Method as part of a Performance Solution to show compliance with the relevant Performance Requirement(s). The designer can use the DTS Provisions of Part F7 or another Performance Solution as a means of verifying that the Performance Requirements will be achieved.

The basic premise of the Verification Methods F7V1 to F7V4 is to measure in-situ (i.e. on-site) the transmission of airborne and impact generated sound through floors and walls against the quantified values specified in the applicable Verification Method. If the values measured are greater than or equal to the quantified values in the applicable Verification Method, then the solution complies.

The advice of an appropriately qualified person should be sought to undertake the assessment and analysis where required.

Appendix D of this document provides further background information on testing and reporting methods.

2.4.3.1 Apartments and hotels

There are 2 NCC Verification Methods that can be used to meet the relevant Performance Requirements for sound insulation for apartments and hotels. They are:

(1) F7V1 Sound transmission through floors

(2) F7V2 Sound transmission through walls.

These are discussed in the following sections.

F7V1 Sound transmission through floors

F7V1 Sound transmission through floors is a means of verifying whether a floor achieves the requirements of F7P1 in minimising the transmission of airborne and impact generated sound through the floor. F7V1 only applies to Class 2 and 3 buildings.

If F7V1 is used to verify compliance, when tested on site the floor must have a weighted standardised level difference with spectrum adaption term $D_{nT,w}$+C_{tr} not less than 45 when determined under AS/NZS ISO 717.1 and a weighted standardised impact sound pressure level $L_{nT,w}$ not less than 62 when determined under AS ISO 717.2.

F7V2 Sound transmission through walls

F7V2 Sound transmission through walls is a means of verifying if a wall complies with requirements of F7P2(a) in minimising the transmission of airborne sound through the wall. F7V2 only applies to Class 2 and 3 buildings.

Unlike F7V1, the requirements differ depending on the location of the wall.

Walls separating SOUs require a $D_{nT,w}$+C_{tr} not less than 45 when determined under AS/NZS ISO 717.1.

Walls separating SOUs and areas such as plant rooms, lifts shafts, stairways, public corridors, public lobbies or the like, or part of a different classification, must have a $D_{nT,w}$ not less than 45 when determined under AS/NZS ISO 717.1.

C_{tr} does not apply in these instances, as the walls separate units from areas that are not likely to produce low frequency noise, which C_{tr} accounts for.

Door assemblies are permitted in walls between SOUs and public corridors, stairways or the like, providing the door assembly has a $D_{nT,w}$ not less than 25 when determined under AS/NZS ISO 717.1. Door assemblies are also permitted in walls between SOUs providing the door assembly has the same level of sound insulation as the wall i.e. $D_{nT,w}$+ C_{tr} not less than 45.

2.4.3.2 Residential care buildings

There are 2 NCC Verification Methods that can be used to meet the relevant Performance Requirements for sound insulation for residential care buildings. They are:

(1) F7V3 Sound transmission through floors

(2) F7V4 Sound transmission through walls.

These are discussed in the following sections.

F7V3 Sound transmission through floors

F7V3 is a means of verifying whether a floor achieves the requirements of F7P3 in minimising the transmission of airborne and impact generated sound through the floor.

If F7V3 is used to verify compliance, when tested on site the floor must have a weighted standardised level difference ($D_{nT,w}$) not more than 40 when determined under AS/NZS ISO 717.1 and a weighted standardised impact sound pressure level ($L_{nT,w}$) not more than 62 when determined under AS ISO 717.2.

F7V4 Sound transmission through walls

F7V4 is a means of verifying if a wall complies with the requirements of F7P4(1)(a) and (2) in minimising the transmission of airborne sound through a wall.

If F7V4 is used to verify compliance, when tested on site the wall separating SOUs must have a weighted standardised level difference $D_{nT,w}$ not less than 40 when determined under AS/NZS ISO 717.1.

A wall separating an SOU from a kitchen, bathroom, sanitary compartment (not being an associated ensuite), laundry, plant room or utilities room has a weighted standardised level difference $D_{nT,w}$ not less than 40 when determined under AS/NZS ISO 717.1.

Reminder

For Verification Methods F7V1 to F7V4, $D_{nT,w}$ is a measure of airborne sound insulation, similar to R_w.

C_{tr} is a spectrum adjustment factor which adjusts for low frequency sound levels. C_{tr} has been chosen in recognition of the problems caused by the high bass frequency outputs of modern home theatre systems and music reproduction equipment used by occupants of Class 2 and 3 buildings.

$D_{nT,w}$ and C_{tr} must be determined in accordance with AS/NZS ISO 717.1 Acoustics - Rating of sound insulation in buildings and of building elements - Airborne sound insulation. AS/NZS ISO 717.1 outlines how to use test results to determine the $D_{nT,w}$ and C_{tr} of a building element. The test results must be obtained by testing a building element in accordance with ISO 140-4. ISO 140-4 is the method for testing the airborne sound insulation of building elements in the field.

$L_{nT,w}$ is a measure of impact sound insulation. The lower the $L_{nT,w}$, the better the floor's impact sound insulation rating. The $L_{nT,w}$ must be determined in accordance with AS ISO 717.2 Acoustics - Rating of sound insulation in buildings and of building elements - Impact sound insulation. This document outlines how to use test results to determine the $L_{nT,w}$ of a building element. The test results must be obtained by testing of the floor in accordance with ISO 140-7. ISO 140-7 is the method for testing impact sound insulation of building elements in the field.

Note that ISO 140-4 Acoustics - Measurement of sound insulation in buildings and of building elements - Field measurements of airborne sound insulation between rooms, and ISO 140-7 Acoustics - Measurement of sound insulation in buildings and of building elements - Field measurements of impact sound insulation of floors, are not NCC referenced Standards.

2.4.4 DTS Provisions

The DTS Provisions provide a prescriptive approach that can be used to comply with Performance Requirements. A solution that complies with DTS Provisions is deemed to have met the Performance Requirements.

Table 2.1 shows the DTS clauses for sound insulation in Volume One.

Table 2.1 Sound insulation DTS clauses in Volume One

DTS Provisions	Clause reference
Deemed-to-Satisfy Provisions	F7D1
Application	F7D2
Determination of airborne sound insulation ratings	F7D3
Determination of impact sound insulation ratings	F7D4

Sound insulation rating of floors	F7D5
Sound insulation rating of walls	F7D6
Sound insulation rating of internal services	F7D7
Sound insulation of pumps	F7D8

These DTS Provisions are grouped based on their application to apartments and hotels (Class 2 and 3 Buildings) and residential care buildings (Class 9c buildings). Additionally, there are DTS Provisions that are applicable to both groups.

2.4.4.1 Apartments, hotels and residential care buildings

The NCC DTS Provisions that can be used for both Class 2 and 3 buildings (apartments and hotels) and Class 9c buildings (residential care buildings) to meet the relevant Performance Requirements for sound insulation are:

- F7D3 Determination of airborne sound insulation ratings
- F7D4(1) and (3) Determination of impact sound insulation ratings
- F7D6(5) and (6) Construction requirements for a sound rated wall that has floor or roof above
- F7D7 Sound insulation rating of internal services
- F7D8 Sound insulation of pumps.

These are discussed in the following sections.

F7D3 Determination of airborne sound insulation ratings

F7D3 clarifies the means of determining the airborne sound insulation rating (R_w, R_w+C_{tr}). Throughout the DTS Provisions of Part F7, some forms of construction are required to have an R_w or R_w + C_{tr}. These values must be:

- determined under AS/NZS ISO 717.1 using laboratory measurements, or
- in compliance with specification 28.

Specification 28 lists the weighted sound reduction index R_w for some common forms of construction. See Table 2.2.

Table 2.2 Specification 28 Sound insulation for building elements

Specification 28 reference	Clause title
S28C1	Scope
S28C2	Discontinuous construction
S28C3	Construction Deemed-to-Satisfy
S28C4	Acceptable forms of construction for walls- masonry
S28C5	Acceptable forms of construction for walls- concrete
S28C6	Acceptable forms of construction for walls- autoclaved aerated concrete
S28C7	Acceptable forms of construction for walls- timber and steel framing
S28C8	Acceptable forms of construction for floors- concrete
S28C9	Acceptable forms of construction for floors- autoclaved aerated concrete
S28C10	Acceptable forms of construction for floors- timber

Note to Table 2.2: Discontinuous construction is a term defined in F7D4(3).

F7D4(1) Determination of impact sound insulation ratings

In F7D4(1), floors that require impact sound rating are required to have an $L_{n,w}$ determined in accordance with AS ISO 717.2 using laboratory measurement. Alternatively, the sound insulation must comply with Specification 28. See Table 2.2.

In F7D4(1), $L_{n,w}$ is a measure of impact sound insulation. The type of impact generated noise passing through floors that the requirements aimed at minimising are noise associated with footsteps and moving of furniture.

F7D6(5) and (6) Sound insulation rating of walls

F7D6(5) and (6) contains additional requirements for sound insulated walls. F7D6(5) and (6) requires sound insulated walls to extend to either the roof/floor above or a ceiling that provides the required level of sound insulation. This is to ensure there is no space above the wall which could provide a flanking path for sound to travel through (Refer to Section 3.5.1 and Figure 3.3 of this document).

F7D7 Sound insulation rating of internal services

The intent of F7D7 is to minimise the transmission of sound that may arise from services that pass through more than one SOU.

F7D7 details separation requirements for services. The requirements only apply to services which pass through more than one SOU unit or are located in a wall or floor cavity which separates SOUs. F7D7 does not apply if the pipe is only located in a single unit, or any part of a Class 2, 3 or 9c building which is not part of an SOU.

The R_w+C_{tr} values specified do not take account of the inherent acoustic properties of a pipe material.

F7D8 Sound insulation of pumps

The intent of F7D8 is to minimise transmission of sound from a pump. F7D8 requires flexible couplings at connection points to or from a pump to minimise vibration and any consequent sound transmission along the piping.

2.4.4.2 Apartments and hotels

The NCC DTS Provisions that can be used to meet the relevant Performance Requirements for sound insulation only for apartments and hotels are:

(1) F7D4(2)(a) Determination of impact sound insulation ratings for walls

(2) F7D5(1) Sound insulation rating of floors

(3) F7D6(1) and (2) sound insulation rating of walls and a door incorporated in a sound rated wall.

These are discussed in the following sections.

F7D4(2)(a) Determination of impact sound insulation ratings

In F7D4(2)(a) the walls of Class 2 and 3 buildings that require an impact sound insulation rating must be of discontinuous construction.

Discontinuous construction is a term defined for Part F7 of NCC Volume One as stated in F7D4(3). It applies to all of Part F7 including Specifications 28 and 29.

Alert

As a defined term in the NCC Volume One, discontinuous construction means:

(a) a wall having a minimum 20 mm cavity between 2 separate leaves, and
  (i) for masonry, where wall ties are used to connect leaves, the ties are of the resilient type, and
  (ii) for other than masonry, there is no mechanical linkage between the leaves, except at the periphery, and
(b) a staggered stud wall is not deemed to be discontinuous construction.

F7D5(1) Sound insulation rating of floors

The intent of F7D5(1) is to minimise the transmission of sound through floors separating SOUs and floors separating SOUs and certain types of areas or parts of a different classification. F7D5(1) contains requirements for Class 2 and 3 buildings.

For Class 2 and 3 buildings, a floor requires R_w+C_{tr} (airborne) not less than 50 and impact sound insulation $L_{n,w}$ not more than 62 if it separates SOUs, an SOU from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification.

F7D6(1) and (2) Sound insulation rating of walls

F7D6(1) and (2) apply to Class 2 and 3 buildings. The intent of F7D6(1) is to minimise the transmission of sound through walls separating SOUs and walls separating SOUs and certain types of spaces or parts of a different classification.

F7D6(2) applies to a door assembly in a wall that separates an SOU from a common area.

F7D6(1) outlines airborne and impact sound insulation requirements for walls. The airborne sound requirements apply to walls separating SOUs and an SOU from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification. For walls separating SOUs, the wall must have an R_w+C_{tr} not less than 50. For walls separating an SOU from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification, the wall must have an R_w not less than 50.

For walls separating habitable areas (excluding a kitchen) in one SOU from a bathroom, laundry, kitchen or sanitary compartment in an adjoining unit or an SOU from a plant room or lift shaft, the wall must be discontinuous construction.

F7D6(2) provides a concession for a door assembly located in a wall that separates an SOU from public corridor or the like. The door requires an R_w of not less than 30 whereas the wall requires an R_w of not less than 50.

2.4.4.3 Residential care buildings

The NCC DTS Provisions that need to be complied with to meet the relevant Performance Requirements for sound insulation for residential care buildings are:

- F7D4(2)(b) Determination of impact sound insulation ratings for a wall required to have an impact sound insulation rating
- F7D5(2) Sound insulation rating of floors
- F7D6(3) and (4), sound insulation rating of walls

These are discussed in the following sections.

F7D4(2)(b) Determination of impact sound insulation ratings

In F7D4(2)(b), the walls of Class 9c buildings that require an impact sound insulation rating must:

- for other than masonry, be two or more separate leaves without rigid mechanical connection except at the periphery, or
- be identical with a prototype that is no less resistant to the transmission of impact sound when tested in accordance with specification 29 than a wall listed in S28C4 to S28C7. See Table 2.2 and Table 2.3 for Specification 28 and 29.

Table 2.3 Summary of requirements of specification 29

Specification 29 reference	Key requirements
S29C1 Scope	• Specification 29 describes a method of test to determine the comparative resistance of walls to the transmission of impact sound.
S29C2 Construction to be tested	• The test is conducted on a specimen of prototype wall construction and on a specimen of one or other of the constructions specified in S28C4 to S28C7. • The testing of a construction specified in S28C4 to S28C7 doesn’t need to be repeated for subsequent comparisons provided – – complete records of the results are retained, – the test equipment and the technique of testing are kept so that identical equipment can be employed, and – an identical technique can be adopted in the testing of specimens of prototype wall construction.

S29C3 Method	• The wall constructions to be compared must be tested in accordance with AS 1191 Acoustics – Method for laboratory measurement of airborne sound transmission insulation of building elements. • A horizontal steel platform 510 mm x 460 mm x 10 mm thick must be placed with one long edge in continuous and direct contact with the wall to be tested on the side of the wall on which the impact sound is to be generated. • A tapping machine complying with ISO 140/6 - 1998 (E) Acoustics - Measurement of sound insulation in buildings and of building elements - Laboratory measurements of impact sound insulation of floors must be mounted centrally on the steel platform. • The sound transmission through the wall must be determined in accordance with AS 1191, except a tapping machine mounted on a steel platform must be used as the source of sound. • The impact sound pressure levels measured in the receiving room must be converted into normalised levels using a reference equivalent absorption area of 10 m^2.

F7D5(2) Sound insulation rating of floors

For residential care buildings, a floor requires to have an R_w (airborne) not less than 45 if it separates SOUs.

F7D6(3) and (4) Sound insulation rating of walls

F7D6(3) and F7D6(4) apply to Class 9c buildings. F7D6(3) covers sound transmission through a wall separating SOUs or an SOU from a kitchen, bathroom, sanitary compartment (not being an associated ensuite), laundry, plant room or utilities room. The list of adjoining rooms and spaces in these clauses, does not include the words ‘or the like’ because it is intended to be specific to only those areas.

F7D6(4) applies to a wall that separates an SOU from a kitchen or laundry. The walls of SOUs prescribed in F7D6(3) and F7D6(4) must be at least R_w 45.

F7D6(4) has additional requirements for a wall separating an SOU in a Class 9c building from a kitchen or laundry. It requires the wall to comply with F7D4(2).

The list of spaces in F7D6(3) does not include stairways, public corridors, hallways, etc. The reason is that aged care buildings should be provided with a level of sound insulation around the resident bedroom/sleeping areas to ensure a level of privacy, but still allow the residents to be reassured they are not alone. If the R_w of the wall is too high, it may create a feeling of isolation for the residents, and this can be detrimental to their well-being. Being able to hear sounds that are outside their bedroom provides reassurance that assistance is available.

Reminder

For DTS Provisions F7D1 to F7D8, R_w is a measure of airborne sound insulation. C_{tr} is a spectrum adjustment factor which adjusts for low frequency sound levels. C_{tr} has been chosen in recognition of the problems caused by the high bass frequency outputs of modern home theatre systems and music reproduction equipment used by occupants of Class 2 and 3 buildings.

The R_w and C_{tr} must be determined in accordance with AS/NZS ISO 717.1 Acoustics - Rating of sound insulation in buildings and of building elements - Airborne sound insulation. These documents outline how to use test results from testing a building element to determine the R_w and C_{tr} of the building element. The test results must be obtained by testing the building element in accordance with ISO 140-3. ISO 140-3 is the method for testing the airborne sound insulation of building elements in the laboratory.

$L_{n,w}$ is a measure of the impact sound insulation. The type of impact generated noise passing through floors that the requirements are aimed at minimising are noise associated with footsteps and moving furniture.

Note that ISO 140-3 Acoustics - Measurement of sound insulation in buildings and of building elements - Laboratory measurements of airborne sound insulation of building elements, is not an NCC referenced Standard.

Note the requirements for walls and floors differ between Class 2 and 3 buildings, and Class 9c buildings. This is due to SOUs in Class 2 and 3 buildings being ‘noisier’ than SOUs in Class 9c buildings. The reasons include the presence of televisions, stereos and DVDs and activities that may be conducted in Class 2 and 3 buildings. Therefore, C_{tr} only applies to Class 2 and 3 buildings. Also, the level of airborne sound insulation required in Class 9c buildings is less.

2.4.5 Other Performance Solutions

As outlined in section 2.3 of this document, there are 3 options available to demonstrate compliance with the Performance Requirements:

- a Performance Solution
- a DTS Solution, or
- a combination of a Performance Solution and a DTS Solution.

An overview of how to comply with the NCC is in Appendix C of this document, with further guidance available from the ABCB website.

A Performance Solution can be used in an individual situation where the desired solution meets the Performance Requirements of the NCC, but not the relevant DTS Provisions. These solutions are often flexible in achieving the outcomes required and encourage innovative design and technology use.

This section outlines some potential options for Performance Solutions that do not use an NCC Verification Method as the Assessment Method.

2.4.5.1 Assessment Methods

Assessment Methods are used when determining if a Performance Solution complies with the relevant Performance Requirements.

The following Assessment Methods are listed in the NCC (see A2G2 and A2G3) and each, or any combination, can be used to demonstrate compliance for a Performance Solution where appropriate:

- Evidence of Suitability
- Expert Judgement
- Comparison with the DTS Provisions
- Verification Methods.

2.4.5.2 Performance Solution process

To help ensure a Performance Solution provides the level of intended performance, clause A2G2(4) of the NCC mandates a process for developing Performance Solutions. This process must be followed regardless of whether the Performance Solution is simple or complex in nature.

In simple terms, the 4 steps of the Performance Solution process include:

(1) preparing a brief

(2) carrying out analysis

(3) evaluating results

(4) preparing a final report.

More information on this process is in the Performance Solution Process Guidance Document and the ABCB Performance Solution Process Handbook, which are available from the ABCB website.

2.5 Volume Two

To meet the objective outlined, the NCC has detailed sound insulation provisions in Part H4 of Volume Two (Health and Amenity) and references Part 10.7 Sound insulation of the ABCB Housing Provisions.

The types of buildings these requirements relate to is Class 1 buildings, but they only apply to single dwellings with common walls separating dwellings or attached dwellings like a town house, row house or the like.

Refer to the NCC for exact definitions of the different building classifications.

2.5.1 Performance Requirement

The NCC Performance Requirements prescribe the minimum necessary technical requirements for building elements and plumbing and drainage systems. They must be met to demonstrate compliance with the NCC.

H4P6 is the Performance Requirement for sound transmission in NCC Volume Two. H4P6 applies to Class 1 buildings and relates to walls separating dwellings. It covers both airborne and impact generated sound.

For H4P6, impact generated sound is only a consideration for walls separating a bathroom, sanitary compartment, laundry or kitchen in a dwelling from a habitable room (other than a kitchen) in an adjoining dwelling. The Performance Requirement H4P6 is reproduced below.

H4P6 Sound Insulation

(1) Walls separating dwellings must, to provide insulation against the transmission of airborne sound, have a weighted standardised level difference with spectrum adaptation term ($D_{nT,w}+C_{tr}$) not less than 45.

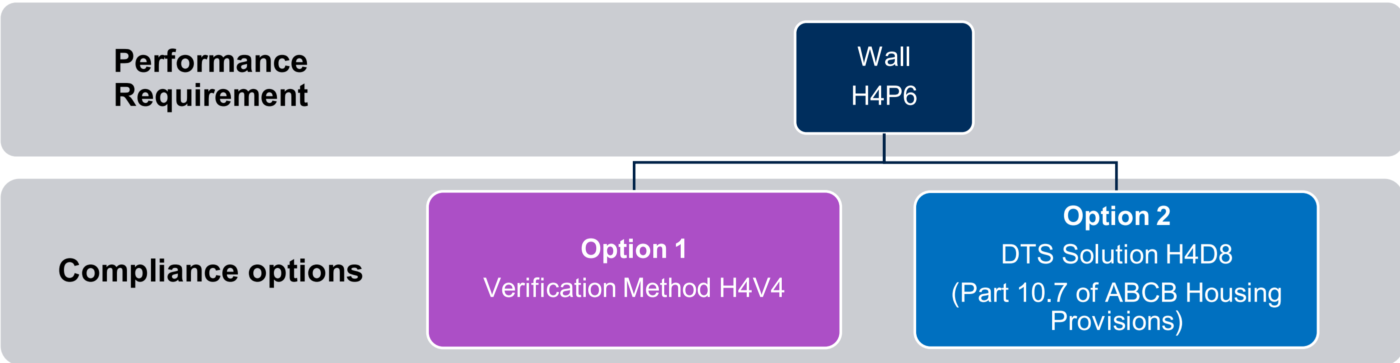
(2) Walls separating a bathroom, *sanitary compartment*, laundry or kitchen in a dwelling from a *habitable room* (other than a kitchen) in an adjoining dwelling, must provide insulation against impact generated sound sufficient to prevent illness or loss of amenity to the occupants.

(3) The *required* sound insulation of walls must not be compromised by the incorporation or penetration of a pipe or other service element.

2.5.2 Compliance options

Sound insulation compliance options for Class 1 buildings are shown in Figure 2.6.

Figure 2.6 Sound insulation compliance options for Class 1 buildings



Note to Figure 2.6: Blue shading indicates a DTS Solution, purple shading indicates a Performance Solution.

2.5.3 Verification Method

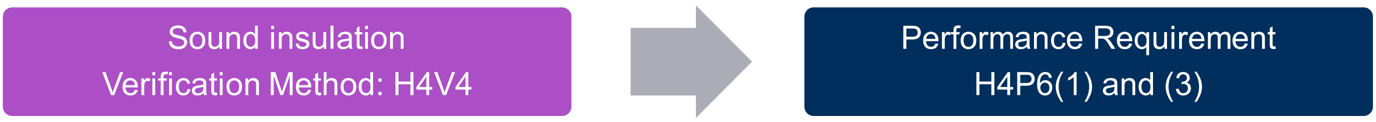
Verification Method H4V4 provides designers with a Performance Solution pathway to demonstrate compliance.

The basic premise of the Verification Method H4V4 is to measure in-situ (i.e. on-site) the transmission of airborne and impact generated sound through floors and walls against the quantified values specified in the applicable Verification Method. If the values measured are greater than or equal to the quantified values in the applicable Verification Method then the solution complies.

The advice of an appropriately qualified person should be sought to undertake the assessment and analysis where required. Appendix D of this document provides further background information on testing and reporting methods.

Figure 2.7 below matches the Verification Method to the relevant Performance Requirement.

Figure 2.7 Sound Insulation Verification Method for attached dwellings



2.5.3.1 Attached dwellings (Class 1 buildings)

There is only one NCC Verification Methods for sound insulation that can be used to meet the relevant Performance Requirement for attached dwellings (Class 1 buildings).

H4V4 is the Verification Method to comply with H4P6(1) and (3). If H4V4 is used to verify compliance, when tested on site the wall must have a weighted standardised level difference with spectrum adoption term $D_{nT,w}$+ C_{tr} not less than 45 when determined under AS/NZS ISO 717.1.

Reminder

For Performance Requirement H4P6 and Verification Method H4V4, $D_{nT,w}$ is a measure of airborne sound insulation, similar to R_W. C_{tr} is a spectrum adjustment factor which adjusts for low frequency sound levels. C_{tr} has been chosen in recognition of the problems caused by the high bass frequency outputs of modern home theatre systems and music reproduction equipment used by occupants of Class 1.

$D_{nT,w}$ and C_{tr} must be determined in accordance with AS/NZS ISO 717.1 Acoustics - Rating of sound insulation in buildings and of building elements - Airborne sound insulation. AS/NZS ISO 717.1 outlines how to use test results to determine the $D_{nT,w}$ and C_{tr} of a building element. The test results must be obtained by testing the building element accordance with ISO 140-4. ISO 140-4 is the method of testing the airborne sound insulation of building elements in the field.

Note that ISO 140-4 Acoustics - Measurement of sound insulation in buildings and of building elements - Field measurements of airborne sound insulation between rooms, is not an NCC referenced Standard.

There is no Verification Method for determining compliance with H4P6(2). H4P6(2) outlines the impact generated sound insulation requirements for walls. Therefore, in this instance the options for compliance are a DTS Solution or another means of verifying that H4P6(2) will be achieved. See section 2.5.5.

The Verification Method H4V4 is reproduced below.

H4V4 Sound insulation

Compliance with H4P6(1) and (3) to insulate against transmission of airborne sound through walls separating dwellings is verified when it is measured in-situ that the wall has a weighted standardised level difference with spectrum adaptation term ($D_{nT,w}$ + C_{tr}) not less than 45 when determined under AS/NZS ISO 717.1.

2.5.4 DTS Provisions

2.5.4.1 Attached dwellings (Class 1 buildings)

The DTS Provisions provide a prescriptive approach that can be used to comply with Performance Requirements. In NCC Volume Two, DTS Provision H4D8 can be used as a DTS Solution to meet the Performance Requirement H4P6. H4D8 outlines that compliance with Part 10.7 of the ABCB Housing Provisions satisfies Performance Requirement H4P6 for sound insulation. Table 2.4 shows the DTS Provisions of Part 10.7 for compliance with H4P6.

Table 2.4 Part 10.7 of the Housing Provisions

Part 10.7	Housing Provisions reference
Sound insulation requirements	10.7.1
Determination of airborne sound insulation ratings	10.7.2
Construction of sound insulated walls	10.7.3
Services	10.7.4
Acceptable forms of construction for masonry walls	10.7.5
Acceptable forms of construction for concrete walls	10.7.6
Acceptable forms of construction for autoclaved aerated concrete walls	10.7.7
Acceptable forms of construction for timber and steel framed walls	10.7.8

10.7.1 Sound insulation requirements

Compliance with 10.7.1 is verified when the requirements of 10.7.1(1) and 10.7.1(2) are met.

In 10.7.1(1) a wall between Class 1 buildings or a wall that separates a Class 1 building from a Class 10a building which is not associated with the Class 1 building require airborne (R_w+C_{tr}) not less than 50.

Reminder

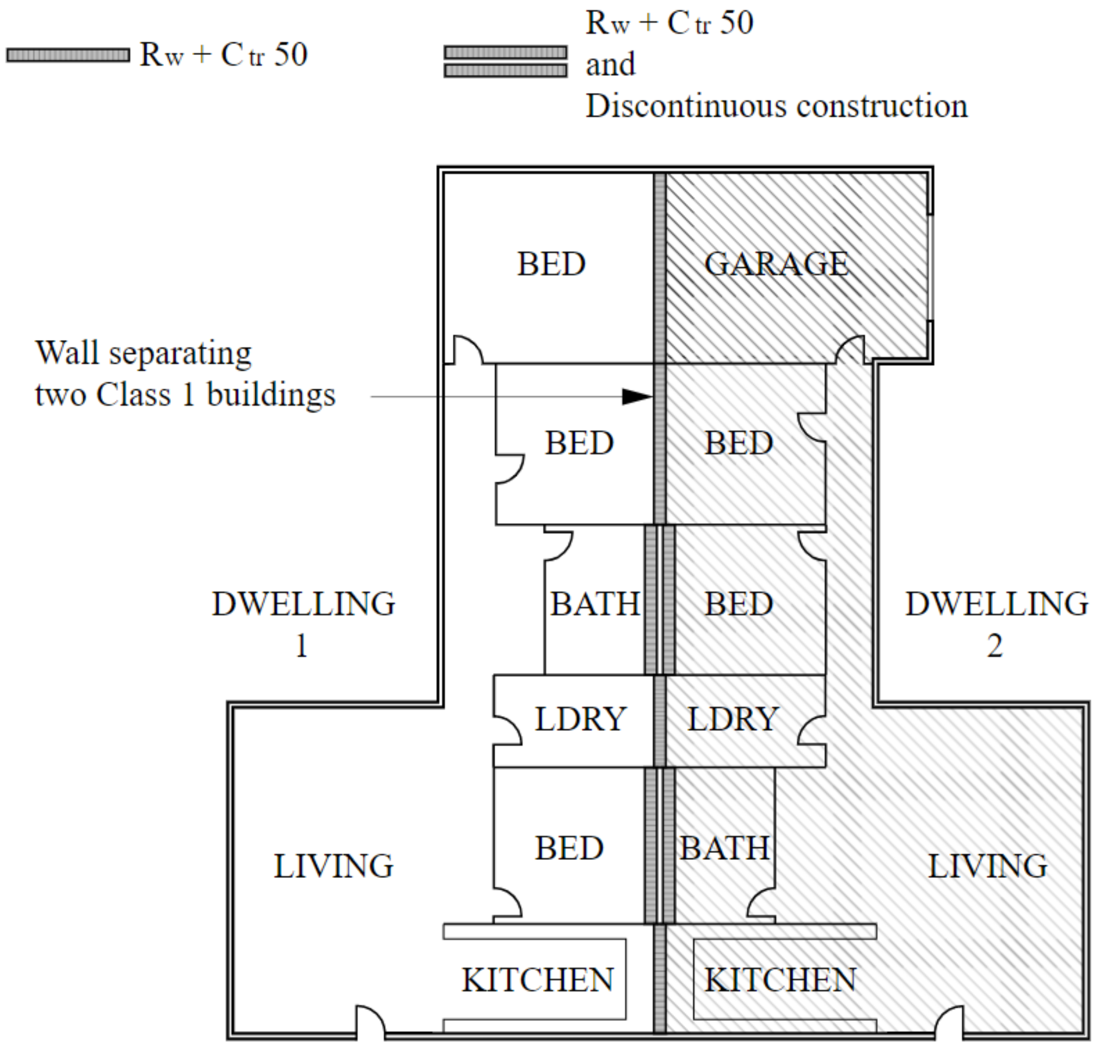
R_w is a measure of airborne sound insulation. C_{tr} is a spectrum adjustment factor which adjusts for low frequency sound levels. C_{tr} has been chosen in recognition of the problems caused by the high bass frequency outputs of modern home theatre systems and music reproduction equipment used by occupants of Class 1 buildings.

The R_w and C_{tr} must be determined in accordance with AS/NZS ISO 717.1. This standard outlines how to use test results from testing a building element to determine the R_w and C_{tr} of the building element. The test results must be obtained by testing the building element in accordance with ISO 140-3. ISO 140-3 is the method for testing the airborne sound insulation of building elements in the laboratory.

Note that ISO 140-3 Acoustics - Measurement of sound insulation in buildings and of building elements - Laboratory measurements of airborne sound insulation of building elements, is not an NCC referenced Standard.

10.7.1 (1) also requires the wall to be of discontinuous construction if it separates a bathroom, sanitary compartment, laundry or kitchen in one Class 1 building from a habitable room (other than a kitchen) in an adjoining Class 1 building. See Figure 2.8.

Figure 2.8 Required airborne and impact sound insulation - Plan view (Figure 10.7.1 of the Housing Provisions)



Discontinuous construction

Means:

- (a) a wall having a minimum 20 mm cavity between 2 separate leaves, and
  - (i) for masonry, where wall ties are used to connect leaves, the ties are of the resilient type, and
  - (ii) for other than masonry, there is no mechanical linkage between the leaves, except at the periphery, and
- (b) a staggered stud wall is not deemed to be discontinuous construction.

Note discontinuous construction is a defined term in the Housing Provisions.

10.7.1(2) requires sound insulated walls to extend to underside of the roof above or to the ceiling that provides the sound insulation required for the wall. This is to ensure that there is no space above the wall which could provide a flanking path for sound to travel through. See Figure 3.3 of this document.

Alert

In Part 10.7, insulation to reduce both airborne and impact noise transmission is required for parts of a wall that are common to adjoining Class 1 buildings. It is not required for parts of a wall located in the subfloor.

10.7.2 Determination of airborne sound insulation ratings

This clause has two options to determine $R_w + C_{tr}$ to meet the requirements of 10.7.1(1)(a) as follows:

- be determined in accordance with AS/NZS ISO 717.1, using results from laboratory measurements, or
- comply with 10.7.5 to 10.7.8 and the relevant provisions of 10.7.3.

These 2 options are discussed in the following sections.

10.7.3 Construction of sound insulated walls

10.7.3 outlines the construction requirements of sound insulated walls to achieve the appropriate level of sound insulation. They are summarised in Table 2.5.

Table 2.5 Key requirements for the construction of sound insulated walls

Clause 10.7.3 reference	Key requirements
(a) Stud wall junction	• Junctions of sound insulated walls with any perimeter walls and roof cladding must be sealed in accordance with Figure 10.7.3a.
(b) Masonry	• Units must be laid with all joints filled solid. • This does not apply to articulation joints that meet clause 5.6.8, including those between the masonry and any adjoining construction.
(c) Concrete panels	• Must have joints between panels and any adjoining construction filled solid.

(d) Plasterboard sheeting	• If two layers are required, the second layer joints must not coincide with those of the first layer (see Figure 10.7.3b). • Joints between sheets including the outer layer or between sheets and any adjoining construction must be taped and filled solid.
(e) Steel framed and perimeter members construction	• Steel framing members must be at least 0.6 mm thick. • Studs must be at least 63 mm in depth unless another depth is specified in 10.7.5 to 10.7.8. • All steel members at the perimeter of the wall must be securely fixed to the adjoining structure. The joints must be caulked so there are no voids between the steel members and the wall.
(f) Timber- framed and perimeter members construction	• Noggings and like members must not bridge between studs supporting different wall leaves. • All timber members at the perimeter of the wall must be securely fixed to the adjoining structure. The joints must be caulked so there are no voids between the timber members and the wall.

Note to Table 2.5: All the figures mentioned in the table are available in the ABCB Housing Provisions, which is available from the ABCB website.

10.7.4 Services

10.7.4 contains the sound insulation requirements for services located in separating walls as specified in Table 2.6.

Table 2.6 Key requirements for services

Clause 10.7.4 reference	Key Requirements
(1)	• Services must not be chased into concrete or masonry separating walls.
(2)	• Where a duct, soil, waste supply or stormwater pipe is located within a separating wall, any door or access panel to the duct or pipe must: – not open into any habitable room, except for kitchens – be securely fixed, overlapping the frame or rebate of the frame by at least 10 mm. – be constructed of wood, plasterboard or blockboard not less than 33 mm thick, or compressed fibre reinforced cement sheeting not less than 9 mm thick, or other suitable material with a mass per unit area not less than 24.4 kg/m^2. • A water supply pipe: – must only be installed in discontinuous construction – if it serves a single dwelling, it should not be fixed to the wall leaf on the side of any other dwelling and have a clearance not less than 10 mm to the other wall leaf.
(3)	• Electrical outlets must be offset from each other. In masonry walling, the gap should not be less than 100 mm; and in timber or steel-framed walling, the gap should not be less than 300 mm.

Note to Table 2.6: A separating wall is a defined term in the Housing Provisions and is a wall that is common to adjoining Class 1 buildings.

10.7.5 Acceptable forms of construction for masonry walls

10.7.5 outlines the acceptable forms of construction for masonry walls. The key requirements are summarised in Table 2.7.

Table 2.7 Key requirements for acceptable forms of construction for masonry walls

Clause 10.7.5 reference	Key Requirements
(1)	• Acceptable forms of construction for masonry walls are set out in (2) to (6).
(2)	• Two leaves of 110 mm clay brick masonry constructed in accordance with Figure 10.7.5a has R_w+C_{tr} of not less than 50 with: – a cavity not less than 50 mm between leaves, and – 50 mm thick glass wool insulation with a density of 11 kg/m^3 or 50 mm thick polyester insulation with a density of 20 kg/m^3 in the cavity.
(3)	• Two leaves of 110 mm clay brick masonry constructed in accordance with Figure 10.7.5b has R_w+C_{tr} of not less than 50 with: – a cavity not less than 50 mm between leave, and – 13 mm cement render on each outside face.
(4)	• A single leaf of 110 mm clay brick masonry constructed in accordance with Figure 10.7.5c has R_w+C_{tr} of not less than 50 with: – a row of 70 mm x 35 mm timber studs or 64 mm steel studs at 600 mm centres, spaced 20 mm from the masonry wall, and – 50 mm thick mineral insulation or glass wool insulation with a density of 11 kg/m^3 positioned between studs, and – one layer of 13 mm plasterboard fixed to outside face of studs and outside face of masonry.
(5)	• A single leaf of 90 mm clay brick masonry constructed in accordance with Figure 10.7.5d has R_w+C_{tr} of not less than 50 with: – a row of 70 mm x 35 mm timber studs or 64 mm steels studs at 600 mm centres, spaced 20 mm from each face of the masonry wall, and – 50 mm thick mineral insulation or glass wool insulation with a density of 11 kg/m^3 positioned between studs in each row, and – one layer of 13 mm plasterboard fixed to studs on each outside face.

(6)	• A single leaf of 220 mm brick masonry with 13 mm cement render on each face has an R_w+C_{tr} of not less than 50, if constructed in accordance with Figure 10.7.5e.

Note to Table 2.7: All the figures mentioned in the table are available in the ABCB Housing Provisions, which is available from the ABCB website.

10.7.6 Acceptable forms of construction for concrete walls

10.7.6 outlines the acceptable form of construction for concrete walls. The key requirements are summarised in Table 2.8.

Table 2.8 Key requirements for acceptable forms of construction for concrete walls

Clause 10.7.6 reference	Key Requirements
(1)	• Acceptable forms of construction for concrete walls are set out in (2) to (5).
(2)	• 150 mm thick plain off form concrete, has an R_w+C_{tr} of not less than 50, if constructed in accordance with Figure 10.7.6a.
(3)	• 200 mm thick concrete panel with one layer of 13 mm plasterboard or 13 mm cement render on each face, has an R_w+C_{tr} of not less than 50, if constructed in accordance with Figure 10.7.6b.
(4)	• A 100 mm thick concrete panel constructed in accordance with Figure 10.7.6c has R_w+C_{tr} of not less than 50 with: – a row of 64 mm steel studs at 600 mm centres, spaced 25 mm from the concrete panel, and – 80 mm thick polyester insulation or 50 mm thick glass wool insulation with a density of 11 kg/m^3, positioned between studs, and – two layers of 13 mm plasterboard fixed to the outside face of studs and one layer of 13 mm plasterboard fixed to the outside face of the concrete panel.
(5)	• A 125 mm thick concrete panel constructed in accordance with Figure 10.7.6d has R_w+C_{tr} of not less than 50 with: – a row of 64 mm steel studs at 600 mm centres, spaced 20 mm from the concrete panel, and

	– 70 mm polyester insulation with a density of 9 kg/m^3, positioned between studs, and – one layer of 13 mm plasterboard fixed to the outside face of the studs.

Note to Table 2.8: All the figures mentioned in the table are available in the ABCB Housing Provisions, which is available from the ABCB website.

10.7.7 Acceptable forms of construction for autoclaved aerated concrete walls

10.7.7 outlines the acceptable form of construction for autoclaved aerated concrete walls. The key requirements are summarised in Table 2.9.

Table 2.9 Key requirements for acceptable forms of construction for autoclaved aerated concrete walls

Clause 10.7.7 reference	Key Requirements
(1)	• Acceptable forms of construction for autoclaved aerated concrete walls are set out in (2) to (4).
(2)	• A 75 mm thick autoclaved aerated concrete wall panel constructed in accordance with Figure 10.7.7.a, has R_w+C_{tr} of not less than 50 with: – a row of 64 mm steel studs at 600 mm centres, spaced 20 mm from the autoclaved aerated concrete wall panel, and – 75 mm thick glass wool insulation with a density of 11 kg/m^3 positioned between studs, and – one layer of 10 mm moisture resistant plasterboard or 13 mm fire protective grade plasterboard fixed to outside face of studs and outside face of autoclaved aerated concrete wall panel
(3)	• A 75 mm thick autoclaved aerated concrete wall panel constructed in accordance with Figure 10.7.7.b, has R_w+C_{tr} of not less than 50 with: – a row of 64 mm steel studs at 600 mm centres, spaced 35 mm from the autoclaved aerated concrete panel wall, and – 28 mm metal furring channels fixed to the outside face of the autoclaved aerated concrete wall panel, with 50 mm thick polyester insulation with a density of 9 kg/m^3 positioned between furring channels and one layer of 13 mm fire protective grade plasterboard fixed to furring channels, and

	– 105 mm thick glass wool insulation with a density of 7 kg/m^3 positioned between studs, and – one layer of 13 mm fire protective grade plasterboard fixed to the outside face of the studs.
(4)	• Two leaves of 75 mm autoclaved aerated concrete wall panel constructed in accordance with Figure 10.7.7.c, has R_w+C_{tr} of not less than 50 with: – a cavity not less than 30 mm between panels containing 50 mm glass wool insulation with a density of 11 kg/m^3, and – one layer of 10 mm plasterboard fixed to outside face of each panel.

Note to Table 2.9: All the figures mentioned in the table are available in the ABCB Housing Provisions, which is available from the ABCB website.

10.7.8 Acceptable forms of construction for timber and steel framed walls

10.7.8 outlines the acceptable forms of construction for timber and steel framed walls. The key requirements are summarised in Table 2.10.

Table 2.10 Key requirements for acceptable forms of construction for timber and steel framed walls

Clause 10.7.8 reference	Key Requirements
(1)	• Acceptable forms of construction for timber and steel framed walls are set out in (2) and (3).
(2)	• Two rows of 90 mm x 35 mm timber studs or two rows of 64 mm steels studs at 600 mm centres constructed in accordance with Figure 10.7.8.a, has R_w+C_{tr} of not less than 50 with: – an air gap not less than 20 mm between the rows of studs, and – 50 mm thick glass wool insulation or 60 mm thick polyester insulation with a density of 11 kg/m^3, positioned between one row of studs, and – two layers of 13 mm fire protective grade plasterboard or one layer of 6 mm fibre cement sheet and one layer of 13 mm fire protective grade plasterboard, fixed to outside face of studs.

(3)	• Two rows of 64 mm steel studs at 600 mm centres constructed in accordance with Figure 10.7.8.b, has R_w+C_{tr} of not less than 50 with: – an air gap not less than 80 mm between the rows of studs, and – 200 mm thick polyester insulation with a density of 14 kg/m^3 positioned between studs, and – one layer of 13 mm fire-protective grade plasterboard and one layer 13 mm plasterboard on one outside face and one layer of 13 mm fire-protective grade plasterboard on the other outside face.

Note to Table 2.10: All the figures mentioned in the table are available in the ABCB Housing Provisions, which is available from the ABCB website.

2.5.5 Other Performance Solutions

As outlined in section 2.3 of this document, there are 3 options available to demonstrate compliance with the Performance Requirements:

- a Performance Solution
- a DTS Solution, or
- a combination of a Performance Solution and a DTS Solution.

An overview of how to comply with the NCC is in Appendix C of this document, with further guidance available from the ABCB website.

A Performance Solution can be used in an individual situation where the desired solution meets the Performance Requirements of the NCC, but not the relevant DTS Provisions. These solutions are often flexible in achieving the outcomes required and encourage innovative design and technology use.

This section outlines some potential options for Performance Solutions that do not use an NCC Verification Method as the Assessment Method.

2.5.5.1 Assessment Methods

Assessment Methods are used when determining if a Performance Solution complies with the relevant Performance Requirements.

The following Assessment Methods are listed in the NCC (see A2G2 and A2G3) and each, or any combination, can be used to demonstrate compliance for a Performance Solution where appropriate.

- Evidence of Suitability.

- Expert Judgement.
- Comparison with the DTS Provisions.
- Verification Methods.

2.5.5.2 Performance Solution process

To help ensure a Performance Solution provides the level of intended performance, clause A2G2(4) of the NCC mandates a process for developing Performance Solutions. This process must be followed regardless of whether the Performance Solution is simple or complex in nature.

In simple terms, the 4 steps of the Performance Solution process include:

(1) preparing a brief

(2) carrying out analysis

(3) evaluating results

(4) preparing a final report.

More information on this process is in the Performance Solution Process Guidance Document and the ABCB Performance Solution Process Handbook, which are available from the ABCB website.

3 Design practice

Effective sound insulation requires careful consideration of building design, materials, and construction techniques. The best time to manage and minimise the amount of sound entering a dwelling or unit from adjoining dwellings or units is in the design and construction phase of the dwelling(s). This includes the following.

- Determining the strategy and planning the approach that will be used to comply with the NCC Performance Requirement(s) before initiating the design.
- Using wall, floor, ceiling, bulkhead and riser systems which have been tested and documented.
- Consulting with relevant authorities and/or professionals as needed.

The followings are some key considerations for building design, material selection, and implementing sound insulation techniques that can effectively manage sound intrusion in buildings.

3.1 Building layout and planning

When designing the layout of dwellings or units, the followings key considerations can help to minimise the sound transmission entering a dwelling or unit from adjoining dwellings or units.

- Plan quiet areas in a unit adjacent to quiet areas in adjoining units.
- Plan quiet areas in a unit away from services.
- Plan buffer areas between units where possible.
- Locate services away from sensitive areas in a unit.
- Consult the body corporate if intending to modify or renovate existing units.

To minimise the amount of noise entering a dwelling or unit from adjoining dwellings or units and minimise the cost of construction, it is recommended to locate noise-sensitive rooms away from noisy areas where possible, both within each unit and between adjoining units.

Noisy areas such as living rooms, kitchens, laundries, and bathrooms should be grouped together, possibly sharing common walls. Quiet areas such as study and bedrooms should be grouped away from noisy areas (refer to Figure 3.1 and Figure 3.2).

Locating wet areas above one another can result in significant cost savings in relation to sound insulation requirements, particularly where pipes penetrate the separating slab.

Buffer spaces can be set up on each side of common walls, for example garages, wardrobes, store rooms and closets.

Noisy areas external to a unit such as plantrooms, lift shafts, garbage chutes, spa baths, pools, gymnasiums, entertainment rooms and other communal areas or public areas should be located as far away as possible from noise-sensitive areas of a unit.

Figure 3.1 Example of layout planning - Good acoustic practice

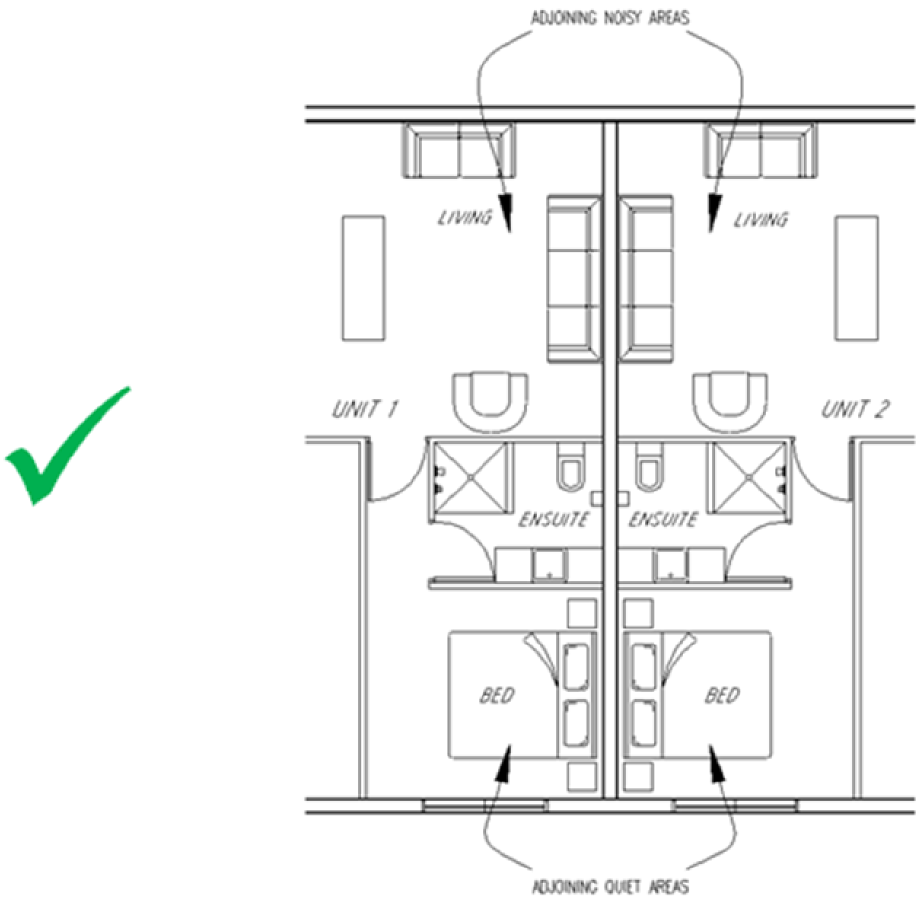
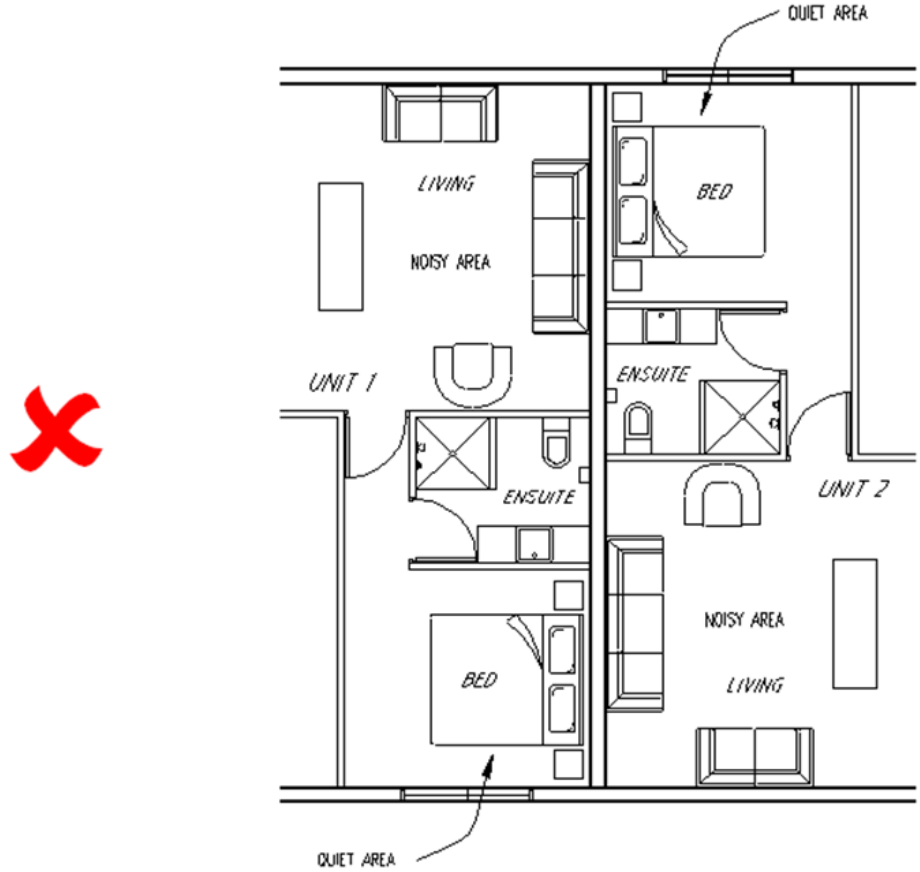


Figure 3.2 Example of layout planning - Bad acoustic practice



3.2 Envelope of dwellings and units

Sound insulation of the envelope of a dwelling or unit is an important consideration when designing a building. This is more important in dwellings or units with adjoining dwellings or units because the residents have less control over the undue sound transmission from adjoining dwellings or units.

For a dwelling or unit envelope design, it is recommended to use systems which have been laboratory tested and have demonstrated compliance with the NCC.

Where a building material supplier is proposing specific building elements for the project, it is preferable to receive a valid test certificate on the system as well as a clear statement on the requirements and techniques for working with the particular system.

The following are some key considerations for a dwelling or unit envelope design.

- Allow sufficient width for party walls and sufficient depth for floor and ceilings in initial planning.
- Provide clear construction drawings detailing junctions of walls, ceilings, and floors.

- Indicate where impact-rated wall systems are required.
- Choose wall systems which are simple to build and reliable.
- Ensure that discontinuities in walls and floors/ceilings can be maintained.
- Use acoustic grade insulation in sound-rated walls and ceiling cavities.
- Design acoustic seals for joints to remain effective over the life of the building.
- It is not recommended to:
  - substitute materials in building elements without proper testing and documentation
  - fix together discontinuous elements of an sound-rated wall or ceiling.

3.2.1 Party walls

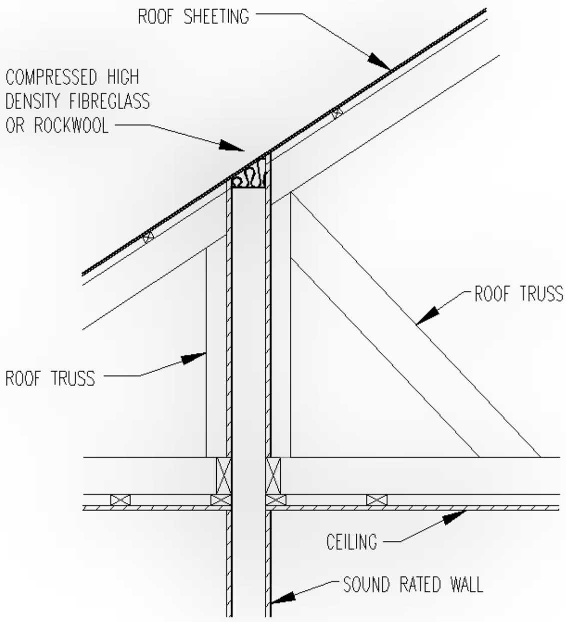
Wall design is principally concerned with ensuring high acoustic performance for minimal thickness, minimal weight and minimal cost. It is not easy to simultaneously meet all these conditions and therefore close attention to design is required.

The acoustic performance of wall systems is generally improved by substituting either thicker/heavier wall systems or substituting systems with larger cavities and moderate cladding thicknesses.

To save weight, some heavy single-leaf wall systems could be replaced by lightweight constructions using thinner leaves of material and insulation filled cavities.

To control sound transfer, it is good design practice to extend sound-rated walls to full height, from slab to soffit, or slab to roof (refer to Figure 3.3). Wall partitions should be selected which allow for a margin of safety in the construction to reduce the risk of non-compliance.

Figure 3.3 Sound-rated wall penetration to roof



There are additional factors which should also be considered in relation to sound-rated walls. These include the following.

- Reliability in the field – is it possible to easily reproduce the laboratory acoustic performance for a sound-rated wall?
- Walls which are impact-rated or discontinuous require more attention to detail.
- If the acoustic performance of the wall fails, is there sufficient space to allow rectification and a further upgrade undertaken to the wall?
- For wall designs which rely on sound-rated ceilings, has detail been developed to control sound intrusion through ceiling penetrations such as downlights, mechanical ventilation grilles, fire service penetrations and ceiling speakers? (Refer to section 3.2.2 and 3.3 of this document)
- Buildability – is it possible to easily build the walls to the same standard as in the laboratory and therefore maintain the acoustic rating? Simple systems will tend to be more reliable than complex systems.
- Has the wall been designed to comply with other NCC requirements such as for fire or structural safety?
- It is not recommended to:
    - use short circuit bracing between separate stud systems

- design wall-mounted furniture to be fixed across walls requiring to be discontinuous.

Reminder

Party walls can be a wall separating an SOU from another SOU, a plant room, lift shaft, stairway, public corridor, public lobby or the like or part of a different classification.

The NCC sound insulation requirements do not cover building elements which separate SOUs from the outside of the building and/or the internal walls within a dwelling or unit.

3.2.2 Floors and ceilings

Some designs require both floors and ceilings to be sound-rated to meet the NCC provisions. When designing floors and ceilings, the following factors should be considered.

- Some floor designs require carpet and underlay to meet the NCC provisions. When substituting material, a carpet should not be replaced with acoustically non-compliant hard floor coverings. It is recommended to develop alternative floor designs which are impact-rated and not reliant on carpet and underlay alone.
- A break in the floorboards should be designed under the party walls of a unit. The break at the boundary in the floorboards and/or joists should be sufficient to isolate horizontally adjacent units and control structure-borne noise intrusion from footsteps. (Refer to Figure 3.4 and Figure 3.5).
- For sound-rated ceilings, the details should be developed to control noise intrusion through ceiling penetrations such as downlights, mechanical ventilation grilles, fire service penetrations and ceiling speakers. (Refer to section 3.3 of this document).

Figure 3.4 Floor lateral vibration isolation - Good design practice

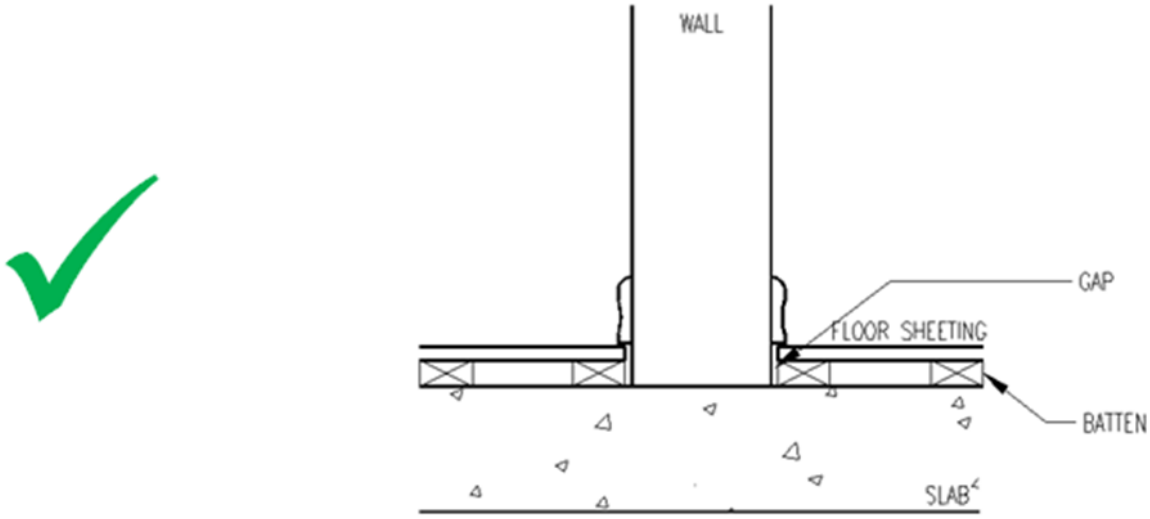
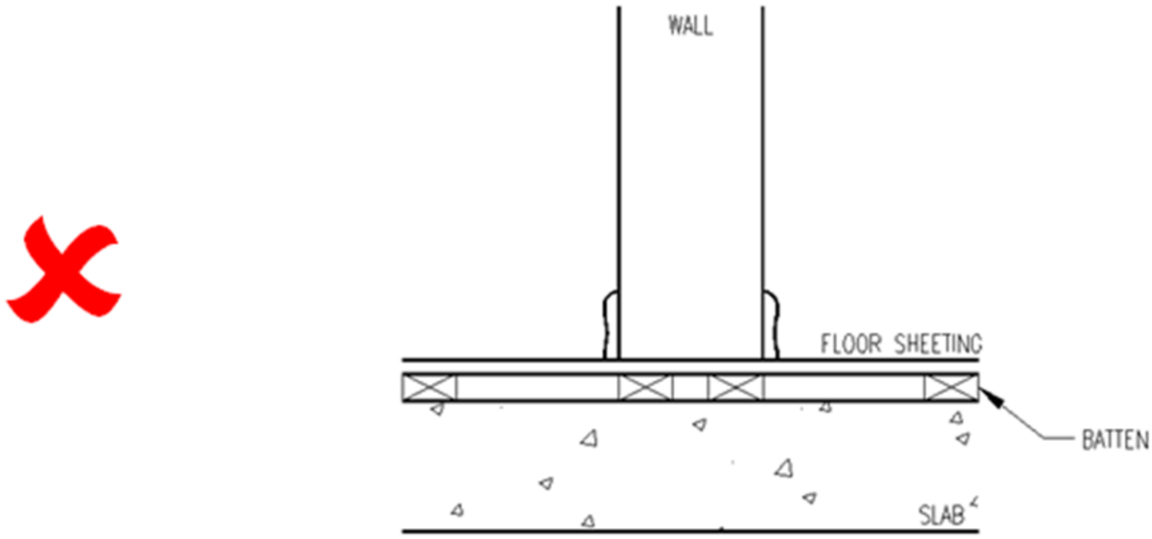


Figure 3.5 Floor lateral vibration isolation - Bad design practice



3.2.3 External doors

Doors are an acoustic weak link and invariably reduce the acoustic performance of walls. To counter this weakness, the NCC requires doors from corridors to units to be sound-rated. Doors may be either thick solid-core doors or proprietary systems. Most sound-rated doors require full acoustic seals around the head, jamb and foot to limit flanking. The installation of a door closer can effectively reduce noise caused by slamming. In addition, the following points should be considered.

- Maximise the buffer distance between entrance doors of adjoining units to limit sound flanking via the doors (refer to Figure 3.7 and Figure 3.8).
- It is not recommended to undercut sound-rated doors.
- For return air flow, it is preferable to use transfer ducts with fire dampers rather than undercut sound-rated doors.
- Air grilles should not be installed in sound-rated doors (refer to Figure 3.6).
- Use full perimeter acoustic seals on external doors. Acoustic seals do not provide suitable performance if they are not properly adjusted. Allow for the adjustments and maintenance of acoustic seals on doors. Seals should be selected based on their performance, simplicity of use, and they should be low maintenance and durable.
- Doors may be installed in sound-rated walls, for example between hotel or resort guestrooms. The acoustic performance of the wall can be degraded where doors are installed. Careful design is required to maintain the sound-rating of the wall/door combination.
- The performance of an acoustic seal can be limited if it seals onto carpet or onto non-smooth materials such as tiles or pavers.
- Consideration should also be given to Performance Requirements that cover other types of seals, such as fire resistance, smoke resistance, chemical resistance, weather resistance, dust resistance and vermin proofing.

Figure 3.6 Treatment around sound-rated doors in sound-rated walls

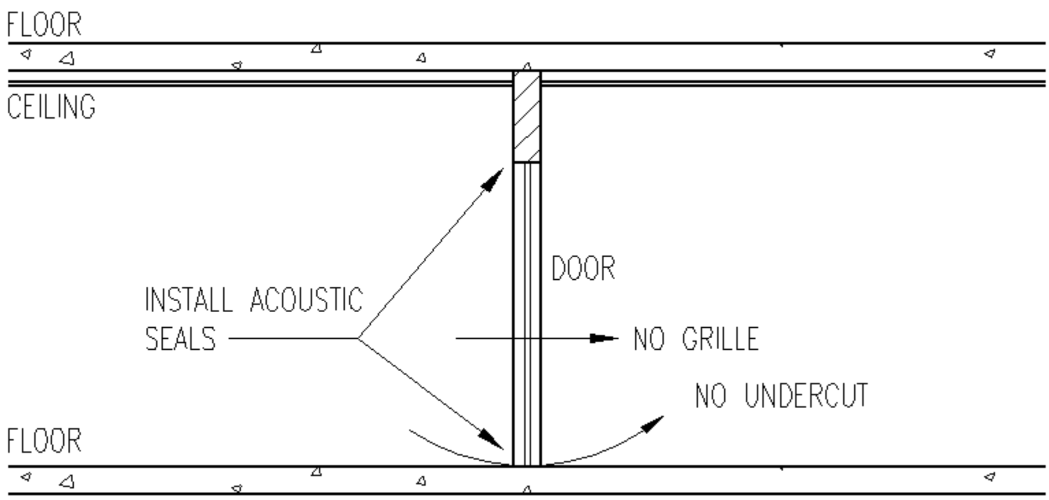


Figure 3.7 Example of layout planning and placement of windows and external doors - Good acoustic practice

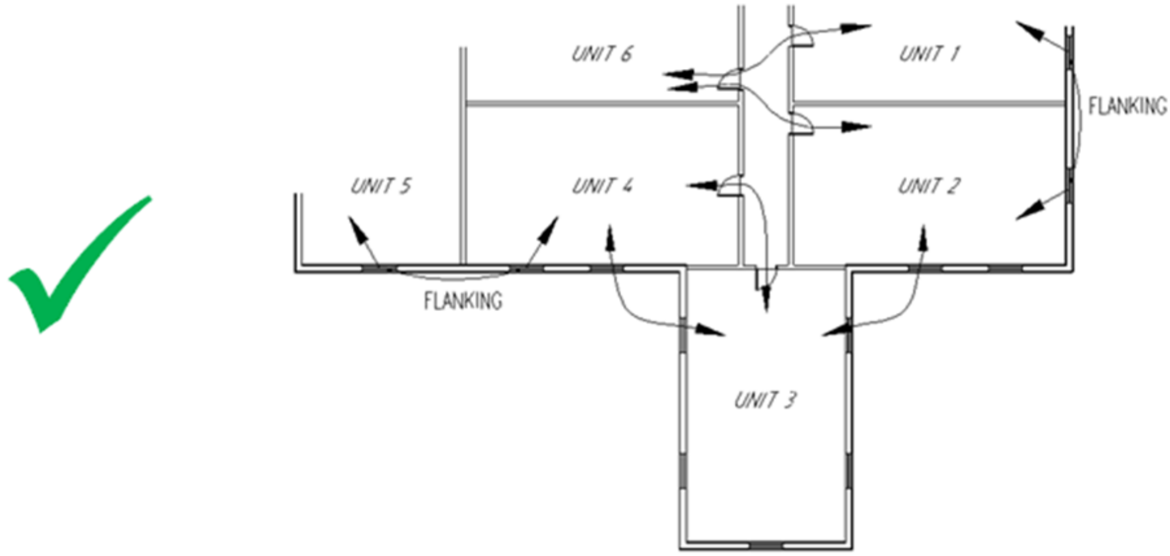
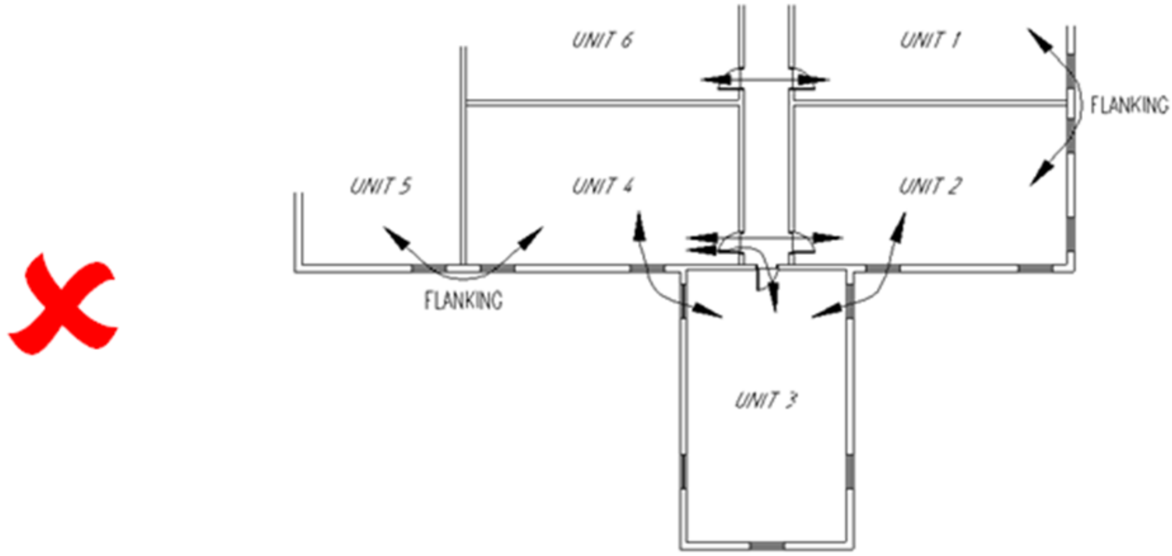


Figure 3.8 shows a bad example of layout planning. It shows that the maximum distance between windows and doors are not maintained. It increases the risk of flanking via external glazing and entrance doors.

Figure 3.8 Example of layout planning- and placement of windows and external doors - Bad acoustic practice



3.2.4 Windows

Façade glazing and glazing installed in external walls of units can reduce the acoustic performance of the sound-rated common walls. They can produce a flanking path for sound transfer as shown in Figure 3.8. Like the doors in section 3.2.3 above, glazing requires careful design to limit sound transfer.

The distance between the external windows of adjoining units should be maximised. This will limit potential flanking sound through the windows especially where there is a common light well, shared courtyard or atrium (refer to Figure 3.7 and Figure 3.8).

Full perimeter acoustic seals should be used on sensitive windows and the design of the window should allow for adjustment and maintenance of acoustic seals on windows.

3.2.5 Façade

The design and layout of the facade can impact sound intrusion. Considerations such as the placement of windows and balconies, as well as the incorporation of setback areas or buffer zones, can help reduce direct sound transmission between adjoining units.

Façade walls can also reduce the performance of sound-rated common walls. They can produce a flanking path for sound transfer as shown in Figure 3.9 and Figure 3.10. Detailed design measures and the use of sound absorption materials may be required to overcome this flanking.

Figure 3.9 External wall flanking control – Good design practice

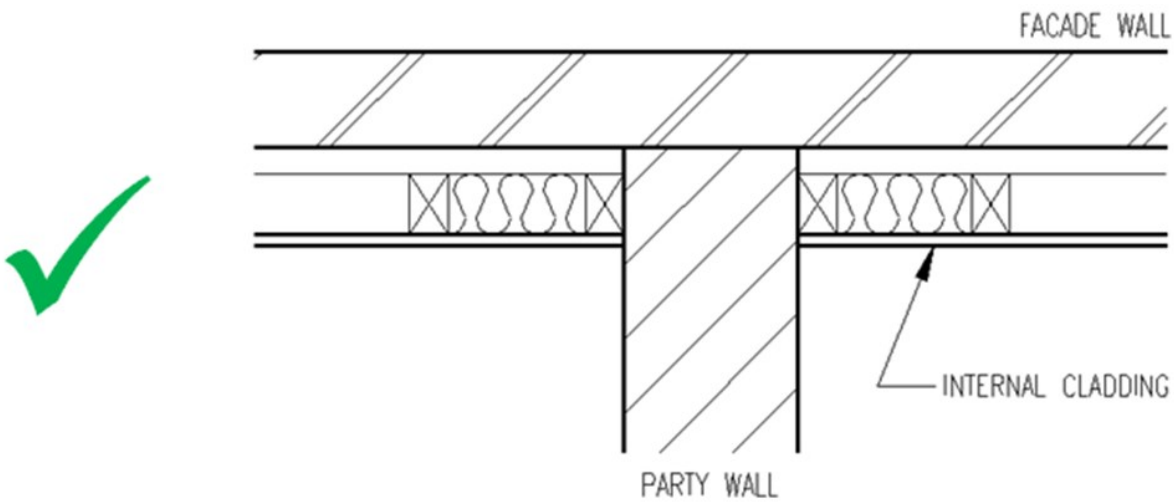
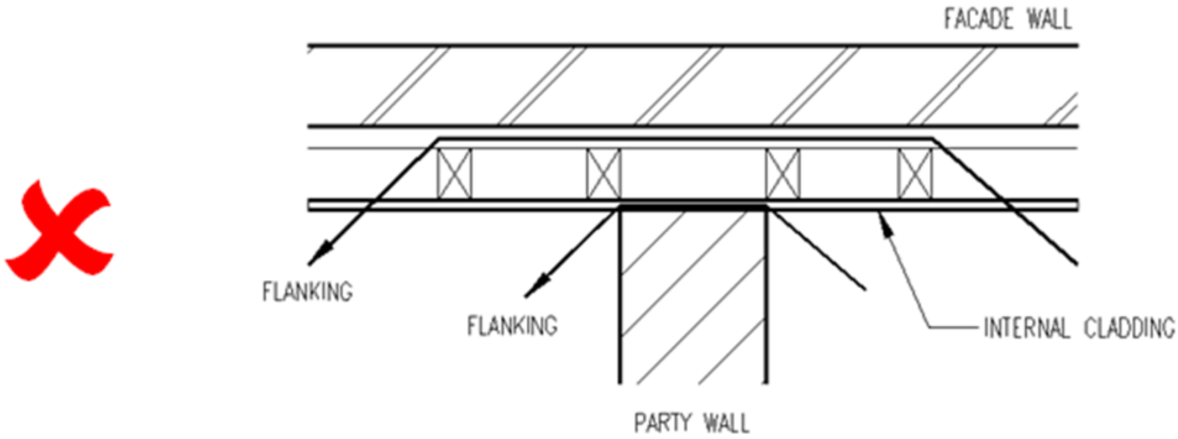


Figure 3.10 External wall flanking control – Bad design practice



The design measures may need to be applied to the entire façade wall at the time of construction to allow suitable flexibility for the location of common walls. For instance, common walls should align at structural columns in the façade where possible and should not be bridged by common air supply grilles or by windows in the façade.

Reminder

Noise entering the building from outside such as noise from industrial processes, vehicle traffic, trains, aircraft or animals are not addressed in the NCC.

3.3 Building services

Historically, sound generated by building services and flanking around building services have been significant problems. The focus of this section is to address the noise from internal building services. Noise generated from the Heating, Ventilation, and Air Conditioning (HVAC) equipment, sewage lines, lifts, ductworks, water supply system, garbage chutes are some of the potential sources that can affect other parts of the building.

Reminder

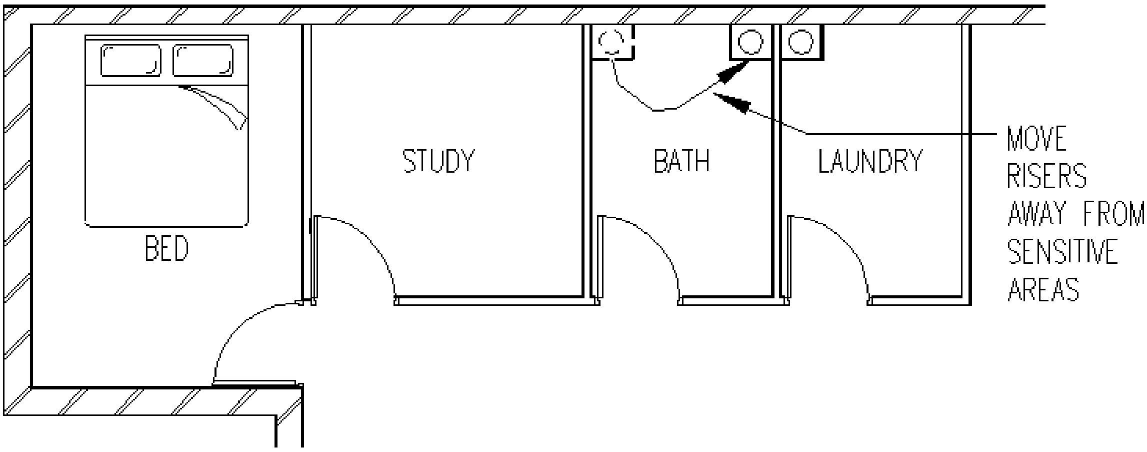
The NCC Requirements only apply to services which pass through more than one SOU or are located in a wall or floor cavity which separates SOUs.

This section does not cover the requirements of NCC Volume Three Part D to prevent excessive noise being generated from a plumbing and drainage system.

Some of the general design practices to manage the noise from building services are summarised below.

- Design for sufficient sound isolation in common ventilation ducts and risers.
- Flexible connectors should be installed for pipes and ducts to limit structure-borne sound transfer.
- Reduce the number of bends and elbows in pipes and ducts.
- Reduce the flow velocity in pipes and ducts.
- Fixing of plumbing and ducting should be via resilient mounts.
- Use quieter pipe constructions to reduce noise generated by pipes.
- Mechanical and hydraulic services should be located away from sensitive areas within the unit (refer to Figure 3.11).
- Services such as power outlets, light switches, plumbing pipes and fittings, and ducts should preferably not be fixed to common walls.
- Services such as plumbing pipes and fittings should not be chased into common walls.
- Design pipe treatment using acoustic wrapping where necessary.
- It is not recommended to:
  - acoustically seal around fire collars without regard for the fire rating
  - design air grilles into bulkheads which contain hydraulic services or ductwork.

Figure 3.11 Location of services



3.3.1 Treatment of services

The noise from building services and pipes can be controlled by effective insulation of the pipes that are considered a potential sound source.

Using lightweight barriers such as plasterboard linings and sound insulation for both risers and bulkheads, along with acoustic lagging of pipes can also help to reduce the pipe sound in buildings.

Pipe acoustic lagging is a method used to reduce the transmission of noise through pipes in buildings. Effective acoustic lagging is characterised by the following points.

- It uses a heavy barrier such as loaded vinyl, isolated from the pipe with foam rubber or fibreglass.
- It extends gap-free along the full length of a pipe.
- The lagging and pipe do not contact ceilings, walls or supports.
- The pipe mounts and supports do not contact the surrounding bulkheads or risers.

Reminder

Care must be exercised with lagging to make sure that the performance of any fire collar, and the like, on the pipe is not impeded by the lagging. In all cases refer to the manufacturer's specific recommendations.

When designing for sound insulation of internal building services, it is important to consider the specific needs and requirements of the building and its occupants, as well as any relevant building codes and standards. Proper installation and maintenance of sound insulation materials and systems can help to ensure their effectiveness and longevity over the lifetime of the building.

3.3.1.1 Hydraulic services

- Where a sound-rated building element is required to isolate sound from pipes, a lighter building element could be constructed. This could occur if a suitable pipe lagging is also incorporated and sufficient space is retained around the pipes to ensure there is no contact with ceilings, risers or supports.
- Where pipe lagging is required to isolate sound, sufficient space should be retained around the pipe and lagging to ensure there is no contact with ceilings, ceiling supports or risers.
- Waste and stormwater can generate sound from turbulent flow within the pipes. Pipe suppliers can supply quiet proprietary pipe systems which reduce sound. It should be noted that additional treatment may still be required to meet the NCC provisions.
- Waste pipes and stormwater pipes should pass above non-habitable areas where possible.
- Sharp bends, elbows and take off points exacerbate pipe sound, so should be minimised.
- Reducing water flow velocity and pressure within pipes to the rated specification can reduce sound.
- Pumps and other plant should have flexible couplings to the services pipes. This is required for pumps in F7D8 Sound isolation of pumps in Volume One.
- Avoid the installation of hydraulic services in plenums containing air grilles.
- Supply pipes should be resiliently fixed to wall structures and not fixed to the neighbour's side of a cavity wall system.
- Pipes should not be lagged at the fire collar.

3.3.1.2 Mechanical services

- Where a sound-rated building element is required to isolate sound from ducts, a lighter building element can be constructed where suitable duct lagging is also incorporated. Sufficient space should be retained around the duct to ensure there is no contact with ceilings, risers or supports.
- Design smooth duct runs and transitions and large radius bends to maintain smooth airflow and reduce the likelihood of generating sound.
- Lower air velocities generate less sound.
- Bends with turning vanes limit turbulent sound generation.
- Doors with undercuts allow flanking sound. Such doors would not meet the NCC provisions. Fit acoustic seals onto doors and design return air paths via acoustically treated transfer ducts.

- Where ducts penetrate sound-rated walls, acoustic treatment is required around the ducts, especially between the duct and the slab soffit above.

3.3.1.3 Electrical services

- Sound barriers should be provided to control sound from cooling fans, transformers and other sound producing electrical equipment in electrical plantrooms and from the regular operation, servicing and testing of stand-by generators.
- Sound-rated electrical outlets and switches should be used, or outlets and switches should be surface mounted on sound-rated walls. The mounting boxes to be airtight and to be sealed with acoustical caulk.
- Note the NCC also requires electrical outlets in a wall to be offset.
- It is recommended not to:
  - design for non-rated (acoustic) power outlets and switches to be installed in sound-rated walls
  - design power outlets and light switches to be installed back-to-back.

3.3.1.4 Other Services and penetrations

- To limit sound intrusion from lift shafts, it may be useful to isolate the lift rails from the surrounding structure.
- Control air-rush whistle sound through doors.
- Slower travelling cars make less sound than faster travelling cars.
- Minimise the call signal volume as much as practical.
- Where sprinklers are located in sound-rated ceilings, the penetrations are to be treated to control sound transfer.
- Gaps and penetrations around fire collars need to be acoustically sealed while maintaining their fire rating.
- Penetrations in sound-rated ceilings, for example downlights and other recessed lights, air grilles, fire services sprinklers and speakers, need to be acoustically treated to maintain the overall acoustic rating of the ceiling.

3.4 Improving sound insulation of building elements

3.4.1 Additional material

Using additional layer of materials to increase mass and using materials of greater mass per unit can enhance the sound insulation of building elements. When additional mass is incorporated into walls, floors or ceilings, the added mass acts as a barrier that reduces transmission of sound waves. The mass absorbs and dissipates the sound energy, preventing it from passing through and entering (or escaping) the enclosed spaces. This improvement in sound insulation is particularly effective in reducing airborne noise.

Use of additional skins of materials such as an additional layer of plasterboard with a cavity can effectively reduce sound transmission. The depth of the cavity impacts its effectiveness and helps to interrupt sound transmission path. Larger depth cavities provides better sound insulation.

In addition, there are various other strategies that can contribute to better sound insulation, including:

- the use of limp materials or materials with low stiffness
- the addition of damping, especially to thin stiff elements in a partition system.

3.4.2 Sound absorption

The sound insulation of a lightweight building element can be improved by introducing sound absorption into cavities. Where absorption is already present, some marginal improvements can be achieved by upgrading the sound absorption material.

The sound absorption performance of a material can be quantified by its noise reduction coefficient (NRC). Different materials such as glass wool, rock wool, polyester fibre, natural wool or cellulose fibre are sound absorptive. The sound absorption performance can be marginally improved by:

- using thinner fibres within a material
- increasing the density of, and hence number of fibres within a given material
- increasing the thickness of the absorbing material itself.

3.5 Avoidance of sound leakage

3.5.1 Flanking

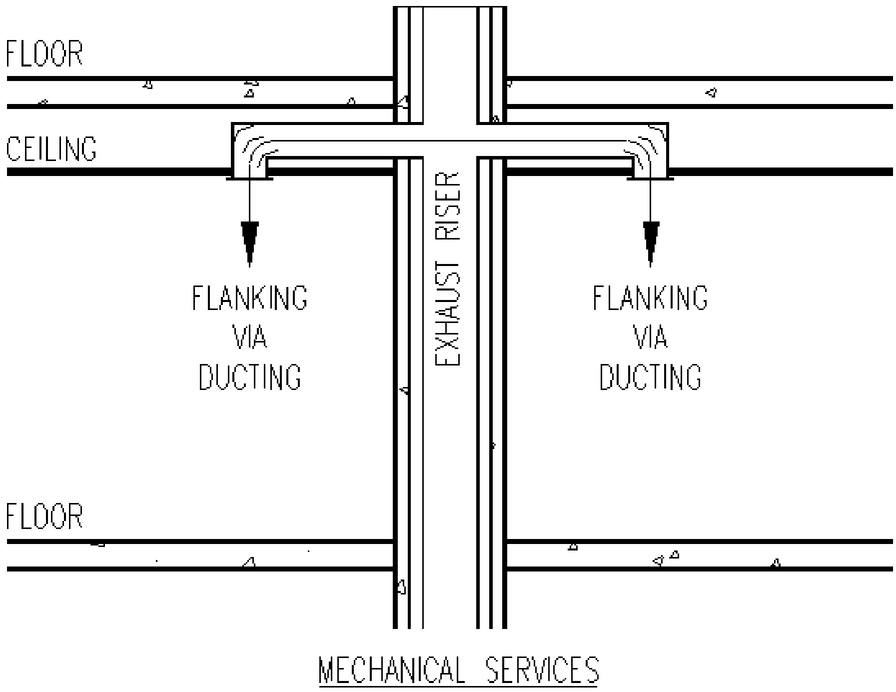
Flanking reduces the effectiveness of acoustically rated building elements that separate spaces. Flanking should be minimised to ensure that the element performs to the desired level. Some flanking paths are presented in Figure 3.12.

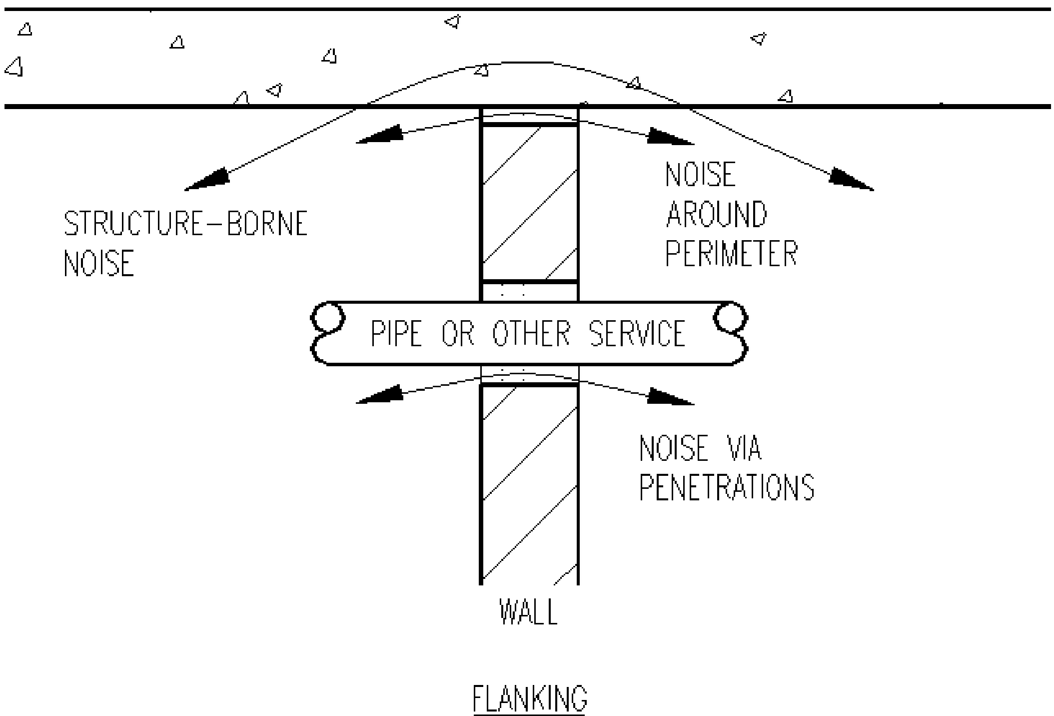
Typical problem flanking paths in units include:

- sound travelling through air conditioning ducting
- sound travelling through kitchen or toilet exhaust ducting

- sound passing through gaps and weaknesses around building elements
- structure-borne sound passing through perimeter building elements, such as floors, ceilings and façade walls which pass across a sound-rated wall
- sound passing through gaps and penetrations associated with building services penetrations
- sound travelling through lift shafts or garbage chutes.

Figure 3.12 Internal flanking paths





3.5.2 Penetrations

- Design penetrations in acoustically rated building elements, such as ceilings, floors, walls, bulkheads, and risers, so as not to reduce the sound rating of the building element.
- Design acoustic seals at penetrations to last as long as the building design life.
- Minimise the incidence of penetrations in sound-rated walls and floors.
- Minimise the incidence of other flanking paths in the design.
- Design for the sealing of all gaps at building element perimeters and penetrations, including gaps behind skirting boards and cornices.
- It is not recommended to:
  - use non-sound-rated downlights or other fittings in sound-rated ceilings
  - install return air grilles on sound-rated doors
  - leave untreated penetrations in sound-rated walls above ceilings.

3.5.3 Sealing of penetrations

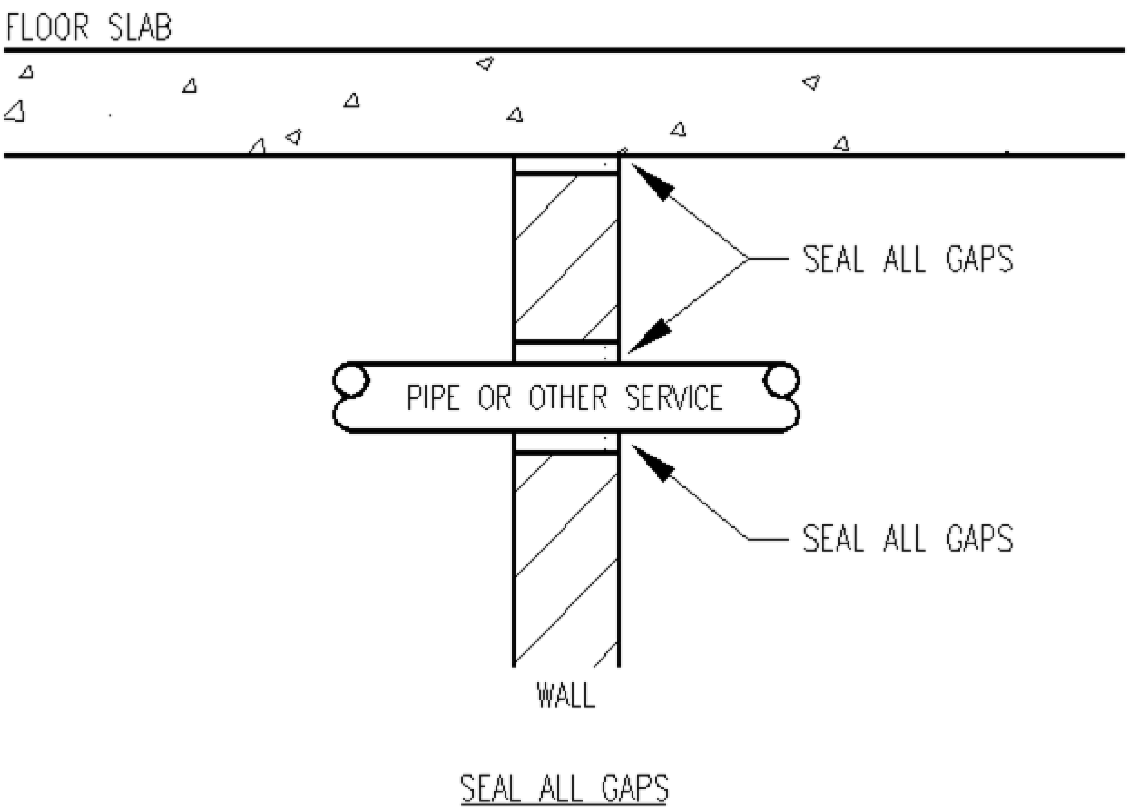
The acoustic performance of a system is severely degraded by the presence of gaps. All gaps in acoustically rated walls and floors, especially around penetrations should be acoustically sealed to minimise flanking (refer to Figure 3.13).

The method of sealing should reflect the environment where the penetration occurs. The seal normally has to remain effective over the life of the building. Sealing is best performed on both sides of the element. The sealing treatments are most effective where the penetrations are cut neatly and are not any larger than necessary.

To maintain suitable long-term performance an acoustic seal should be:

- fire-rated
- heat and temperature resistant
- weatherproof
- remain flexible over the life of the building
- able to withstand movement
- resistant to chemicals.

Figure 3.13 Sealing of flanking paths



3.6 Building movement

Buildings have the potential to move over time. Any settling of the building can translate into movement at the joints. Joints are a prime source of sound intrusion in buildings. As an example, set plaster joints on concrete or set mortar joints have the potential to crack with building movement over time. The residual sound intrusion can be excessive through such joints.

It is important to maintain acoustic ratings by using a design which allows for building movement, especially at penetrations and junctions. This can be done by designing for a flexible acoustic seal between:

- internal walls
- common walls and the adjoining façade
- walls and floors/ceilings.

The sealant or mastic applied at joints as sound barriers should be suitably dense, sufficiently flexible and maintain their flexibility over time. It is important to note that acoustic sealants are not the same as ordinary sealant or caulk. They are formulated to be permanently flexible.

A normal sealant or caulk can crack or shrink or separate from substrates over time and allow for passage of the sound.

Where joints are sealed with mastic, it is not good practice to smear the mastic on in a thin layer. The depth of the mastic in the joint should be sufficient to provide the movement and strength needed while maintaining the acoustic rating of the construction.

Typically, the depth of mastic should be equal to or greater than the width of the joint. Suitable backing rods are also generally required. The manufacturer's installation instructions should be followed to ensure products work as designed.

3.7 Structure-borne sound insulation

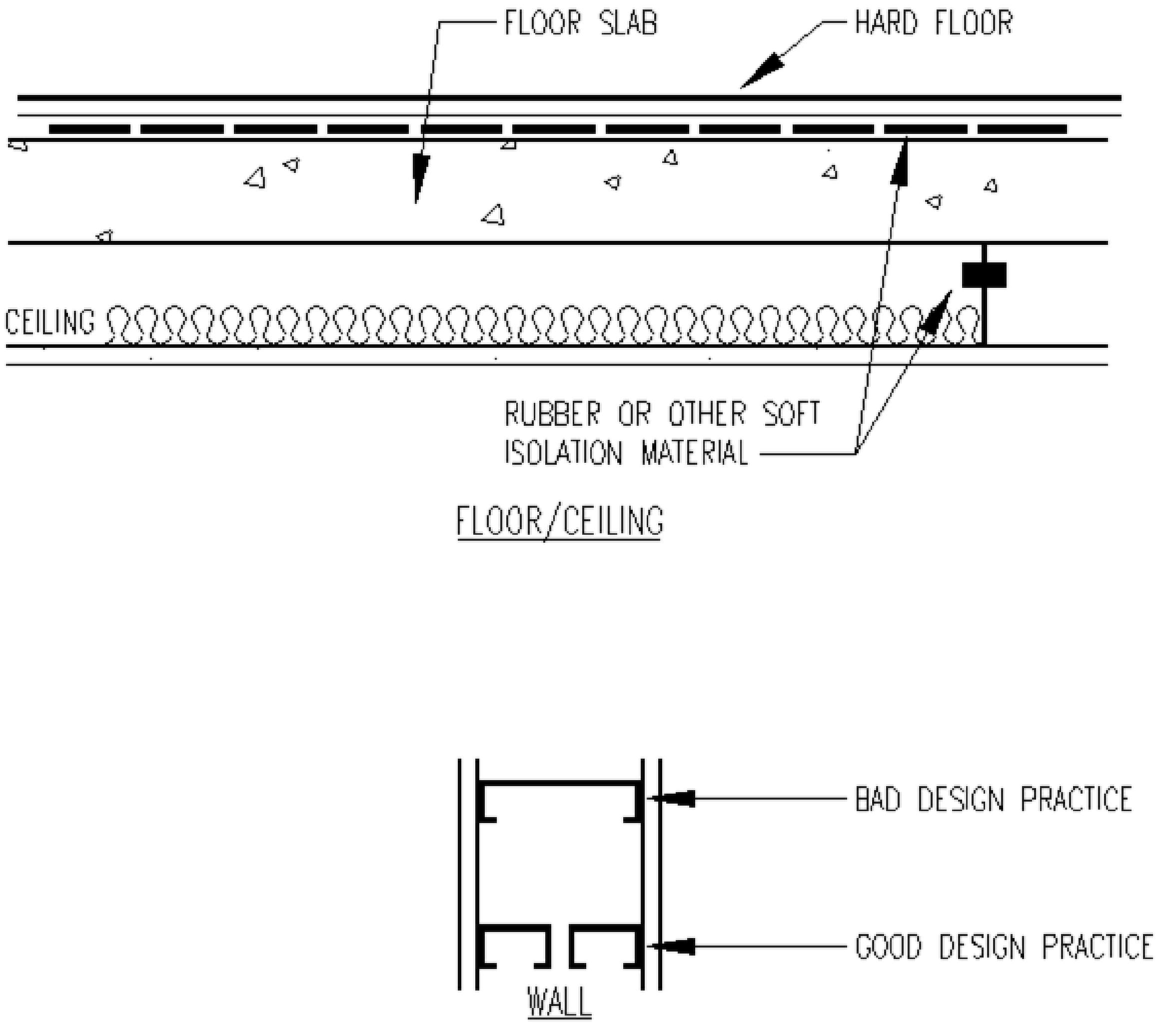
Structure-borne sound is the audible sound generated by vibrations induced in the ground and/or a structure. Vibration can be generated by impact or by direct contact with a vibrating machine.

When designing a building it is important to maintain acoustic ratings by using a design which allows for building movement, especially at penetrations and junctions. A flexible acoustic seal should be designed between internal walls, common walls, and adjoining facades and between walls and floors/ceilings.

It is impossible to eliminate all structure-borne sound in a building, however the amount of structure-borne sound can be reduced by increasing the vibration isolation in a system. This can be done by:

- using a suitably soft connecting material such as rubber, neoprene, or isolation springs between the elements within a building element
- designing and installing a break in continuity of a panel, for example using double studs (not touching) instead of large single studs (refer to Figure 3.14)
- increasing the size of the air gap or cavity between the panels
- introducing vibration isolated floors to adjacent rooms located on a common slab.

Figure 3.14 Vibration isolation treatments



4 Construction

This chapter outlines good practice tips for construction. These should be applied during the building phase.

4.1 General

- When using proprietary building elements, the specific installation instructions from suppliers should be accurately followed.
- No substitutions should be permitted which have not been thoroughly documented and approved by an acoustic consultant, manufacturer, supplier or testing authority.
- All building element systems should be constructed and installed in accordance with manufacturing requirements.
- Design drawings should be followed.
- Where conflicts occur which have not been documented, designers should be consulted.
- Thorough inspections should be conducted and documented during construction.

4.2 Windows and external doors

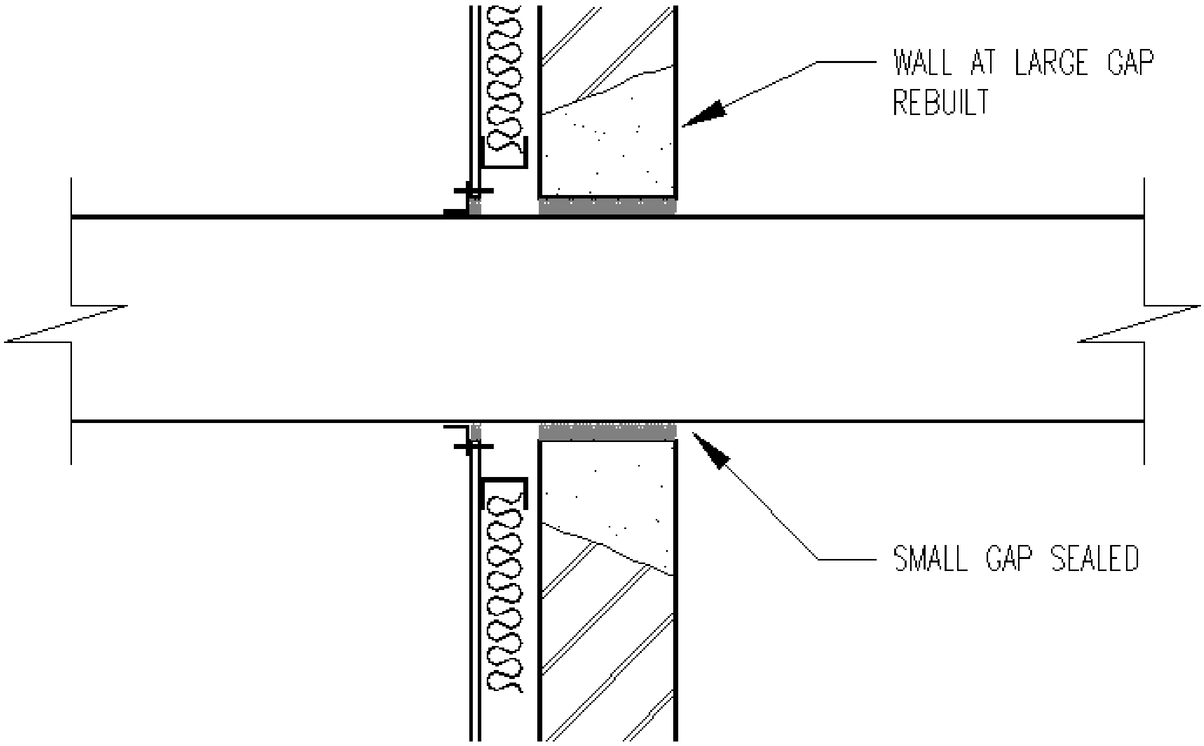
- Seals should not be removed from sound-rated doors or windows.
- Acoustic seals on all sound-rated doors should be properly adjusted and operational.

4.3 Penetrations and gaps

- There should be no residual gaps around full-height walls.
- Joints at wall and floor perimeters should be sealed and airtight, using approved mastic.
- The depth of mastic in joints should be equal to or greater than the depth of the joint.
- Joints in dissimilar materials may open up if there is building movement. It is important that the acoustic seal in joints will accommodate building movement.
- Gaps around all penetrations in sound-rated walls, floors and ceilings should be treated and sealed to maintain acoustic ratings. This includes around bundles of cables as well as around and above ducts installed close to a slab soffit overhead.
- All penetrations in sound-rated building elements should be neatly cut or drilled. Avoid excessively sized penetrations.

- The wall/floor around any large penetration should be rebuilt with the same material. Small residual gaps at penetrations can be sealed with a suitable mastic (refer to Figure 4.1).
- Sealing should be effective, resilient, and resistant to the surrounding environment and designed to last for the life of the building.
- It is not good practice to install insulation in small gaps over wide elements after installation. The insulation should be planned and applied prior to installation.
- The normal tolerance in building construction should be considered when installing penetrations and at wall/floor junctions. Revised detailing may be needed where residual gaps are too large to allow effective sealing with mastic.
- It is good practice to cut sizes of holes to suit. It is not advisable to knock large holes into walls by using a sledgehammer or other similar method.

Figure 4.1 Treatment of gaps around penetrations

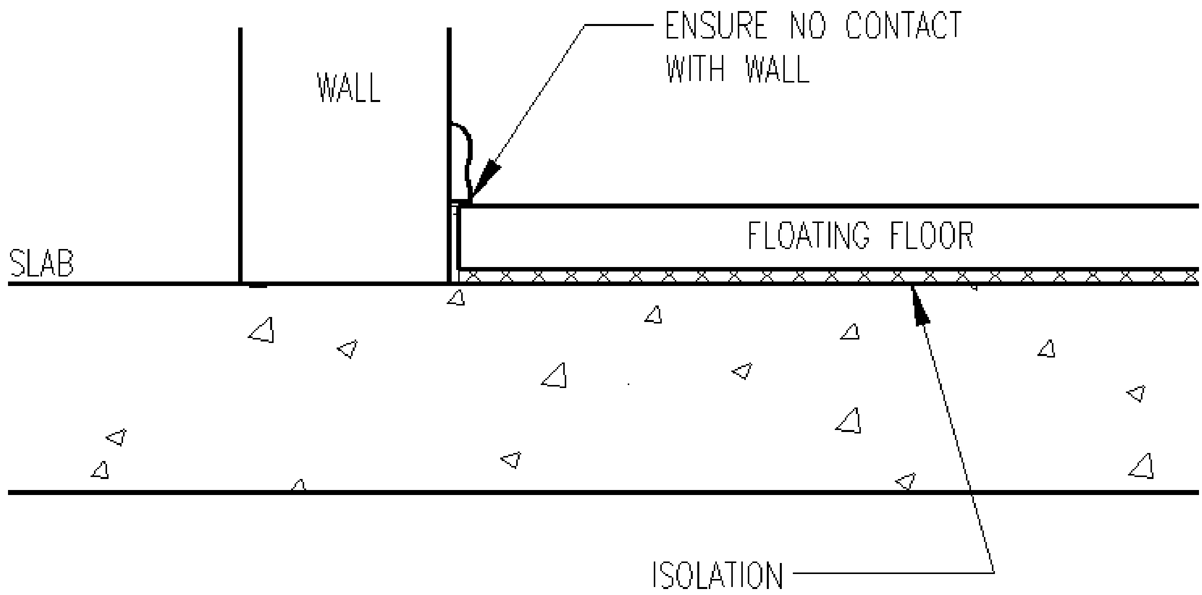


4.4 Floors/ceilings

- It should be ensured that the resilient rubber underlay used for isolated floors is not ‘bridged’ or short circuited by nails and screws connecting the floor to the slab underneath. These penetrate the rubber underlay and diminish its performance.

- Isolated floors should not be installed in contact with side walls. Isolation is also important between the floor and side wall (refer to Figure 4.2).
- It is not good practice to bridge across breaks or vibration isolation joints in floor and ceiling construction.
- Any penetrations in a sound-rated ceiling should be acoustically treated.

Figure 4.2 Treatment around the perimeter of isolated floors



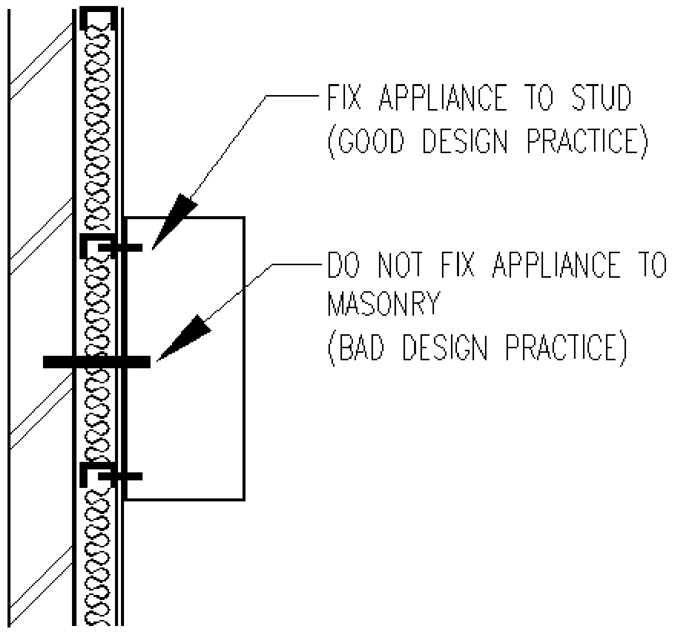
4.5 Wall construction

4.5.1 Wall design

Sufficient space should be provided to allow construction of suitable sound-rated walls.

Take care when fixing wall furniture so it does not bridge across vibration isolation elements in walls. This is particularly the case for fixing of cupboards, toilet bowls, clothes dryers and other appliances to drywall cladding or its associated stud work rather than to any free-standing masonry or the separate studs forming the discontinuous wall behind the cladding (refer to Figure 4.3)

Figure 4.3 Mounting of wall furniture



4.5.2 Sheeted walls

- Joints in sheeting systems, including plasterboard systems, should be staggered and, where multiple layers of material are used on walls, the joints must not overlap (refer to Figure 4.4).

Full height walls should not stop short of the slab soffit or roof above.

- There should be no residual gaps around full-height sound-rated walls, especially around roof structure such as rafters and purlins (refer to Figure 3.3).
- Any discontinuity in isolated walls should not be ‘bridged’ or short circuited by:
  - nails or screws
  - noggins, battens or packers
  - joists or floor boards on the floor supporting the wall (refer to Figure 3.4 and Figure 3.5).
- Building debris or rubbish should not be left in wall or ceiling cavities. This material can span the discontinuity causing bridging or short circuiting.
- When installing sanitary fixtures onto walls, noggins which span across the discontinuous studs on both sides of the wall should not be installed.
- Cupboards, wall furniture, appliances and toilet cisterns should be mounted onto the cladding/supports of the front wall only.

- In timber construction, it is good practice to install walls and ceilings on isolation mounts to improve impact isolation between floors (refer to Figure 4.5).
- Insulation should be evenly spaced throughout the entire cavity where needed.

Figure 4.4 Optimum plasterboard sheeting configuration

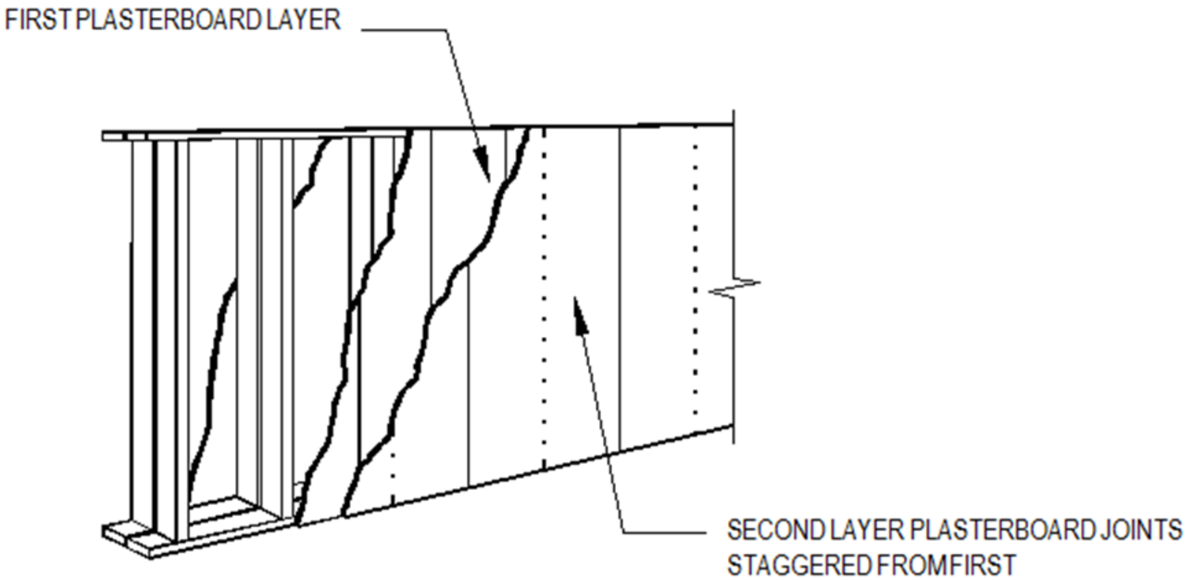
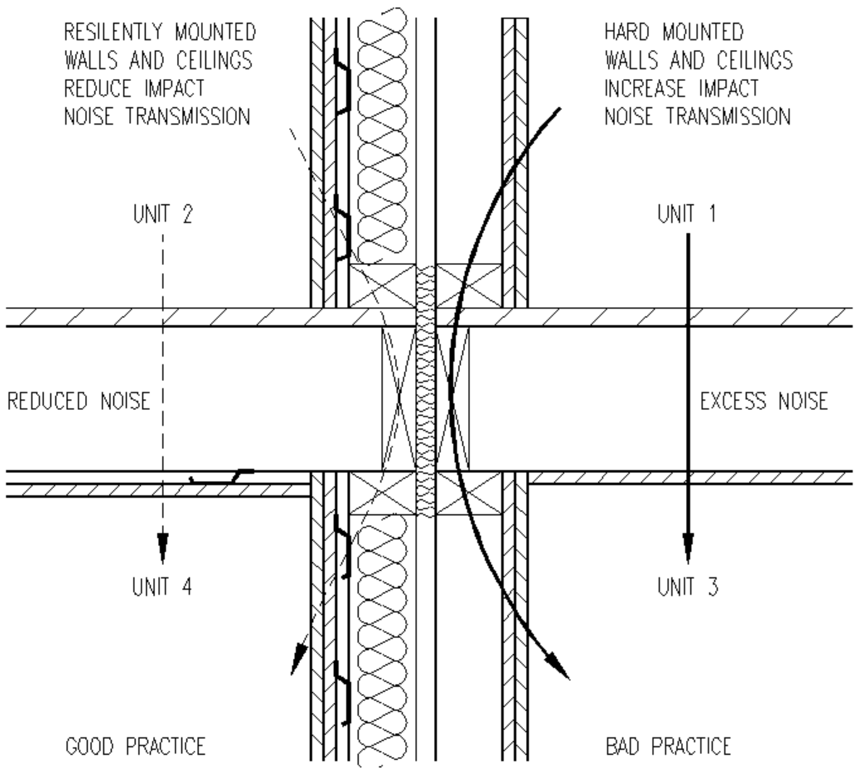


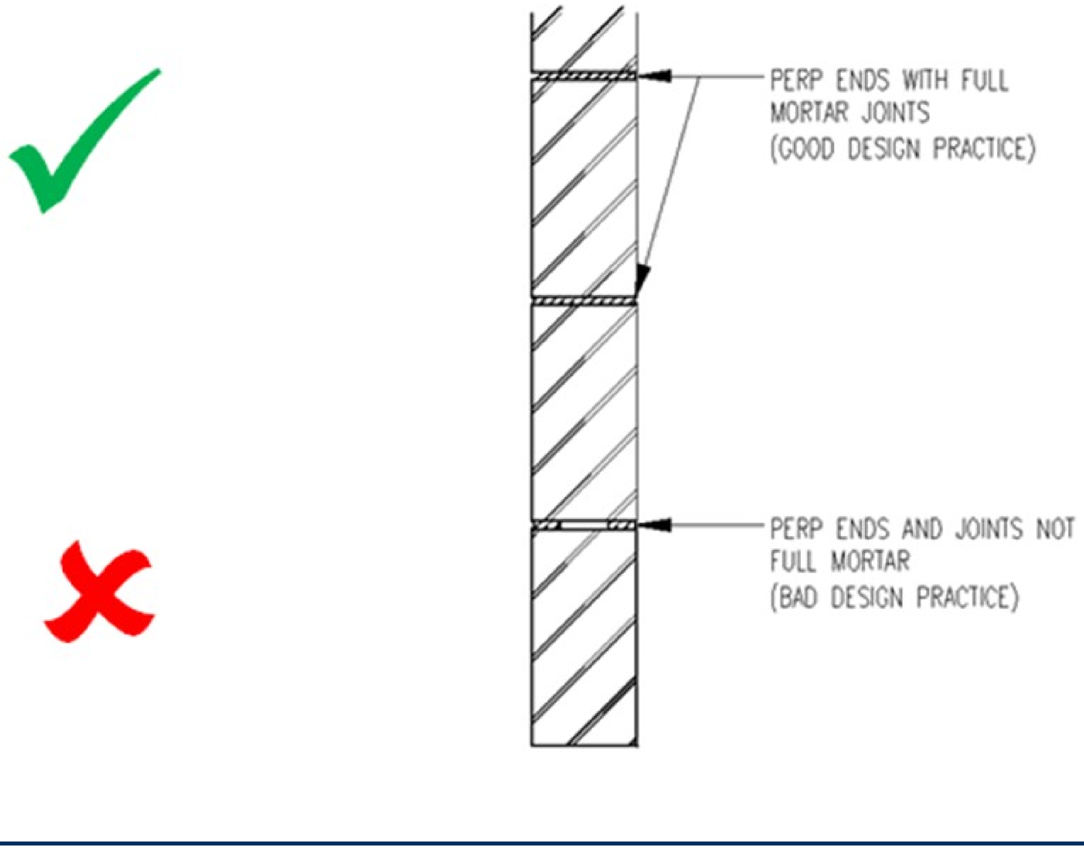
Figure 4.5 Wall and ceiling isolation in timber construction



4.5.3 Masonry walls

- Joints in sheeting in dry wall/masonry combination systems should be staggered and, where multiple layers of material are used on walls, the joints should not overlap.
- Full height walls should not stop short of the slab soffit or roof above.
- There should be no residual gaps around full-height sound-rated walls, especially around roof structure such as rafters and purlins (refer to Figure 3.3).
- Discontinuity in isolated walls should not be 'bridged' or short circuited by noggins, battens or packers of plaster linings.
- There should be no building debris or rubbish left in wall or ceiling cavities. This material can span the discontinuity causing bridging or short circuiting.
- Cupboards, wall furniture, appliances and toilet cisterns should be mounted onto the cladding/supports of the front wall only. Wall elements should not be supported behind a wall discontinuity (refer to Figure 4.3).
- Services should not be chased into masonry or concrete walls.
- Full-mortar joints should be used where a sound-rated masonry wall system is used. Special care is required at perpends to ensure full-mortar joints (refer to Figure 4.6).
- Insulation should be evenly spaced throughout the entire cavity where needed.

Figure 4.6 Treatment of joints in masonry walls



4.6 Services

- Waste pipes, water supply pipes, stormwater pipes and ductwork in ceiling cavities and risers should be acoustically treated. Alternatively, acoustically treat the ceilings and riser walls themselves as well as any penetrations in these elements.
- Installation of pipe/duct lagging should be gap-free and in accordance with the manufacturer's requirements.
- Electrical wiring or lighting should not be covered with acoustic blankets if not designed to be covered.
- Flexible connectors in pipes should be operational and not bridged.
- Unnecessary bends and elbows in pipes and ducts should be avoided.
- Resilient fixings of pipes and ducts to party-walls should be used.
- Pipes and ducts should only be attached to the side of the wall to which the services belong. It is not good practice to bridge across wall discontinuities.
- An access door or panel that provides access to a duct, pipe or other services should not open into any habitable room such as a bedroom.

5 Refurbishing existing buildings

Refurbishments have the potential to severely compromise the acoustic ratings within a building.

In addition, the majority of buildings undergoing refurbishment were constructed during a period when previous regulatory regimes had lower acoustic standards in place. Therefore, when substituting materials during the refurbishment process, it becomes essential to ensure that the new materials meet the current, higher acoustic standards.

Failing to do so could compromise the building's sound insulation performance and potentially lead to non-compliance with current NCC building regulations. It is crucial to seek expert advice, conduct necessary testing, and obtain proper documentation and approvals to ensure that any material substitutions do not negatively impact the building's sound insulation capabilities.

To this end, the following areas may require extra detailing and attention.

- Wall constructions (refer to section 3.2.1).
- Limiting flanking paths around the walls, ceilings and floors (refer to Section 3.5).
- The treatment applied to seal gaps should be sufficiently flexible to allow for building movement (refer to section 3.6).
- Controlling sound and vibration travelling through timber floorboards, joists, beams, external walls or ceilings (refer to Figure 3.4).
- The avoidance of fire hazards from the acoustic treatment, for example by covering electrical wiring or lighting with acoustic insulation.
- Gaps appearing over time from building movement. This limits the sound isolation and may lead to non-compliance with the NCC.
- Robust acoustic design to allow for site conditions where surfaces may not be straight, true or square. This is especially an issue around joints, walls, floors, ceiling junctions and penetrations.
- Adding mass to building elements where upgrading acoustic ratings without exceeding maximum acceptable structural loading (refer to section 3.4).
- Variations in the building fit out driven by unexpected site conditions which may require revised designs.
- Where renovation is performed, for example in a unit, it is advisable to ensure that sufficient detail is readily available to the future occupants via the body corporate for any floor, ceiling and wall modifications made (refer to section 5.1).

5.1 Floor, ceiling and wall modifications

5.1.1 Floor design

Some designs require floors to be sound-rated to meet the NCC provisions. Carpet may only be one option to meet the impact rating on floors. Alternative hard-floor systems also need to be considered. This is the case whether the hard floor covering is installed as part of the initial fit out or as part of a future occupant upgrade. The design for both the hard floor covering and carpet options should allow for:

- sufficient ceiling height being maintained in all rooms
- an excessively high step is not formed between carpet and hard floor covering systems within the unit.

Where carpet is replaced during renovation works by hard floor finishes, the impact isolation performance of the floor will invariably reduce. This reduction in performance can result in as much as 25 to 30 dB extra sound transmission. This increased sound is difficult to reduce, and the use of resilient suspended ceilings becomes an important part of any design solution.

After the installation of resilient ceilings and floors, a NCC compliant floor/ceiling system may still transmit sound at 15 to 20 dB higher than the original carpet design. It is not unusual for complaints to be registered by the neighbour in the unit underneath in this situation.

5.1.2 Ceiling design

Where carpet is installed on the floor above a ceiling to comply with the floor impact requirements, consideration should be given to the potential of occupants to upgrade their own carpets to hard floor coverings.

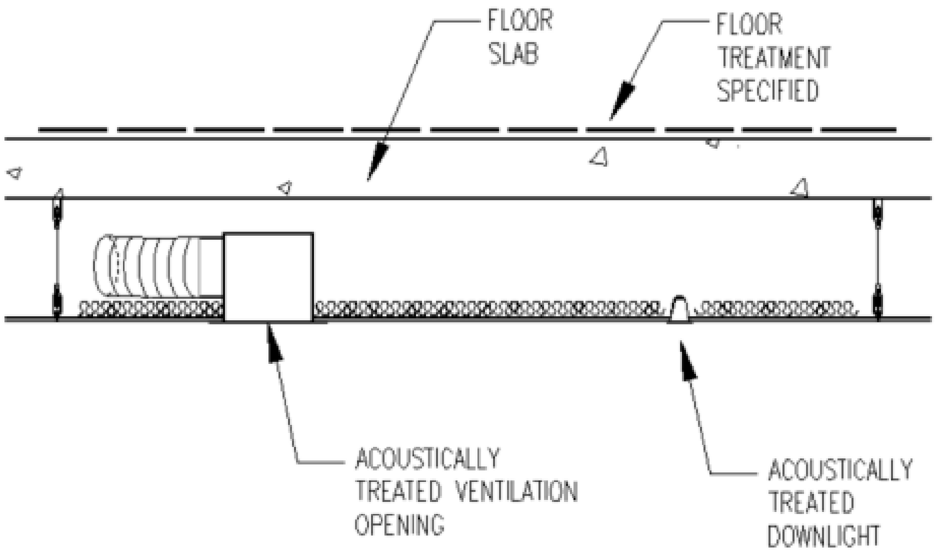
The replacement of carpet with hard floor coverings in the unit or dwelling above can cause a reduction in acoustic performance and this may require an acoustically rated ceiling to be installed underneath. The ceiling would need to be installed at the time of building construction as there is no guarantee of access to the unit or dwelling underneath to retrofit later.

Penetrations in sound-rated ceilings which require acoustic detail to be developed include:

- downlights
- mechanical ventilation
- air conditioning
- ceiling speakers
- fire sprinklers.

The construction details should be made available to the occupants as part of the body corporate approval for these works. The combined ceiling and floor treatments should be covered (refer to Figure 5.1)

Figure 5.1 Sound-rated treatments for ceilings and floors



5.2 Substitution of materials

The sound insulation performance of modern, high-performance building elements is highly sensitive to specific material chosen for construction. Different materials have varying sound absorption and transmission properties. Therefore, substituting building materials without proper consideration can have a significant impact on the sound insulation of a building.

Extensive testing by product suppliers has identified the most efficient way to meet the specified performance standards for different building systems. The substitution of materials may also affect the compatibility and integration of different components within the building system.

It is important to avoid substituting materials unless it can be proven that the new material will not compromise the overall insulation performance of the building element. Any substitution has the potential to reduce sound insulation levels and may lead to non-compliance with NCC building regulations. Therefore, substitutions should only be considered after seeking expert advice, conducting testing to ensure acceptable residual performance, and obtaining the necessary approvals. This applies to all aspects of the design, including cavity insulation materials, cladding or masonry products used in walls, vibration isolation products for resilient floors, walls, and ceilings, as well as acoustic sealants.

Appendices

Appendix A Abbreviations

The following table, Table A.1 contains abbreviations and symbols used in this document.

A. 1 Abbreviations and symbols

Abbreviations	Meaning
ABCB	Australian Building Codes Board
AS	Australian Standard
BCA	Building Code of Australia
C_I	Spectrum adaptation value
C_{tr}	Spectrum adaptation value
dB	decibels
$D_{nT,w}$	Weighted standardised level difference
DTS	Deemed-to-Satisfy
Hz	Hertz
ISO	International Standardization Organisation
$L_{nT,w}$	Weighted standardised field impact sound pressure level
$L_{n,w}$	Weighted normalised impact sound pressure level
NCC	National Construction Code
NRC	Noise reduction coefficient
NZS	New Zealand Standard
R_w	Weighted Sound Reduction Index
STC	Sound Transmission Class
SOU	Sole-occupancy unit
VM	Verification Method

Appendix B Glossary

B.1 NCC defined terms

NCC definitions for the terms used in this handbook can be found in Schedule 1 of NCC 2022 Volumes One, Two and Three.

Building classifications can be found in Part A6 Building Classifications of NCC 2022 Volumes One, Two and Three.

B.2 Other terms

C_{tr}: A value used to modify the measured sound insulation performance of a wall or floor. This sound insulation performance can be described by the R_W or the $D_{nT,w}$ terms. However, these are not accurate for all sounds, especially for low frequency bass sound from modern stereo systems.

The value is referred to as a “spectrum adaptation value” and is added to either the R_W or $D_{nT,w}$.

AS/NZS 1276 sets out testing methodologies for the sound insulation properties of building elements and spectrum adaptation values and explains their use.

The C_{tr} for a building element varies according to the insulating material employed. For example, a 90 mm cavity brick masonry wall has a C_{tr} value of -6, as does a wall constructed of 150 mm core-filled concrete blocks. By contrast, a brick veneer wall may have a C_{tr} of -12.

Smaller negative C_{tr} values are more favourable than large negative values.

$D_{nT,w}$: A measure of the sound insulation performance of a building element. It is characterised by the difference in sound level on each side of a wall or floor. It is measured in the field and is therefore subject to the inherent inaccuracies involved in such a measurement.

The term is referred to as the “weighted standardised field level difference” and it indicates the level of speech privacy between spaces. It is a field measurement that relates to the R_W laboratory measurement. The higher the number the better the insulation performance.

Field test: A test of the overall building performance, rather than the performance of a building element. See also ‘laboratory test’.

The sound insulation performance of a building can be measured by conducting a field test. The field test is a test which is conducted, typically at the construction site when the spaces are ready for testing.

A field test is conducted in a non-ideal acoustic environment. It is generally not possible to measure the performance of an individual building element as the results can be affected by numerous field conditions (refer to Appendix D).

Flanking: The mechanism of sound passing from one space to another through paths around a building element rather than through the building element material directly (refer to section 3.5.1).

Frequency: All sounds can be described by their frequency or their mix of frequencies. Sounds have a mix of frequencies which are peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a mix of predominantly high frequencies, and the sound of a bass drum or large truck has a mix of predominantly lower frequencies. Frequency can be measured on a scale in units of Hertz (Hz).

Impact sound: The sound in a room, caused by impact or collision with the perimeter walls or floor of the room. The impact sound of interest to the NCC occurs in the adjoining tenancy and occurs on the floor or common wall of that tenancy. Typical sources of impact are footsteps on the floor above a tenancy and the slamming of doors on cupboards mounted on the common wall between tenancies.

$L_{nT,w}$: A measure of the sound impact performance of a floor. It is characterised by how much sound reaches the receiving room from a standard tapping machine. It is measured in the field and is therefore subject to the inherent inaccuracies involved in such a measurement.

The term is referred to as “weighted standardised field impact sound pressure level”. It is a field measure of the amount of impact sound reaching a space via a floor. It is the equivalent field measurement to the $L_{n,w}$ laboratory measurement. The lower the number the better the performance.

$L_{n,w}$: A measure of the sound impact performance of a floor. It is measured in very controlled conditions in a laboratory and is characterised by how much sound reaches the receiving room from a standard tapping machine.

The term is referred to as the “weighted normalised impact sound pressure level”. It is a laboratory measure of the amount of impact sound reaching a space via the ceiling/floor overhead. The lower the number the better the performance.

Laboratory test: The sound insulation performance of a building element can be accurately measured in a laboratory. The sound insulation performance of the entire building cannot. This is because laboratory tests are not subject to the same site conditions as building elements installed in the field (refer to Appendix D and ‘field test’).

Noise reduction coefficient (NRC): A measure of the ability of a material to absorb sound. The NRC is generally a number between 0 and 1. A material with an NRC rating of 1 absorbs 100% of incoming sound, that is, no sound is reflected back from the material.

R_W: A measure of the sound insulation performance of a building element. It is measured in very controlled conditions in a laboratory.

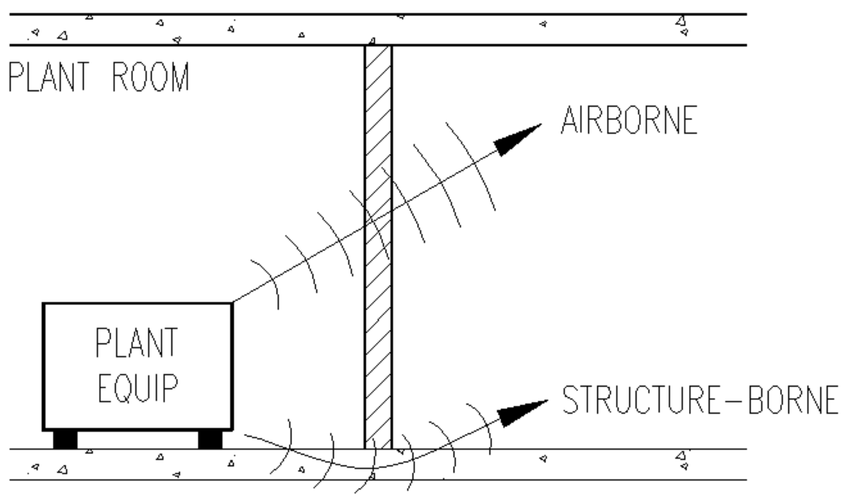
The term symbolises the "weighted sound reduction index" and is a laboratory measurement similar to STC. R_W is measured and calculated using the procedures from AS/NZS 1276 and AS 1191. The related field measurement is the $D_{nT,w}$. The higher the number the better the performance.

Sound: Sound can be classified into airborne and structure-borne components to identify the two mechanisms by which sound is transferred.

Airborne sound: Airborne sound is sound that travels through air, generally through a direct or open path between the sound source and the listener (refer to Figure B.1)

Structure-borne sound: Audible sound which is generated by vibrations induced in the ground and/or a structure. Vibration can be generated by impact or by direct contact with a vibrating machine (refer to Figure B.1).

Figure B.1 Airborne and structure-borne sound



Structure-borne sound cannot be attenuated by barriers or walls but requires the isolation of the vibration itself. Isolation is improved by using a resilient element such as rubber, neoprene or springs in the structure, or by a gap in the structure through which the vibration cannot pass. Examples of structure-borne sound include the sound of air-conditioning plant in a plant room, the sound of footsteps on the floor above a listener and the sound of a lift car passing in a shaft. See also 'impact sound'.

Sound absorption: The ability of a material to absorb sound. In doing so, the sound energy is converted to heat energy. Sound absorptive materials are useful within internal cavities of double skin partitions as they help absorb sound within the cavity and hence improve the acoustic performance of the building element. A measure of sound absorption is the NRC.

Efficient sound absorbers are typically made from glass wool, rock wool, polyester fibre, natural wool or cellulose fibre.

Sound insulation: Sound Insulation refers to the ability of a construction or building element to limit sound transmission through the building element. The sound insulation of a material can be described by the R_W or $D_{nT,w}$ of the system.

Sound Transmission Class (STC): A measure of the sound insulation performance of a building element. It is measured in very controlled conditions in a laboratory.

Specification: A specification provides technical data in the NCC which is relied upon as a component of one or more DTS Provisions. A specification may be referenced by multiple DTS Provisions, wherever the same data needs to be referred to by different parts of the NCC. Including this common information in a single specification avoids the need to repeat the same information across multiple parts of the NCC.

Standardising: A method of adjusting the measured sound results so that they are independent of the measuring space. The standardising of results is the NCC required method of adjusting field measured results to give consistency. This relates to the Verification Methods in NCC Volume One and Two.

The sound level in a room is affected by the amount of sound entering the room as well as by the acoustic behaviour of the room. For example the standardised $L_{nT,w}$ impact sound pressure level measured in the field is dependent on the amount of sound entering through the floor and also the amount of absorptive material in the receiving room. Impact sound pressure level results are standardised when the reverberation time within the receiving room is set to half a second. See also ‘normalising’.

Appendix C Compliance with the NCC

C.1 Responsibilities for regulation of building and plumbing in Australia

State and territory governments are responsible for regulation of building, plumbing and development/planning in their respective state or territory.

The NCC is a joint initiative of the Commonwealth and State and Territory Governments in Australia and is produced and maintained by the ABCB on behalf of the Australian Government and each state and territory government. The NCC provides a uniform set of technical provisions for the design and construction of buildings and other structures, and plumbing and drainage systems throughout Australia. It allows for variations in climate and geological or geographic conditions.

The NCC is given legal effect by building and plumbing regulatory legislation in each state and territory. This legislation consists of an Act of Parliament and subordinate legislation (e.g. Building Regulations) which empowers the regulation of certain aspects of buildings and structures, and contains the administrative provisions necessary to give effect to the legislation.

Each state's and territory's legislation adopts the NCC subject to the variation or deletion of some of its provisions, or the addition of extra provisions. These variations, deletions and additions are generally signposted within the relevant section of the NCC and located within appendices to the NCC. Notwithstanding this, any provision of the NCC may be overridden by, or subject to, state or territory legislation. The NCC must therefore be read in conjunction with that legislation.

C.2 Demonstrating compliance with the NCC

Compliance with the NCC is achieved by complying with the NCC Governing Requirements and relevant Performance Requirements. The Governing Requirements are a set of governing rules outlining how the NCC must be used and the process that must be followed. The Performance Requirements prescribe the minimum necessary requirements for buildings, building elements, and plumbing and drainage systems. They must be met to demonstrate compliance with the NCC. There are 3 options available to demonstrate compliance with the Performance Requirements. These are:

- a Performance Solution
- a Deemed-to-Satisfy Solution, or
- a combination of a Performance Solution and a Deemed-to-Satisfy Solution.

All compliance options must be assessed using one or a combination of Assessment Methods, as appropriate. These include:

- Evidence of Suitability
- Expert Judgement
- Verification Methods
- Comparison with DTS Provisions.

A figure showing the hierarchy of the NCC and its compliance options is provided in Figure C.1. It should be read in conjunction with the NCC.

To access the NCC or for further general information regarding demonstrating compliance with the NCC visit the ABCB website.

Figure C.1 Demonstrating compliance with the NCC

Appendix D Acoustic testing and specification

D.1 Difference between laboratory and field-testing results

The airborne sound insulation performance of walls is characterised by the "weighted sound reduction index", R_w, which may be modified to give $R_w + C_{tr}$, to account for low frequency sound energy. In a similar way, the measured floor impact performance, $L_{n,w}$ can also have a spectrum correction, C_I applied to it and, up to 2015 this was an option in the BCA. However, while the ISO 717-2 (2014) standard from the International Standards Organisation has retained this option, it was removed from the BCA in 2016 at the request of industry.

The terms R_w and $L_{n,w}$ describe acoustic properties of a material or building element. They are only measurable in a laboratory where accurate measurements are conducted with precise techniques and equipment and where noise travelling via flanking paths has been minimised in vibration isolation chambers.

The measured performance of a floor or wall panel in the field can be affected by flanking paths and non-ideal measurement conditions as outlined below.

- The size or volume of the test rooms being too small to allow uniform sound distribution at all frequencies.
- The size of the building element under test not being uniform. Variations in the size can give both higher and lower readings when compared to standard panel sizes in laboratories.
- Absorption in the field space not being uniform and invariably being greater than that in a laboratory. Noise measurements in such environments can have a reduced accuracy.
- Flanking paths via floors, ceilings, penetrations and external walls could reduce the element's apparent performance.
- Flanking via structure-borne noise may reduce the element's apparent performance.
- Background noise within field spaces are generally higher than in laboratories, potentially reducing the accuracy of tests.

Other factors can also reduce the performance of wall and floor systems. These include:

- insufficient acoustic treatment around penetrations
- insufficient acoustic sealing at the wall junctions with surrounding walls, floors, ceilings, or
- substandard wall/floor construction.

D.2 Acoustic specification

An acoustic specification is recommended for each project undertaken. The following information summarises the necessary elements of the specification. Additional requirements should be incorporated as needed.

- Nominate the acoustic performance rating for all building elements between adjoining units.
- Nominate the materials and building systems that have to meet the acoustic performance requirements. This includes all systems proposed for construction and also where alternative systems are available to the building occupants, for example changing from carpet to hard floor finishes by building occupants.
- Nominate that, where a proprietary system is used, the manufacturer's installation instructions should be strictly followed.
- Nominate the procedure for reviewing and approving alternative construction techniques.
- Nominate details on construction techniques, for example penetrations, building element constructions and the treatment of services.
- Specifying the process for establishing compliance, i.e. whether laboratory tested results or field tested results take precedence.
- Nominate who is responsible for, and the frequency of periodic inspections.
- Nominate the procedure for rectifying defects.
- Nominate who is responsible for, and the extent of, any compliance measurements to be conducted at the site.
- Nominate the maximum acceptable deviation in performance between field and laboratory results.
- Address whether the sound insulation performance of the walls or floors relies on an installed acoustic ceiling system and the minimum current and future requirements of that ceiling, i.e. what treatments are required to modify the ceiling.
- Specifying how many penetrations are permitted in the wall or floor/ceiling to maintain the acoustic rating. Consider alternative forms of treatment where excessive numbers of penetrations are proposed.
- Specify the method of treatment and support for services within wall and ceiling cavities.
- Reference to acoustic compliance does not necessarily provide compliance within other NCC requirements, for example fire-rating, structural loading, wind loading, weather proofing and energy efficiency.

D.3 Testing

A testing regime is required when the NCC sound insulation Verification Methods are used to demonstrate compliance. The main features of acoustic testing are outlined below. For a full guide on testing methods refer to the ABCB Handbook Evidence of Suitability, which can be accessed through the ABCB website.

D.3.1 Regime of testing

A selection of randomly chosen building elements should be tested. A risk assessment should be performed to determine:

- how many building elements need to be evaluated
- which building elements require evaluation
- for which building elements are the test results valid.

As a minimum, the following testing is recommended for:

- representative walls and floors/ceilings of all different types
- any building element which had faults or defects during construction.

In addition to the above:

- at least one test on each storey
- 10% of the common walls and separating floors/ceilings on a project should be tested
- for difficult or complex projects, more testing should be undertaken.

Other building elements should also be tested where there is a higher risk of non-compliance. Note that the higher the building element acoustic performance, or the more complex the structure, the greater the risk of failure.

It is worth noting that the building occupants themselves can commission acoustic testing on their own elements. Where such testing demonstrates failure with the NCC field performance requirements, then the procedures outlined in section 2.4.5 and section 2.5.5 should be used to resolve disputes.

D.3.2 Testing of completed units

Acoustic testing can be conducted in rooms before they are fully complete. For example, it is not necessary to have a room which is fully carpeted and furnished. The minimum room requirements are as follows.

- The room to be tested is to be a defined volume, preferably rectangular in shape with all four (or more) walls complete and fully sealed. The preferred size of floors and walls is 10 m^2.

- Both external and any internal glazing, and all doors, access panels and hatches to the rooms under consideration are to be installed and complete.
- No furniture or building materials should cover or shield the building element under test, on either side of the building element. All penetrations to the building element, and fittings, such as general purpose outlets, light switches, fire sprinklers, and mechanical registers, are to be installed and complete.
- Where testing sound-rated doors, then a comparative test should be conducted with the door open and closed. The overall performance of the wall/door combination is evaluated and the performance of the door itself deduced from the results.

D.3.3 Reporting requirements

Any test results should, as a minimum, state the following:

- the name of the organisation and test officer who conducted the tests
- the name of the organisation and the person who commissioned the tests
- the date and place of the testing
- which standards were used as references for the test procedure. Where departure from the standards was necessary, a statement on the effect of this departure on the results
- a description of the test sample including age, size, weight and composition
- a description of the test rooms including dimensions, volumes and finishes within the spaces
- a description of the test procedure and equipment used for testing
- a description of the microphone locations and source speaker/tapping machine locations
- a description of the test sound and how it was produced
- an indication of results which have been affected by the test conditions, and a statement of the effect, for example, of a high background sound during the testing, sound via flanking paths, etc
- a summary of the measured reverberation times, source room sound levels and receiver room sound levels in each frequency band
- the overall weighted standardised results and third-octave band frequency results, both tabulated and graphed
- an indication of the overall precision of the results.

Appendix E Resources

E.1 Australian & International Standards

The following Australian & International Standards may be applicable when measuring the acoustic performance of building elements:

- AS 1191 (2002) ‘Acoustics – Method for laboratory measurement of airborne sound transmission loss of building partitions’, Standards Australia International Ltd.
- AS/NZS 1276.1 (1999[2]) ‘Rating of sound insulation in buildings and of building elements – Part 1 – Airborne sound insulation’, Standards Australia International Ltd.
- AS/NZS ISO 717.1 (2004) ‘Acoustics - Rating of sound insulation in buildings and of building elements - Airborne sound insulation’, Standards Australia/Standards New Zealand.
- AS ISO 140.6 (2006) ‘Acoustics – Measurement of sound insulation in buildings and of building elements – Part 6 – Laboratory measurements of impact sound insulation of floors’, Standards Australia International Ltd.
- AS ISO 717.2 (2004) ‘Acoustics – Rating of sound insulation in buildings and of building elements – Part 2 – Impact sound insulation’, Standards Australia International Ltd.

E.2 Other sources

ABCB Handbook: Performance Solution Process	abcb.gov.au
ABCB Handbook: Evidence of Suitability	abcb.gov.au

E.2.1 Useful textbooks

- D. Bies, C. Hansen & C. Howard (2018) ‘Engineering Noise Control’, Taylor and Francis Group
- L. Beranek (2005) ‘Noise and Vibration Control’, John Wiley & Sons, Inc.
- P. Lord & D. Templeton (1995) ‘Detailing for Acoustics’, Taylor and Francis Group

2 Available superseded

E.2.2 Associations and Professional Bodies

The following organisations (listed alphabetically) can provide additional information on acoustic issues related to building construction:

Association of Australian Acoustical Consultants	aaac.org.au
Association of Wall and Ceiling Industries – Aus & NZ	awci.org.au
Australian Acoustical Society	acoustics.org.au
Australian Institute of Refrigeration, Air Conditioning & Heating	airah.org.au
Australian Glass and Window Association	agwa.com.au
Cement, Concrete and Aggregate Australia	ccaa.com.au
Concrete and Masonry Association of Australia	cmaa.com.au
Wood Solutions	woodsolutions.com.au