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Timber-Framed Construction for Multi-Residential Buildings Class 2 & 3

Design and construction guide for BCA compliant sound and fire-rated construction

Technical Design Guide issued by Forest and Wood Products Australia

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Introduction

This Guide covers fire and sound. It also picks up where the NCC leaves off – in areas of increasing interest to users.

Fire and sound are essential issues in residential construction. Sound insulation tends to govern the choice of construction system because of its daily impact on the quality of life. In contrast, fire-resisting construction is vital for protecting against extreme events. This Guide aims to assist in both areas and is specifically written for use by designers, specifiers, builders, code officials and certifying authorities. It is set out according to a simple step-by-step process shown in Figure 1. The steps are then used as the basis for headings throughout the rest of the document.

Scope

The National Construction Code Series Volume 1 Building Code of Australia (NCC) for Class 2 and 3 buildings has more than one Deemed-to-Satisfy provision to meet the NCC's fire resistance performance requirements. This Guide focuses on the NCC's Deemed-to-Satisfy concession contained in Specification C1.1 Clause 3.10 and 4.8 that address one to three storey timber residential buildings. The NCC solution called 'fire-protected timber' is not addressed in this Guide; readers are referred to WoodSolutions Guide #37R and #38 for more information.

The Guide provides certified construction details that utilise the NCC's Deemed-to-Satisfy Provisions. Specific areas of performance addressed include:

- sound transmission and insulation of wall, floor and ceiling elements relevant to Sole Occupancy Units and surrounding construction; and
- fire-resisting construction of wall, floor and ceiling elements relevant to Sole Occupancy Units and surrounding construction.

In addition, this Guide provides assistance for those wanting to improve and upgrade sound performance beyond minimum NCC requirements, including low-frequency impact sound, vibration-induced sound and flanking noise. Unmistakably, these issues are beginning to dominate end-user requirements and require specific attention. This Guide does not deal with all aspects of fire safety and sound insulation. For further details on this issue refer to Appendix B – Deemed-to-Satisfy fire requirements not covered by this Guide.

Finally, this Guide does not provide advice on which tested wall and floor systems should be used as there are many suppliers of these systems. The Guide provides advice in many instances on how these tested systems are joined and interact while maintaining the objectives of the NCC.

Evidence of Suitability

The NCC requires every part of a building to be constructed in an appropriate manner to achieve the requirements of the NCC. This Guide is the basis of a series of two Guides that include WoodSolutions Guide #1. These two guides have similar fire-resistance details, and these details have been reproduced in WoodSolutions Guide #6.

WoodSolutions Guide #6 is based on an assessment carried out by an Accredited Testing Laboratory – WarringtonFire Australia Pty Ltd. The materials and form of construction were submitted to the tests listed in the report, and setting out the results of those tests and any other relevant information that demonstrates its suitability for use in the building. This assessment report is 22221A, The likely fire resistance performance of various MRTFC roof and wall junctions in fire-resistant wall construction if tested in accordance with AS1530.4.

This assessment report provides evidence for use within building regulations. It is available from WoodSolutions. Other information sources that support this Guide are referenced in Appendix C of this Guide.

Other Building System Information

This Guide contains no information on the tested wall, floor and ceiling systems in timber-framed buildings. Information on these systems can be sourced from suppliers of building products, such as timber suppliers, lining manufacturers or associated product suppliers. Evidence of suitability in accordance with the NCC is the responsibility of these suppliers..

Although national, some NCC provisions differ by state. It's vital to know key variations for your area.

Regulatory Differences Between States of Australia

This publication focuses on current NCC requirements. From time to time, State/Territory-based amendments may vary requirements. Users of this Guide should make themselves aware of these differences and their implications. This edition of the Guide is also based on building regulations approved in 2020.

Step 1 – High-Level BCA Design Issues

- Determine the Class of building
  - Determine the basis for complying with BCA Performance Requirements, i.e. Deemed to Satisfy Provisions to be used
    - Determine the setout of Sole Occupancy Units in the building

Step 2 – Define BCA Sound Design Requirements

- Utilise the Deemed to Satisfy Provisions for sound transmission design
  - Determine sound-insulation requirements for elements, e.g. walls. floors and shafts

Step 3 – Improving Sound Performance

- Attention to building design (space and form)
  - Address flanking noise
    - Strategies for improving sound performance

Step 4 – Define BCA Fire Design Requirements

- Utilise the Deemed to Satisfy Provisions for fire design
  - Determine the Type of Construction required for fire-resistance
    - Determine the Fire Resistance Levels of elements, e.g. walls, floors and shafts
      - Address special fire issues, e.g. stairs, shafts and openings

Step 5 – Select fire/sound rated timber construction

- Principles in fire/sound rated timber construction
  - Select a fire/sound rated timber-framed system
    - Detail the selected system, e.g. joints, penetrations

Step 6 – Further design assistance (Appendices)

- Structural considerations, other BCA requirements, references, glossary

Figure 1: Design process for sound and fire-resistance of timber-framed construction.

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Step 1 – High-Level NCC Design Issues

This Guide covers NCC Class 2 and 3 buildings.

The NCC is the regulatory framework for determining *minimum* construction requirements for all types of buildings in Australia. It contains different levels of detail that subsequently cause different levels of decisions to be made on a building project. A selection of high-level design issues relating to fire-resisting and sound-insulating construction are addressed in this section of the Guide.

1.1 Determine the Class of Building

The NCC contains mandatory Performance Requirements that apply to 10 primary classes of building. The classes are determined according to the purpose for which the building may be used. The classes relevant to this Guide are:

- **Class 2 buildings –** buildings containing two or more sole-occupancy units each being a separate dwelling e.g. apartment buildings.
- **Class 3 buildings –** a residential building which is a common place of long-term or transient living for a number of unrelated persons, including:
  - A boarding-house, guest house, hostel, lodging-house or backpacker's accommodation
  - A residential part of a hotel, motel, school, detention centre or health-care building (where accommodating members of staff)
  - Accommodation for the aged, children or people with disabilities.

1.2 NCC Compliance – Deemed-to-Satisfy or Performance Solution

NCC's Performance Requirements can be achieved for the above building classes in two ways:

- Deemed-to-Satisfy Provisions – a specific type of construction that is acknowledged as complying with the NCC's Performance Requirements, or
- Performance Solutions – a solution not dealt with under Deemed-to-Satisfy Provisions and must be proven to satisfy the NCC's Performance Requirements; suitable assessment methods are identified in the NCC.

Refer to: NCC A0.9 and A2.2.

The construction systems and details in this Guide aim to comply with the Deemed-to-Satisfy provisions. For instance, these provisions direct the level of fire and sound resistance that construction elements must achieve in order to meet minimum NCC requirements. Approved NCC methods of assessment are used to ensure that the timber-framed construction systems shown in this Guide comply with the performance required.

If a satisfactory timber-framed solution cannot be obtained under the Deemed-to-Satisfy solutions in the Guide, a Performance Solution is required. Performance Solutions are not dealt with within this Guide, but the following WoodSolutions Guides cover the following areas.

- Timber structural components: #17 Alternative Solution Fire Compliance: Timber Structures
- Timber Facades: #18 Alternative Solution Fire Compliance: Facades
- Internal coverings: #19 Alternative Solution Fire Compliance: Internal Linings

A mixture of Deemed-to-Satisfy Provisions and Performance Solutions can be used, and is often the approach taken to develop an acceptable solution for a building. The user does not need to follow one or the other path.

1.3 More than One Deemed-to-Satisfy Fire Resistance Solution

This Guide focuses on the Deemed-to-Satisfy fire resistance solutions in NCC Specification C1.1 Clause 3.10, 4.3 and 5.1 for Class 2 and 3 building that have a rise in storey of one to three. Clause 3.10 also has a concession for four-storey buildings that have a concrete car park at the ground and three-storey of timber-framing above.

These concessions contain differing fire-resistance requirements, depending on the number of exits used or the use of sprinklers or not. The Guide explains the required fire resistance for all of the options available.

1.4 Deemed-to-Satisfy Solutions and Mass Timber

Mass timber solutions generally have greater redundant fire resistance, and the Deemed-to-Satisfy solution described in this Guide should be appropriate to mass timber use as well. In all cases, it is up to the approving authority that has jurisdiction over the acceptance of the design to decide if mass timber can be used in the Deemed-to-Satisfy solution.

1.5 Deemed-to-Satisfy Solutions Greater than a Rise of Four Storeys

This Guide does not cater for Deemed-to-Satisfy solution above a rise of four storeys. Where the project contains a rise of storeys of five or more, reference to the Deemed-to-Satisfy solution termed 'fire-protected timber' is recommended. WoodSolutions Guide #37R and #38 contain information on fire-protected timber as well as NCC provision C1.13 and Specification C1.13a.

1.6 More than One Deemed-to-Satisfy Fire Resistance Solution

The concept of a Sole Occupancy Unit is central to addressing many issues concerning fire and sound performance in Class 2 and 3 buildings. A Sole Occupancy Unit helps separate a given building into manageable units for dealing with fire and sound performance:

- A Sole Occupancy Unit is a room or other part of a building for occupation by an owner, lessee, tenant or other occupiers, to the exclusion of others.
- Sole Occupancy Units must be designed to restrict fire and sound entering adjoining Sole Occupancy Units and certain other parts of the building.

The wall and floor/ceiling elements that bound a Sole Occupancy Unit (Figure 2) are central in achieving NCC sound and fire performance, but specific requirements vary depending on whether the Sole Occupancy Units are:

- side by side
- stacked on top of each other (as well as side by side)
- adjoining rooms of a different type or space (such as a public corridor)
- adjoining rooms of similar usage back-to-back, e.g. back-to-back habitable areas or back-to-back service rooms such as laundries or kitchens.

Note: Though bounding wall and floor elements of a Sole Occupancy Unit identifies the main sound- and fire-rated elements, it is also highly likely that certain internal walls and floors may also need to be fire-rated when they are supporting fire-rated walls/floors located above.

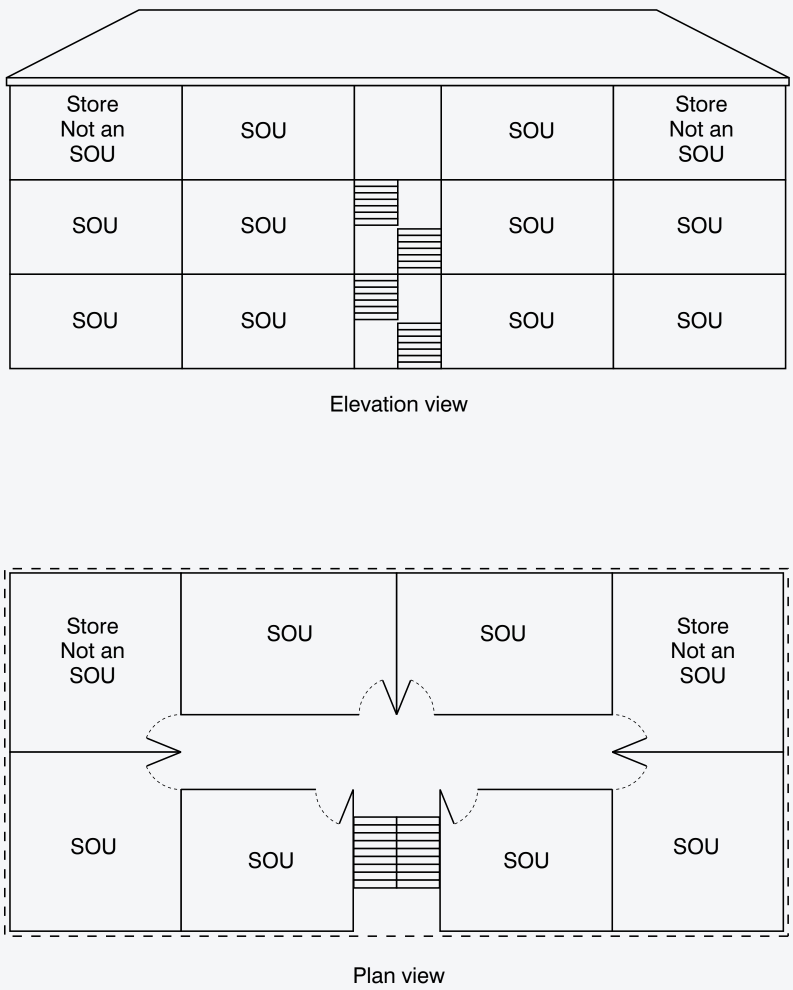


Figure 2: Examples of Sole Occupancy Units.

Step 2 – Define NCC Sound-Design Requirements

2

Refer to: NCC F5.0 to F5.7.

In today's building design, sound insulation tends to govern the choice and structural design of timber-framed construction more than fire requirements. This is best illustrated in that the wall frame configuration used is often determined by the need for sound separation, i.e. double-stud walls used to achieve discontinuous sound separation, or the addition of a floor topping for improved acoustic performance. These system requirements may affect the structural selection and sizing of the floor and wall framing. It is recommended that discussion on the acoustic performance of the building or selection of the acoustic systems occurs early in the design process to minimise redesign of the timber-framed building's design.

In terms of the NCC, designing sound-resisting construction involves a process of understanding how Performance Requirements translate into the more objective and measurable Deemed-to-Satisfy Provisions, then selecting timber-framed construction systems that suit these requirements. As discussed in Step 3, there is a parallel need to address sound induced by poor spatial design of a building, flanking noise problems, and where appropriate, upgraded sound performance requirements to meet the end-user needs.

Airborne and impact sound: different sources need different handling.

2.1 Utilising the NCC's Provisions for Sound Insulation Design

Part F5 of the NCC's Section F is concerned with 'safeguarding building occupants from illness or loss of amenity as a result of excessive noise'. NCC Performance Requirements focus on the sound insulation of wall and floor elements bounding Sole Occupancy Units where separating:

- adjoining Sole Occupancy Units
- common spaces from adjoining Sole Occupancy Units
- different building classification.

Provisions that meet the above Performance Requirements are detailed in the NCC, which covers the airborne and impact sound-insulation ratings for walls, floors and services (Note: the provisions also include the sound isolation of pumps but issues pertaining to this are not dealt with in this Guide). In interpreting these requirements, it is important to understand the difference between airborne and impact sound (see Figure 3).

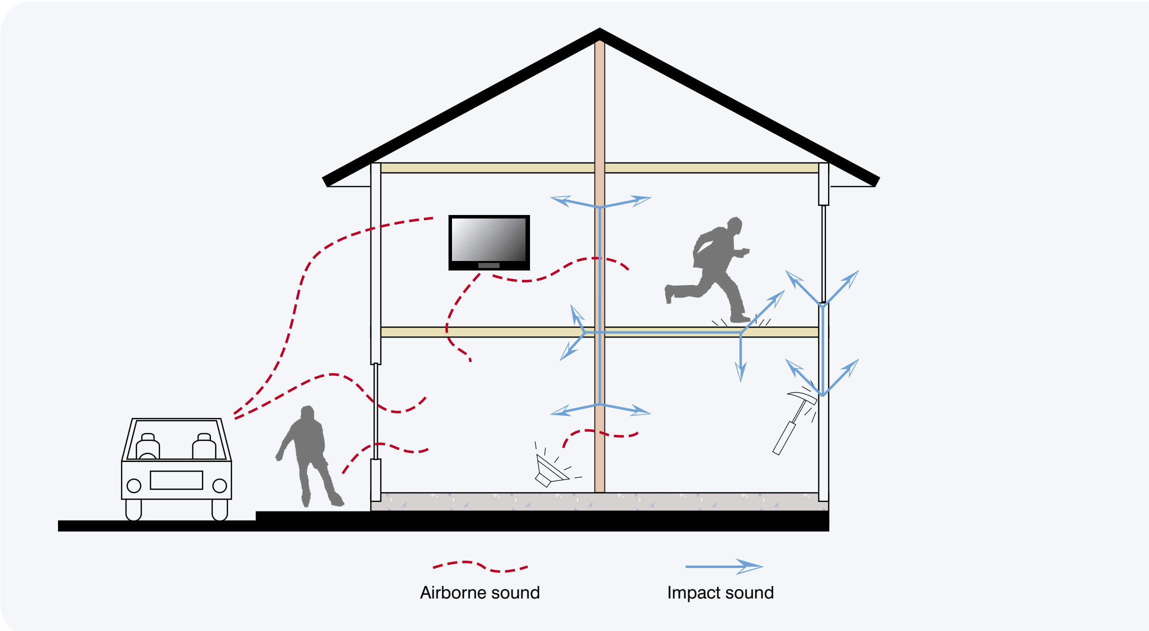


Figure 3: Examples of impact and airborne sound.

The NCC Part F5 has three methods of meeting the Performance Requirements: a Verification Method (field measuring) and two Deemed-to-Satisfy methods (Laboratory Testing or Acceptable Construction solutions). Each method is described further below.

It is important to understand how each type of sound is measured in order to select appropriately sound-insulated wall, floor and ceiling elements (see Figure 4).

Airborne sound is typically measured using the Weighted Sound Reduction Index

- It is typically applied to both wall and floor elements.
- The higher the number, the better the performance.
- It can be used on its own or modified using the spectrum adaption term C_{tr} factor (see below).

A C_{tr} modification factor can be added to the Weighted Sound Reduction Index measurement to bias the overall measurement to take greater account of low frequency noise (bass, sub-woofer).

C_{tr} is usually a negative number with a typical range of -1 to -15, and so, even though it is added to the Weighted Sound Reduction Index value, the net result is a lower number than the value on its own.

Applying the above involves finding out the minimum stated Weighted Sound Reduction Index value or value C_{tr} modification factor

Deemed-to-Satisfy Provisions as dealt with in Section 5.2 in this Guide.

Figure 4: Methods of measuring airborne sound.

For floors, impact sound is typically measured using the Weighted Normalised Impact Sound Pressure. It is:

- typically applied to floor elements
- the lower the number, the better the performance.

2.1.1 Determining Sound Insulation Requirements for Individual Building Elements Using Verification Method

The NCC contains a method to measure the performance of walls and floors in the actual building, post-construction. The Standard AS/NZS ISO 717.1 details a method to conduct site measuring of acoustic performance. Acoustic consultants often have the necessary equipment to undertake this on-site measuring.
Minimum airborne and impact sound insulation requirements for individual building elements are important for construction and this performance is not to be compromised by penetration of services or door assembly. For the NCC's Deemed-to-Satisfy performance from site measured walls see Table 1; for floor elements see Table 2.

Table 1: Minimum site measured sound insulation requirements for Class 2 and 3 walls.

Situation			Wall Rating	Entry Door Rating
First Space		**Adjoining Space**		
Sole Occupancy Unit – all spaces	Separates	**Sole Occupancy Unit – all spaces**	$D_{nTw} + C_{tr}$ (airborne) ≥ 45	N/A
Stairway, public corridor, public lobby or the like	Separates	**Sole Occupancy Unit – all spaces**	D_{nTw} (airborne) ≥ 50	D_{nTw} (airborne) ≥25
Plant room, lift shaft, part of a different NCC building	Separates	**SOU – non-habitable[3] room (including kitchen)**	D_{nTw} (airborne) ≥ 50	N/A

Table 2: Minimum site-measured sound insulation requirements for Class 2 and 3 floors.

Situation			Floor Rating
First Space		**Adjoining Space**	
SOLE OCCUPANCY UNIT – all spaces	Separates	**Sole Occupancy Unit – all spaces**	$D_{nTw} + C_{tr}$ (airborne) ≥ 45 & $L_{nT,w}$ (impact) ≤ 62
Public corridor or lobby or the like	Separates	**Sole Occupancy Unit – all spaces**	$D_{nTw} + C_{tr}$ (airborne) ≥ 45 & $L_{nT,w}$ (impact) ≤ 62
Stair and lift shaft	Separates	**Sole Occupancy Unit – all spaces**	$D_{nTw} + C_{tr}$ (airborne) ≥ 45 & $L_{nT,w}$ (impact) ≤ 62
Plant Rooms	Separates	**Sole Occupancy Unit – all spaces**	$D_{nTw} + C_{tr}$ (airborne) ≥ 45 & $L_{nT,w}$ (impact) ≤ 62
Different NCC Building Classification	Separates	**Sole Occupancy Unit – all spaces**	$D_{nTw} + C_{tr}$ (airborne) ≥ 45 & $L_{nT,w}$ (impact) ≤ 62

Clear definitions +accurate measurements = optimal results.

2.1.2 Determining Sound Insulation Requirements for Individual Building Elements Using Deemed-to-Satisfy Laboratory Tests

The NCC's Deemed-to-Satisfy solution for laboratory testing requires a prototype element to be tested to AS/NZS ISO 717.1. The performance of the element must equal or exceed various ratings for wall elements (see Table 2) and floor elements (see Table 3).

The main point is that the laboratory test results are for the sound transmission performance through the wall or floor itself, as the test specimens are isolated from the connecting structure. The consequence, the flanking noise is not addressed. The NCC compensates for this by requiring laboratory results to have 5 dB better performance than site measured (see Section 2.1.1).

Table 3: Minimum Deemed-to-Satisfy laboratory-tested sound insulation requirements for Class 2 and 3 walls.

Situation			Wall Rating	Entry Door Rating
First Space		**Adjoining Space**		
Sole Occupancy Unit – generally all spaces except those noted below	Separates	**Sole Occupancy Unit – generally all spaces except those note below**	$R_w + C_{tr}$ (airborne) ≥ 50	N/A
A bathroom, sanitary compartment, laundry or kitchen	Separates	**Sole Occupancy Unit – habitable room[1] (except kitchen)**	$R_w + C_{tr}$ (airborne) ≥50, and of discontinuous[2] construction	N/A
A bathroom, sanitary compartment, laundry or kitchen	Separates	**Sole Occupancy Unit – non-habitable[3] room (including**	D_{nTw} (airborne) ≥ 50	N/A
Plant and lift shaft	Separates	**Sole Occupancy Unit – all spaces**	$R_w + C_{tr}$ (airborne) ≥50 and of discontinuous[2] construction	N/A
Stairway, public corridor, public lobby or the like or part of a different NCC building classification	N/A	**Sole Occupancy Unit – all spaces**	R_w (airborne) ≥50	≥R_w (airborne) ≥30 (except a part of a different NCC Building classification)

Notes:

1. Habitable room: A room used for normal domestic activities includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom.

2. Discontinuous construction refers to walls having a minimum 20 mm gap between separate leaves and with no mechanical linkages between the wall leaves, except at the wall periphery.

3. Non-habitable room is a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, clothes-drying room or other space of a specialised nature, occupied neither frequently nor for extended periods. Refer NCC definition for further information.

Table 4: Deemed-to-Satisfy laboratory-tested sound insulation requirements for Class 2 and 3 floors.

Situation			Floor Rating
First Space		**Adjoining Space**	
Sole Occupancy Unit – all spaces	Separates	**Sole Occupancy Unit – all spaces**	$R_w + C_{tr}$ (airborne) ≥50, & $L_{n,w}$ (impact) ≤62
Public corridor or lobby or the like	Separates	**Sole Occupancy Unit – all spaces**	$R_w + C_{tr}$ (airborne) ≥50, & $L_{n,w}$ (impact) ≤62
Stair and lift shaft	Separates	**Sole Occupancy Unit – all spaces**	$R_w + C_{tr}$ (airborne) ≥50, & $L_{n,w}$ (impact) ≤62
Plant Rooms	Separates	**Sole Occupancy Unit – all spaces**	$R_w + C_{tr}$ (airborne) ≥50, & $L_{n,w}$ (impact) ≤62
Different NCC Building Classification	Separates	**Sole Occupancy Unit – all spaces**	$D_{nTw} + C_{tr}$ (airborne) ≥ 45 & $L_{nT,w}$ (impact) ≤ 62

Where a wall is required to have sound insulation and has the floor or roof above it, the wall must continue to the underside of the floor or roof above, or alternatively to a ceiling that has equivalent sound insulation performance as to the wall. (Seek professional advice to upgrade ceiling to the required wall sound insulation.)

Furthermore, if a duct, soil, waste or water supply pipe in a wall or floor cavity serves or passes through more than one Sole Occupancy Unit, it must be separated from the rooms of any Sole Occupancy Unit by construction that has $R_w + C_{tr} \geq 40$ if the room is habitable, or $R_w + C_{tr} \geq 25$ if the adjacent room, is a kitchen or non-habitable room.

2.1.3 Determining sound insulation requirements for individual building elements using Deemed-to-Satisfy construction solutions

The NCC's Specification F5.2 describes a limited number of timber-frame based solutions for wall and floors. In addition to the construction detailed in the table, the perimeter-framing members must be securely fixed to the adjacent structure and bedded in a resilient compound or caulked so that there are no voids between the framing members and the adjacent structure.

NCC's Specification F5.2 Table 2 describes acceptable forms of construction for walls, while NCC's Specification F5.2 Table 3 applies to floors.

2.2 The Next Step

Having used the previous information to understand the NCC's minimum sound insulation requirements, the next step is to either:

- go to Step 3 to find out about improving or upgrading sound performance (e.g. beyond minimum NCC requirements); or
- go to Step 5 to select timber-framed construction that complies with minimum NCC sound requirements.

Once sound-insulation requirements are satisfied, the next step is Step 4 Fire Design Requirements.

3

Step 3 – Improve and Upgrade Sound Performance

Quiet dwellings command premium prices, so it may pay to exceed minimum sound performance standards.

Windows and doors can thwart the best wall systems, but there are smart acoustic solutions.

Sound performance can often be improved by simple attention to the form and spatial arrangement of the building design. Attention to flanking noise represents another essential way to improve sound performance. This Step in the Guide focuses on ways to improve and upgrade sound performance.

3.1 Association of Australian Acoustical Consultants Recommended Acoustic Performance

The goal of the NCC is to have nationally consistent, minimum standards of performance. In acoustic performance, this is the lowest acceptable performance of a system for a regulatory purpose, but it may not necessarily meet occupants' needs.

The Association of Australian Acoustical Consultants (AAAC) in its 'Guideline of Apartment and Townhouse Acoustic Rating 2010' considered the various airborne sound insulation criteria in the NCC to be of a high standard, which achieves a four Star Rating. However, it considers the floor impact sound insulation verification criterion of $L_{nT,w} \leq 62$ to be of a poor standard, resulting in an AAAC two Star Rating.

In acoustic consultants' experience, a typical non-carpeted floor/ceiling installation that simply complies with the NCC impact sound insulation criterion often leads to noise complaints from adjoining occupants. The impact-generated sounds, such as footsteps and moving furniture, result in disturbances that cause significant anguish to occupants, often leading to costly legal battles in consumer tribunals.

Table 5 contains the AAAC's recommended impact performance and demonstrates the AAAC Star Rating improvement over the NCC floor impact criterion.

Table 5: Association of Australian Acoustical Consultants recommended impact performance for various uses.

Recommended Minimum	ACCC Criteria	Improvement over NCC Criterion of $L_{nT,w} \leq 62$ (dB)	AAAC Star Rating
Standard Residential apartments	$L_{nT,w} \leq 55$	7	3
Minimum for luxury residential apartments	$L_{nT,w} \leq 50$	12	4
Luxury residential apartments	$L_{nT,w} \leq 45$	17	5
Hard floor is to have comparable high performance to a carpeted floor	$L_{nT,w} \leq 40$	22	6

3.2 Building Design to Reduce Sound Transmission

Aspects of the form and spatial design of a building can be adapted to improve sound performance.

3.2.1 Room layout

Check that the room layout is beneficial rather than detrimental to sound transmission. Service rooms, including bathrooms, laundries and kitchens create extra sound compared to living rooms and bedrooms. For instance, water movement through plumbing pipes and the vibration from washing machines and dishwashers create sound problems. It is best for the service rooms in one dwelling to back onto the same type of rooms in an adjoining dwelling (but not back onto habitable rooms such as bedrooms or lounge rooms). Also, try to ensure entrances to dwellings are an appropriate distance from adjacent Sole Occupancy Units (see Figure 5).

3.2.2 Windows

Windows typically have lower sound insulation than the walls around them. As a result, highly sound-rated bounding wall systems may become ineffective by virtue of nearby poorly sound-rated windows. For improvement, consider one or more of the following:

- Use thicker glass or double glazing.
- Use fixed glazing in lieu of opening windows. (This may also require sound-insulated ventilation.)
- Locate windows so that they do not face noisy areas.
- Provide adequate separation between windows in adjoining Sole Occupancy Units.
- Reduce the area of windows in the facade.
- Fill voids between the wall frame and window frame with an appropriate acoustic sealant.
- Use acoustic sealing strips/gaskets around the edges of open-able sashes.

Flanking noise (that which passes around walls and floors) can turn up where it's neither wanted nor expected.

3.2.3 Doors

As with windows, doors tend to be the weak link in sound-rated wall systems. Where sound control is desired, solid core doors should be used and treated with soft acoustic gaskets at interfaces with door jambs threshold closers at the bottom of the door or air seals that may assist in reducing sound transmission. In most cases, the sound rating required to be met may require the use of gaskets and seals. Sliding doors should be avoided where optimum sound-control is desired.

3.2.4 Services

The location and detailing of services are two of the most important considerations in controlling sound transmission in residential buildings.

Generally, services and service penetrations should not be located on sound-insulated walls between Sole Occupancy Units but rather on internal walls or dedicated sound-resistant service shafts. In all instances, service pipes should be located away from noise-sensitive parts of the dwelling, such as bedrooms (see Figure 5).

3.2.5 External walls

There are no NCC requirements for sound ratings of external walls, but in some parts of Australia, there may be state planning regulations or local government requirements for external wall sound rating. For information on the sound performance of conventional timber-framed external walls and roofs, refer to Wood Solutions Guide #11.

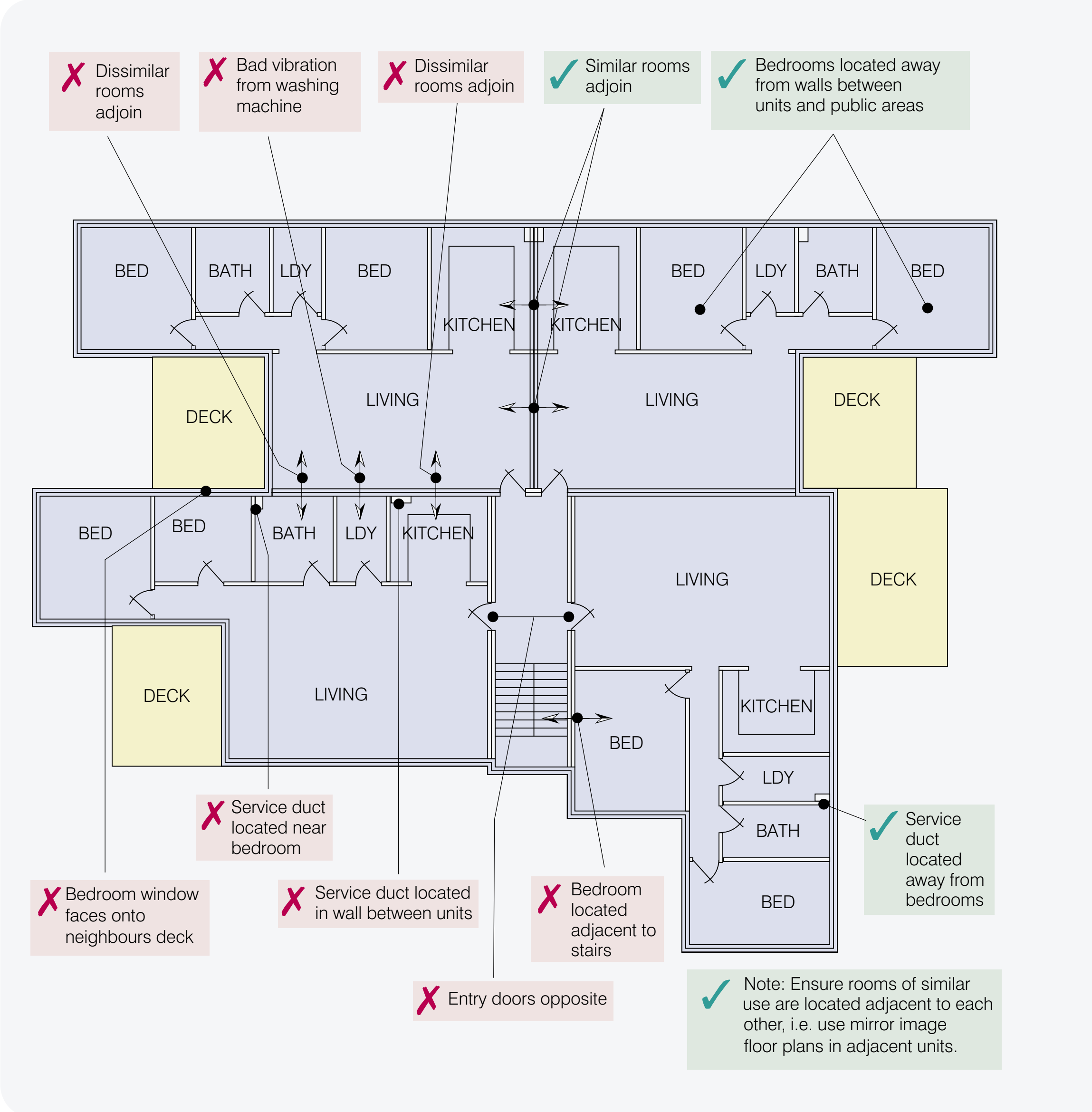


Figure 5: Good and poor sound design practices in building layout – plan view.

Solutions to flanking noise may need to be as oblique as the problem.

3.3 Addressing Flanking Noise

The ability to insulate against sound moving from one dwelling to the next depends not only on insulating individual wall and floor elements, but also on stopping noise from transferring from one building element to the next or, worse still, moving through the building in an uncontrolled way.

The effectiveness of sound-insulated construction depends on addressing flanking noise – the sound passing around rather than through wall/floor elements and manifesting unexpectedly in unwanted places.

The main flanking routes around wall and floor elements are shown in Figure 6. These routes mainly apply to walls and floors separating Sole Occupancy Units but may also apply to external walls and, in some instances, internal walls (within Sole Occupancy Units).

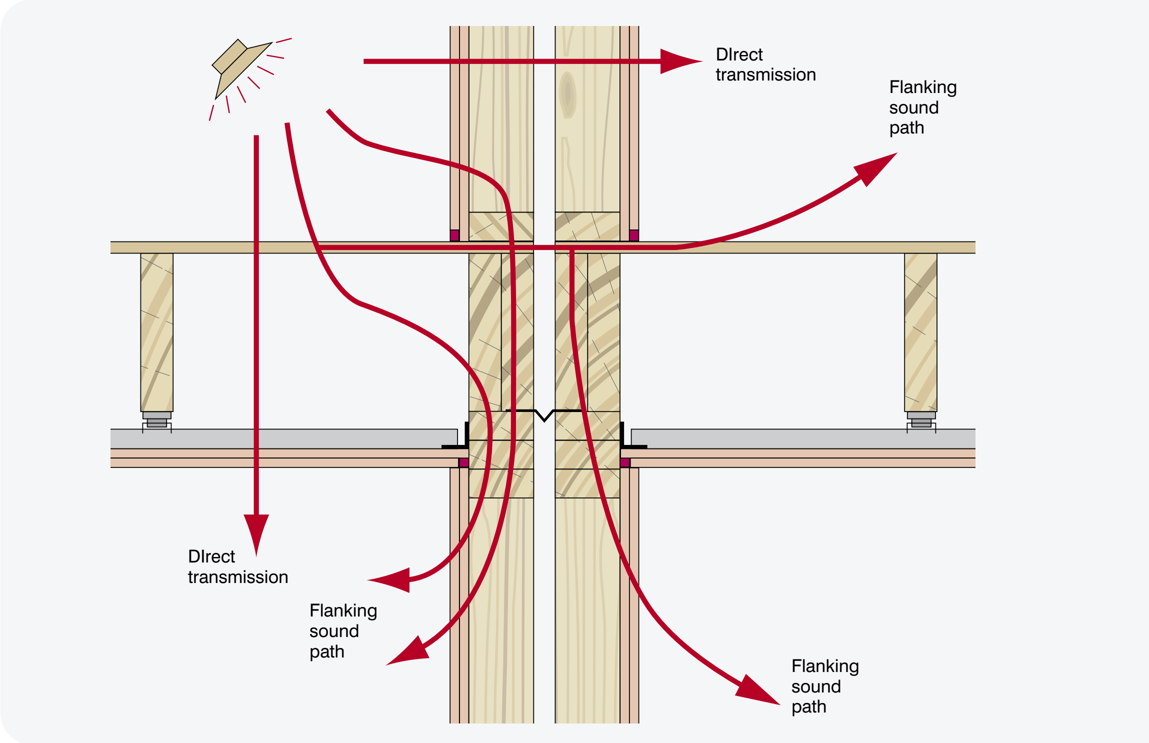


Figure 6: Flanking and direct noise pathways – elevation view.

There are no minimum requirements addressing flanking noise in the NCC's Deemed-to-Satisfy Provisions, though there is an onus on designers and builders to address flanking noise to ensure that laboratory-tested wall and floor elements perform to their full potential.

The Guide considers reducing the flanking noise paths wherever possible. In some instances, there are limits on what can be achieved because of the effect on fire and structural integrity. Even though direct reference to reducing flanking noise has not been made, many of the details incorporate elements within them.

An example of reducing flanking noise can be seen in the standard detail for floor joist and flooring over bounding walls where the joist and flooring are not continuous. This discontinuity of the floor joists has been done purely to reduce flanking noise and has no other purpose (see Figure 7), but affects the structural performance of the structure, particularly diaphragm action of the floor. A balance is needed between addressing flanking noise and maintaining a structural solution for the structure. The following section discusses strategies to minimise flanking noise that can be considered in the design.

Where user tastes (e.g. for powerful home entertainment units) outpace NCC standards, you must think outside the square.

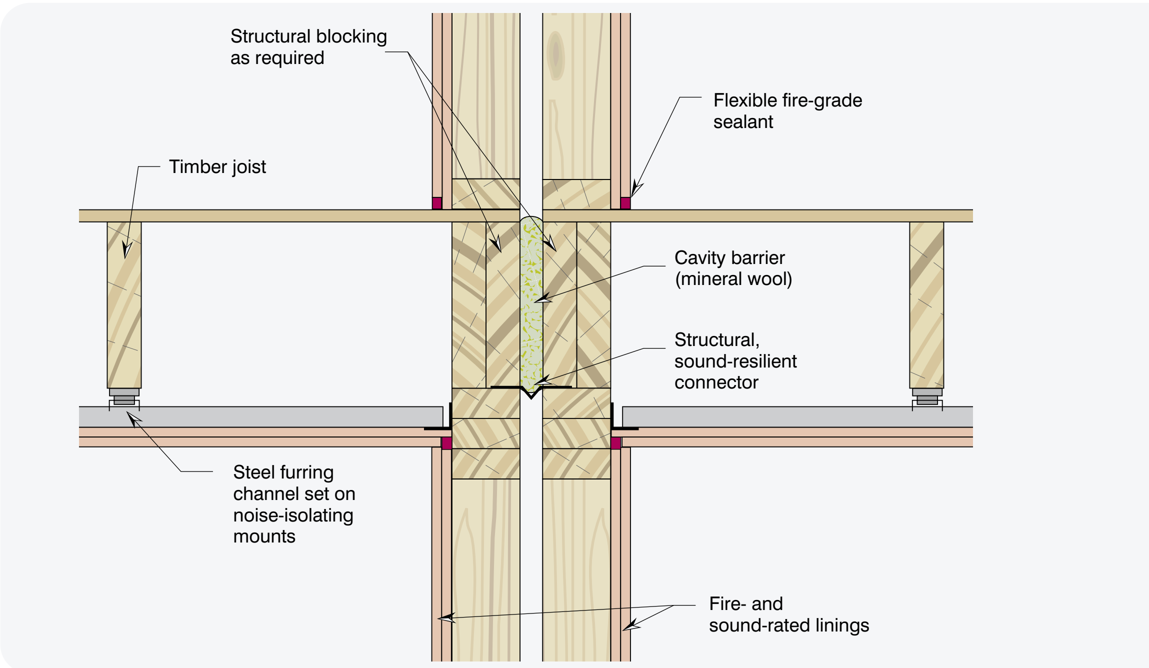


Figure 7: Discontinuous floor joist and floor sheeting – elevation view.

Sound reduction needn't be high tech. Adding mass is a simple yet highly effective measure.

3.4 Understanding Flanking Noise

Flanking transmission noise is effectively structure-borne energy (vibration). In practice, a few pathways transmit most of the energy. In timber construction, the most important paths usually involve the wall/floor junction. This is the focus of most of the following discussion.

3.4.1 Horizontal pathways

Testing at National Research Centre Canada (NRC) on several wall assembly configurations has shown that continuous structural floor sheeting across the wall/floor junction can reduce the effectiveness of the sound-insulated wall performance by 4 to 14 dBs.

The testing found that when the floor joist is perpendicular to the wall, and with floor sheets, it continuously reduces the effectiveness of the sound-insulated wall performance by 4 to 5 dBs. The worst case was found when the floor joist was parallel to the sound-insulating wall, where the effectiveness of the sound-insulated wall performance dropped by 14 dBs.

3.4.2 Vertical pathways

The NRC testing has shown that where floor joists run parallel to the wall, and are constructed with discontinuous double stud framing, the dominant flanking path is through the floor system of the room above and the supporting wall of the room below. In all cases studied by the NRC, the reduction of sound-insulated performance was 1 or 2 dBs.

NRC work found that there was slightly more vertical airborne flanking when the floor joists are perpendicular to the wall (i.e. for a load-bearing wall) than when the joists run parallel to the wall. However, the difference is small, and floor joists are generally parallel to some walls in the room below and perpendicular to others so that an average value can be used with reasonable confidence.

Vertical airborne flanking has been found to be significantly worse, only for the case when a shear wall, with the joists running parallel to the wall and the plates at the top/bottom of the wall framing directly connected to the floor system. Up to 9 dB drop of sound-insulated performance was found in this situation.

3.5 Strategies to Reduce Flanking Noise

The following discusses strategies to reduce flanking noise transmission.

3.5.1 Prevent noise vibration from getting into the structure

Sound transmission occurs when sound waves vibrate the structure and this vibration is transferred to the neighbouring structure. Reducing the sound vibration getting into the structure is the key strategy to reduce flanking noise. Sound can occur in two forms - airborne and impact; for each sound type, there are different strategies to reduce their effect.

For airborne noise, there are two methods available. The first is to isolate the room that is making the noise from the structure. This isolation can be achieved by using a resilient support structure to all linings, i.e. resiliently supported ceiling and wall linings. Resilient support floors are more difficult to construct than ceilings.

The alternative strategy is to increase the mass of the last layers of the wall and floor systems. This can be achieved by using additional heavy wall linings, i.e. having two layers of fire protective plasterboard. For floors, it can be achieved by adding mass to the top surface of the floor, in the form of additional floor sheets that have mass or the use of a cementitious based floor topping, i.e. concrete, sand/cement screed or gypsums concrete. Refer to Figure 8, as well as WoodSolutions Guide #50, for more details on floor topping options.

For impact noise, the addition of a floor topping will not significantly reduce this vibration, as the floor topping is in direct connection with the support structure, transferring this vibration directly into the support structure. To reduce impact noise vibration, a resilient mat is often used under the floor topping and above the structural floor. Alternatively, a carpet and quality underlay on top of the topping can be used.

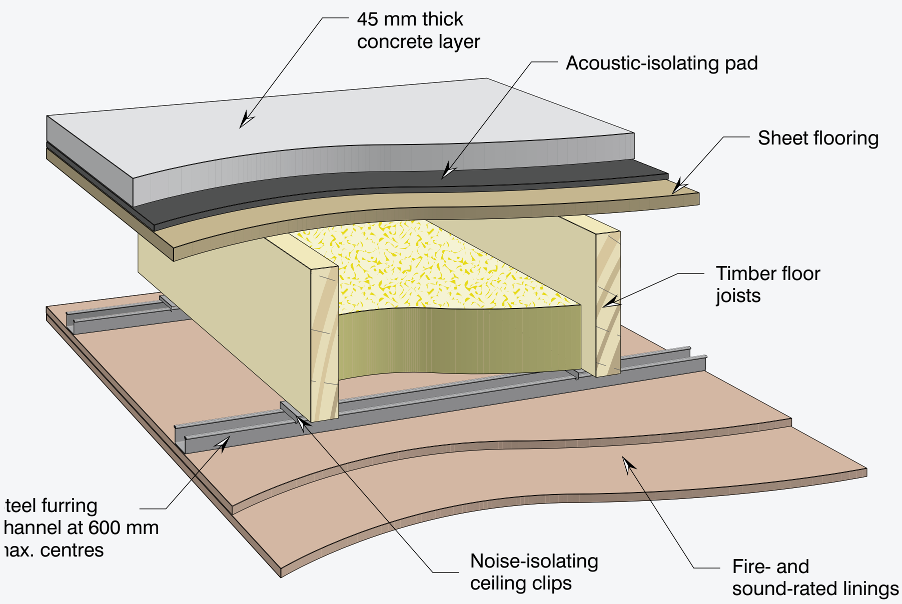


Figure 8: Concrete topping on the floor system with underlying resilient mat.

3.5.2 Strategically placed discontinuous floor sheets

Continuous floor sheet under sound-insulated walls may reduce the wall's effectiveness. However, the use of discontinuous floor sheets under the sound-insulating wall may lead to structural difficulties and inefficiencies. A method around this is the strategic placement of continuous floor sheets. The effect of noise on occupants is usually in the rooms where they spend their time, such as the lounge and bedrooms. Where these rooms abut a wall needing higher sound separation, it is recommended that the floor sheet be discontinuous. However, service rooms, i.e. bathroom, laundries, kitchens abutting similar neighbouring rooms, the impact of reduced sound insulation is less of an impact to the building occupants. Here the floor sheet can be continuous. Other areas of continuous floor sheet could be at the door thresholds, at the corridor wall.

3.5.3 Strategies for upgrading sound performance in construction

Building occupants often want higher sound performance than the minimum requirements in the NCC. This is especially the case for impact noise and the related issue of vibration from footsteps, water movement through pipes, water hammer and any other source of vibration, including washing machines, air conditioning units and dishwashers. Other scenarios not dealt with in the NCC include acoustic requirements for home entertainment areas, noise transfer within a dwelling and noise from outside the building (e.g. busy roads, trains, aircraft noise). Options for upgrading typical construction are provided below; using a combination of options is more likely to give the best performance.

Isolating one side of a bounding construction from the other (e.g. using double stud cavity wall construction) – Discontinuous construction (also known as decoupling) can be useful in reducing both airborne and impact sound. It limit snoise vibration from one side of the element to the other.

Avoiding rigid connections between the opposing sides of isolated (decoupled) elements – This limits the occurrence of sound bridges that would otherwise allow sound to transmit from one side to the other. If required for structural stability, sound-resilient connectors should be used at floor or ceiling level. Where cavity barriers are installed, use fire-resisting mineral wool (see Figure 7).

Using absorptive materials to fill wall and floor cavities – Cellulose fibre, glass fibre or mineral wool can reduce airborne sound transmission.

Sealing sound leaks – At the periphery of wall and floor elements or where penetrations are made for electrical and plumbing services.

For information for the upgrade of external walls, refer to WoodSolutions Guide #11.

Extra mass on the walls – The addition of mass is a simple yet essential means of improving sound performance in timber-framed construction. In its purest form, this involves adding extra layers of material such as plasterboard to the outer layer of the sound rated wall system.

Use 90 mm rather than 70 mm wall studs – The wider the wall, the better its sound performance is. Wider walls particularly improve the C_{rt} scores (being the modification factor for low-frequency bass noise applied to R_w scores). The simplest means of doing this is to use 90 mm wide stud instead of 70 mm wide stud in a double stud wall system.

Upgrade batts in the wall/floor – There are many different types and grades of insulation batts available in the market place. Sound insulation specific batts are best, and also, high-density materials tend to outperform low-density materials. Reference should always be made to the supplier's documented systems recommendations as some systems require insulation or linings to affect different frequencies and therefore may have differing advice.

Extra mass on the ceilings – The addition of mass is a simple yet essential means of improving sound performance in timber-framed construction. At its purest manifestation, this involves adding extra layers of material such as plasterboard to the sound rated ceiling system.

3.6 The Next Step

The strategies and methods shown in this step may involve specialist proprietary systems that go beyond the scope of this publication. As a result, the next step is to either:

- Go to proprietary system suppliers and ask for advice on how to integrate their systems with those discussed in this Guide. As part of this, care must be taken to ensure that the fire and sound performance of systems in this Guide are not compromised in any way.
- Go to Step 4 to find out about fire-resisting construction requirements so that these requirements can be considered in tandem with sound requirements before selecting the appropriate timber-framed construction in Step 5.
- Go to Step 5 to select timber-framed construction that may comply with minimum NCC sound and fire requirements.

4

Step 4 – Define NCC Fire-Design Requirements

Designing fire-resistant construction involves a process of understanding how the BCA's Performance Requirements translate into the more objective and measurable Deemed to Satisfy Provisions, then selecting timber-framed construction systems that suits these requirements.

4.1 Utilising the Deemed-to-Satisfy Provisions for Fire Design

Refer to:
NCC CP1 – CP9.

Section C of the NCC details the fire-resistance requirement for buildings. The performance requirements are concerned with safeguarding people if a fire in a building occurs. Specific attention is given to evacuating occupants, facilitating the activities of emergency services personnel, avoiding the spread of fire between buildings, and protecting other property from physical damage caused by structural failure of the building as a result of the fire.

Deemed-to-Satisfy provisions that meet the above performance requirements are detailed in the NCC under:

- Part C1 – Fire-resistance and stability.
- Part C2 – Compartmentalisation and separation.
- Part C3 – Protection of openings.

These parts deal with a wide range of issues, but it is only the fire-resistance of specific building elements (e.g. wall and floor/ceiling elements) that are dealt with in this Guide, as these elements can be of timber-framed construction. To this end, only relevant clauses from Parts C1, C2 and C3 are discussed in more detail below. To help users understand the full range of fire issues requiring consideration, a checklist is provided in Appendix B.

4.2 Determining the Type of Construction Required

Refer to:
NCC C1.2
NCC C1.5
NCC C1.1.

Given the previous discussion, the main issue of interest for timber-framed construction relates to determining the Type of Construction, as defined in the NCC, required to resist fire for a given building. The issues involved are:

- Calculate the 'rise in storeys' of the building (Note: This is an NCC term and reference to NCC provision C1.2 is recommended).
- Take into account concessions for two-storey Class 2 and 3 buildings. Relevant factors include disregarding non-combustible requirements, the number of building exits, access to open space and the use of sprinkler systems (NCC Provision C1.5).
- Determine if the construction is Type A, B or C construction (NCC Provision C1.1):
  - Type A provides the highest level of passive protection, e.g. structural elements must withstand fire-resistant period applied.
  - Type B provides lower passive protection than Type A, e.g. less of the structure must be able to withstand the fire-resistance period, but generally, the external wall remains intact.
  - Type C provides the lowest passive fire-resistance, e.g. only some elements have specified fire-resistance intended to mainly restrict the horizontal spread of fire to the adjoining dwellings.=

The chart on the next page will help you plot your course.

Figure 9 is a flow chart to assist the selection of the appropriate type of construction a building may have. It also allows users to determine if a timber-framed building solution is possible under the Deemed-to-Satisfy Provisions, or if a Performance Solution may be necessary.

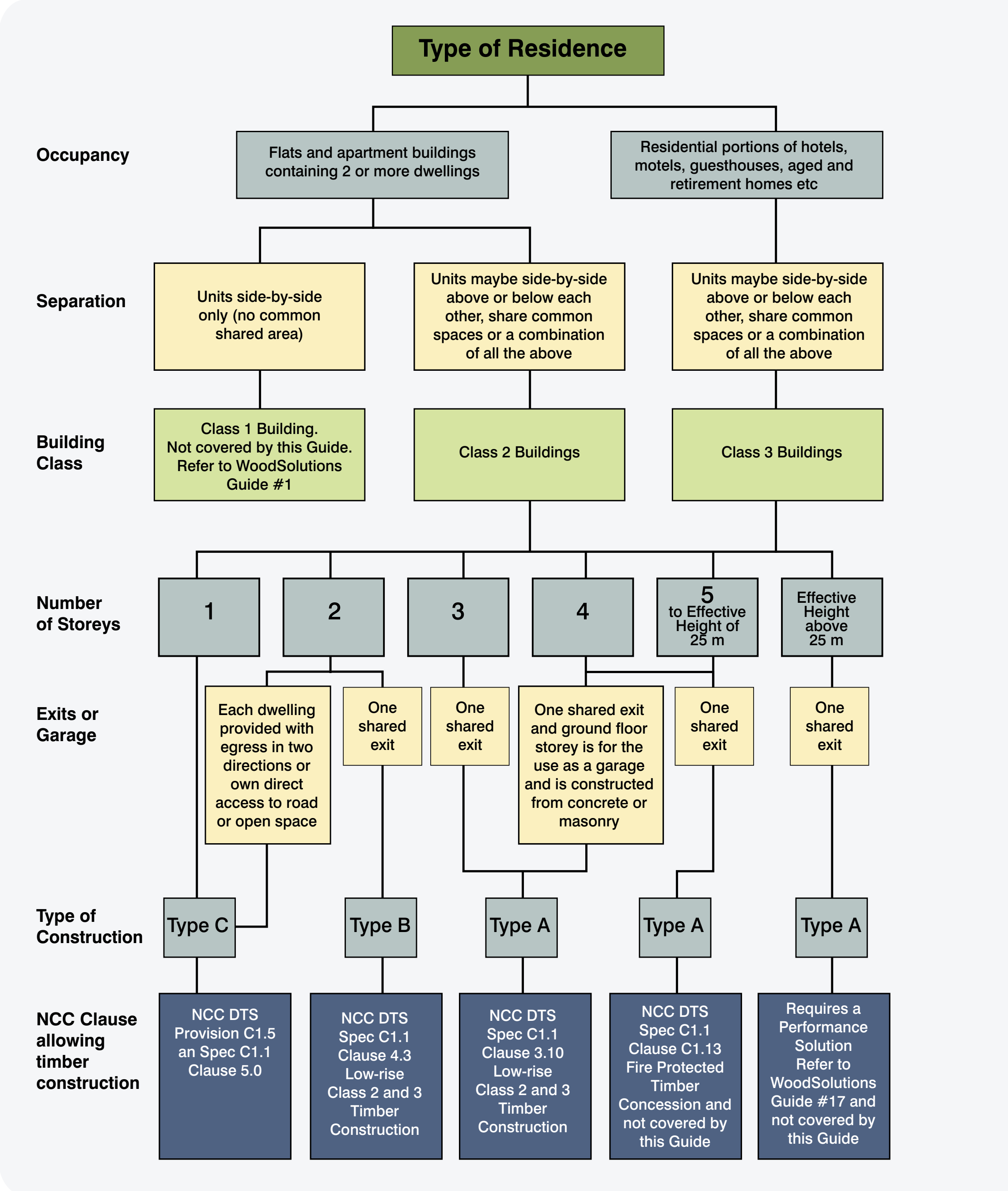


Figure 9: Determine the NCC's type of construction and applicable Deemed-to-Satisfy provision.

Refer to: NCC Spec. C1.1.

4.2.1 Two-Storey Class 2 and 3 Type C Concession

NCC provision C1.5 allows a rise of two-storey Class 2 and 3 building to be classified as a Type C construction if each Sole Occupancy Unit has either access to at least two exits (stair or ramp leading to a road or open space) or its own direct access to a road or open space (space open to the sky and connected directly to a public road) (see Figure 10).

Figure 10: Two-storey Class 2 or 3 building with direct access to an open space or road. (Image: Weathertex)

4.3 Determining Fire-Resistance Levels for Building Elements

FRL = Fire Resistance Level.

Having determined the correct Type of Construction for the building, it is now possible to determine the Fire Resistance Levels required for various wall, floor, ceiling and other building elements (Note: This is possible using specification C1.1 as called up in the NCC's Deemed-to-Satisfy Provisions).

A Fire Resistance Level (FRL) expresses the minimum amount of time (in minutes) that a building component must resist fire as defined by three separate elements:

- Structural adequacy – the ability to withstand loads.
- Integrity – in terms of containing smoke, flames and gases.
- Insulation – in terms of limiting the temperature on one side of the element getting through to the other side.

An example of the way that a Fire Resistance Level is expressed is 60/60/60. Another example where a fire rating is not required for all elements is – /60/ –.

Deemed-to-Satisfy Fire Resistance Levels for building elements in Class 2 and 3, Type A, B and C construction are provided in Tables 6, 7 and 8, and Figures 11, 12 and 13, respectively. There is more than one solution for the Fire Resistance Levels for a specific rise in storey and Type of Construction. Designers are to choose the most appropriate solution that meets their needs. The Fire-Protected Timber NCC Provision C1.13 is also a Deemed-to-Satisfy solution but is outside the scope of this Guide (refer to WoodSolutions Guide #37R).

The figures and tables referred to above are represented an interpreted version of the information contained in NCC Specification C1.1. In interpreting these figures and tables, take care to recognise the variety of different wall, floor and ceiling situations involved. Of note, this includes the particular need for roof void walls that restrict the passage of fire from one Sole Occupancy Unit to another through the roof void. An alternative which is relevant to Type A construction is the use of a Resistant to Incipient Spread of Flame ceiling, which aims to prevent the spread of flame before it gets into the roof void.

Once relevant Fire Resistance Levels have been established for all pertinent elements, it is then possible to select timber-framed construction that may meet the chosen Fire Resistance Levels requirements from Section 5. Also, it is essential to consider more specialised elements as dealt with under the following Section 5.4.

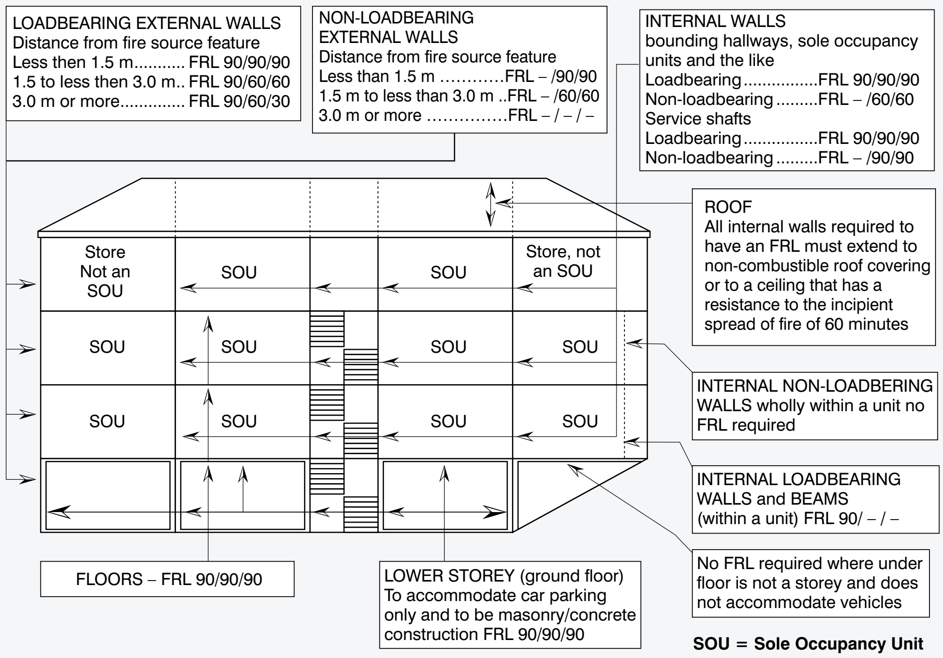


Figure 11a: Type A Construction Deemed-to-Satisfy Requirements – without sprinklers (must have smoke alarms).

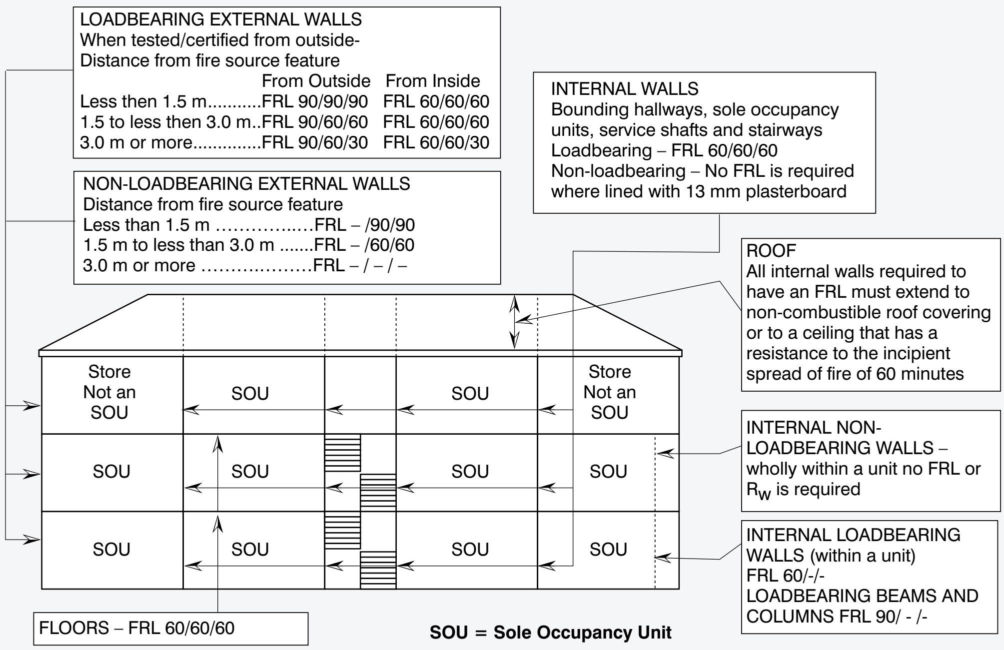


Figure 11b: Type A Construction Deemed-to-Satisfy Requirements – with sprinklers and smoke alarms.

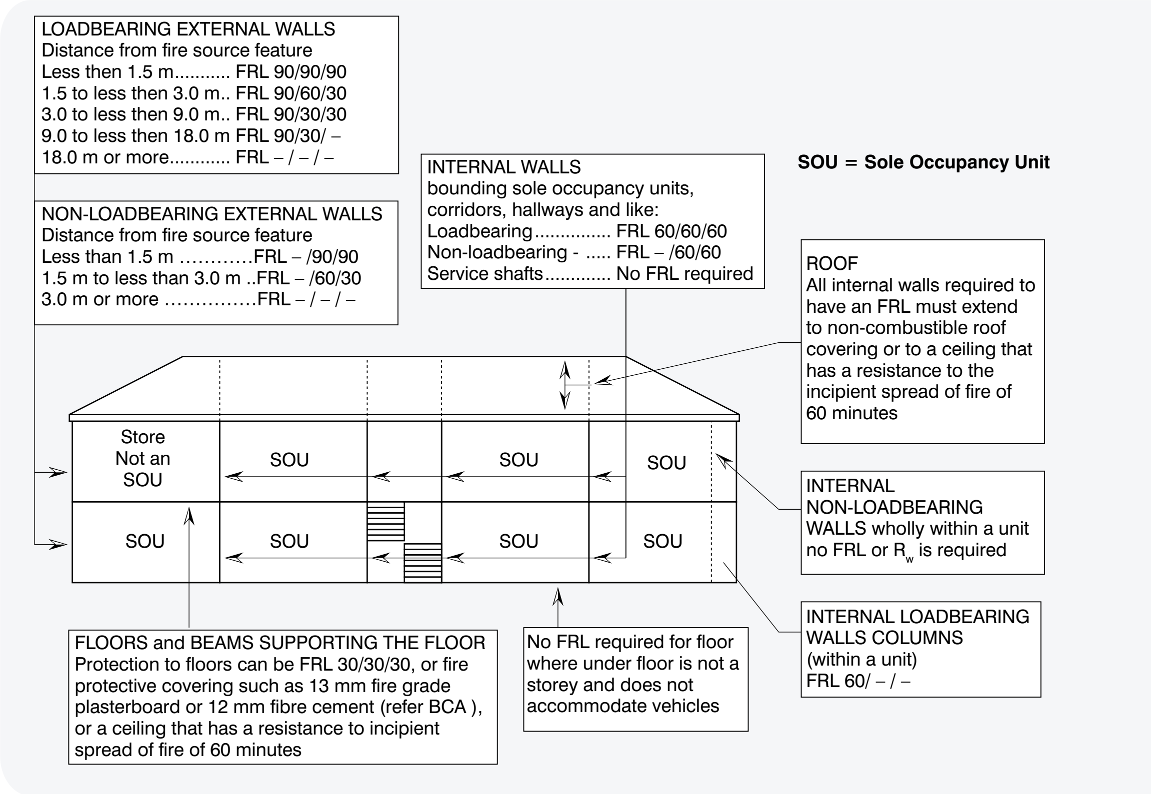


Figure 12a: Type B Construction Deemed-to-Satisfy Requirements – without sprinklers. (must have smoke alarms).

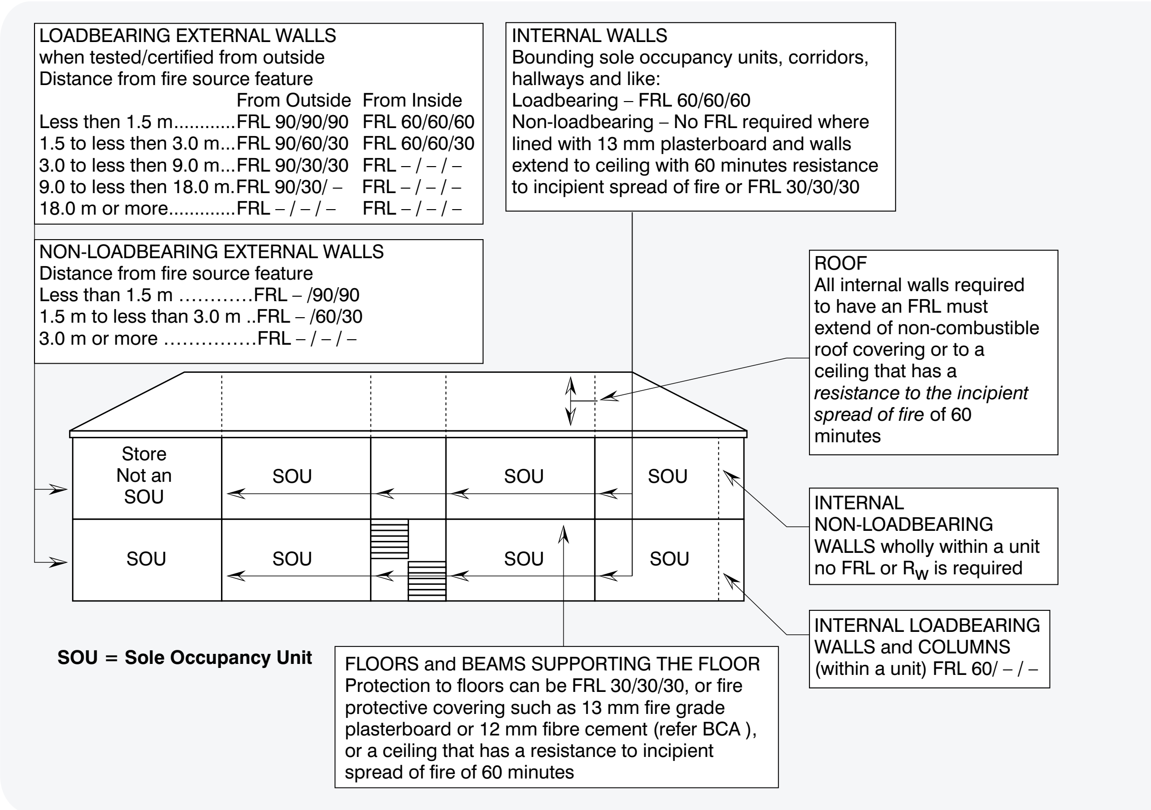


Figure 12b: Type B Construction Deemed-to-Satisfy Requirements – with sprinklers and smoke alarms.

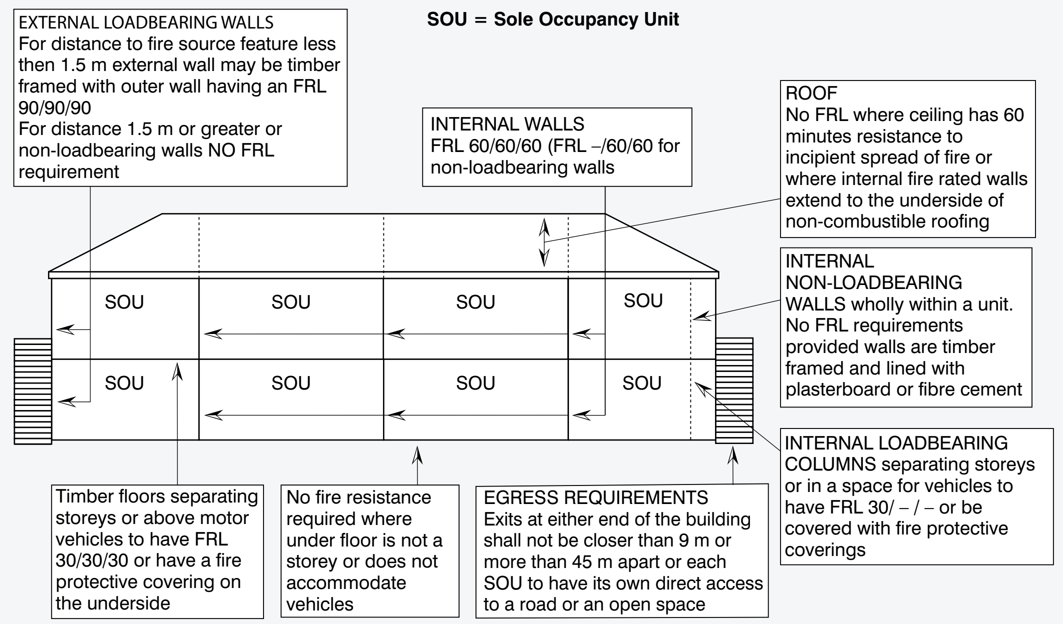


Figure 13: Type C Construction Deemed-to-Satisfy Requirements.

Table 6: Fire Resistance Level Requirements for Various Deemed-to-Satisfy Solutions for Type A Construction.

Type A		**Rise of 3 Storeys No Sprinklers**		**Rise of 3 Storeys with NCC Spec E1.5 Sprinklers**		**Rise of 4 Storeys with Concrete or masonry car park to Ground Storey**	
Element	**Condition**	**Load Bearing**	**Non-loadbearing**	**Load Bearing**	**Non-loadbearing**	**Load Bearing**	**Non-loadbearing**
External Walls	**Less than 1.5 m**	90/90/90	-/90/90	90/90/90	-/90/90	90/90/90	-/90/90
	1.5 to less than 3 m	90/60/60	-/60/60	90/60/60	-/60/60	90/60/60	-/60/60
	3 m or more	90/60/30	-/-/-	90/60/30	-/-/-	90/60/30	-/-/-
Internal Wall	**Fire-resisting lift and stair shafts**	90/90/90	-/90/90	60/60/60	13 mm Standard plasterboard	90/90/90	-/90/90
	Bounding public corridors or lobbies	90/90/90	-/60/60	60/60/60	13 mm Standard plasterboard	90/90/90	-/60/60
	Between of bounding Sole Occupancy Unit	90/90/90	-/60/60	60/60/60	13 mm Standard plasterboard	90/90/90	-/60/60
	Ventilation, pipe, garbage shafts	90/90/90	-/90/90	60/60/60	13 mm Standard plasterboard	90/90/90	-/90/90
	Other Loadbearing internal walls	90/-/-	NA	60/-/-	13 mm Standard plasterboard	90/-/-	NA
Beams	**Loadbearing only**	90/-/-	NA	90/-/-	NA	90/-/-	NA
Columns	**Loadbearing only**	90/-/-	NA	90/-/-	NA	90/-/-	NA
Floors		90/90/90	NA	60/60/60	NA	90/90/90	NA
Roofs		90/60/30	NA	90/60/30	NA	90/60/30	NA

Notes: 1. Fire Protected Timber Concession can also be used; however, it is outside the scope of this Guide.

Table 7: Fire Resistance Level Requirements for Various Deemed-to-Satisfy Solutions for Type B Construction.

Type B		Rise of 2 Storeys No Sprinklers		Rise of 2 Storeys with NCC Spec E1.5 Sprinklers		Rise of 2 Storeys with Concrete or masonry car park to Ground Storey	
Element	**Condition**	**Load Bearing**	**Non-loadbearing**	**Load Bearing**	**Non-loadbearing**	**Load Bearing**	**Non-loadbearing**
External Walls	**Less than 1.5 m**	90/90/90	-/90/90	90/90/90	-/90/90	90/90/90	-/90/90
	1.5 to less than 3 m	90/60/30	-/60/30	90/60/30	-/60/30	90/60/30	-/60/30
	3 to less than 9 m	90/30/30	-/-/-	90/30/30	-/-/-	90/30/30	-/-/-
	9 to less than 18 m	90/30/-	-/-/-	90/30/-	-/-/-	90/30/-	-/-/-
	18 m or more	-/-/-	-/-/-	-/-/-	-/-/-	-/-/-	-/-/-
Internal Wall	**Fire-resisting lift and stair shafts**	90/90/90	-/90/90	60/60/60	13 mm Standard plasterboard	90/90/90	-/90/90
	Bounding public corridors or lobbies	60/60/60	-/60/60	60/60/60	13 mm Standard plasterboard	60/60/60	-/60/60
	Between of bounding Sole Occupancy Unit	60/60/60	-/60/60	60/60/60	13 mm Standard plasterboard	60/60/60	-/60/60
	Other Loadbearing internal walls	60/-/-	NA	60/-/-	13 mm Standard plasterboard	60/-/-	NA
Beams	**Other Loadbearing internal walls**	60/-/-	NA	60/-/-	13 mm Standard plasterboard	60/-/-	NA
Columns	**Loadbearing only**	60/-/-	NA	60/-/-	NA	60/-/-	NA
Floors*		30/30/30 or fire protective covering1 or RTISF 60[2] minutes	NA	30/30/30 or fire protective covering[1] or RTISF 60[2] minutes	NA	30/30/30 or fire protective covering[1] or RTISF 60[2] minutes	NA
Roofs		-/-/-	NA	-/-/-	NA	-/-/-	NA

Note:

1. Fire Protective covering can be:
   - 13 mm fire-protective grade plasterboard
   - 12 mm fibre cement
   - 12 mm reinforced fibrous plaster.
2. RTISF 60 means resistance to the incipient spread of fire of not less than 60 minutes.
3. Fire Protected Timber Concession can also be used; however, it is outside the scope of this Guide.

Table 8: Fire Resistance Level Requirements for various Deemed-to-Satisfy Solutions for Type C Construction.

Type C		**Rise of 1 Storey No Sprinklers**		**Rise of 2 Storeys meeting NCC Provision C1.5[1]**	
Element	**Condition**	**Load Bearing**	**Non-loadbearing[2]**	**Load Bearing**	**Non-loadbearing**
External Walls[3]	**Less than 1.5 m**	90/90/90	-/90/90	90/90/90	-/90/90
	1.5 m or more	-/-/-	-/-/-	-/-/-	-/-/-
Internal Wall	**Stair shafts if required to be fire-rated**	60/60/60	-/60/60	60/60/60	-/60/60
	Bounding public corridors or lobbies	60/60/60	-/60/60	60/60/60	-/60/60
	Between of bounding Sole Occupancy Unit	60/60/60	-/60/60	60/60/60	-/60/60
	Other Loadbearing internal walls[4]	30/30/90	NA	30/30/30	NA
Columns	**Loadbearing only**	30/-/- or fire protective covering[5]	NA	30/-/- or fire protective covering[5]	NA
Floors*		30/30/30[6] or fire protective covering[5]	NA	30/30/30 or fire protective covering[5]	NA
Roofs		-/-/-	NA	-/-/-	NA

Note:
1. NCC Provision C1.5 requires each Sole Occupancy Unit to have at least two exits or own direct exist to a road or open space.
2. Schedule 5 Clause 6, removes the need for structural adequacy criteria for a non-loadbearing element.
3. External walls only require fire resistance from the outside.
4. Other loadbearing walls only require to be fire-rated if they support a fire-rated element, NCC Specification C1.1 Clause 2.2 Fire Protection for a Support of another Part.
5. Fire Protective covering can be:
   - 13 mm fire-protective grade plasterboard
   - 12 mm fibre cement
   - 12 mm reinforced fibrous plaster.
6. A building that has a rise of one storey may require a fire-resisting floor if the floor is over a basement car park or a storage area.
7. Fire Protected Timber Concession can also be used; however it is outside the scope of this Guide.

4.4 Further Requirements

This section discusses the additional requirements that may affect the fire resistance design of the building.

4.4.1 Smoke-proof walls

For Class 2 and 3 buildings, the NCC Provision C2.14 requires that public corridors greater than 40 m long, be divided by smoke-proof walls, at intervals of not more than 40 m.

For construction requirements, the NCC refers to the clause for Class 9a smoke-proof walls, NCC Specification C2.5 clause 2. This clause requires these walls to be built from non-combustible materials, extend to the fire-rated floor, non-combustible roof covering or ceiling having a resistance to the incipient spread of fire of 60 minutes. No glazing is allowed; any junction with the remainder of the building is to be stopped with non-combustible materials; and smoke doors must comply with the NCC Specification C3.4. Unfortunately, there is no timber-based construction possible.

4.4.2 Shafts

Shafts used in Type A buildings for lifts, stair shafts, ventilation, pipes, garbage or similar purpose are required to have Fire Resistance Levels of 90/90/90 or -/90/90. For Type B construction, fire-resisting lift and stair shafts are required to have a fire-resistance level of 90/90/90 or -/90/90. Also, if the star shaft supports a floor or a structural part of it, the floor or part must have a fire-resistance rating of 60/-/- and the junction of the stair shafts must be constructed so that the floor or part of the floor will be free of sag or fall in a fire without causing structural damage to the shaft. Refer to Section 5.6 for further information. For Type C construction, shafts for a stair that is required to be rated must have a fire-resistance of 60/60/60.

Where shafts have a fire-resistance they must also be enclosed at the top and bottom with fire resistance structure equivalent to a wall of a non-loadbearing shaft, i.e. Type A and B -/90/90, and Type C -/60/60. The enclosure is not required if the top of the shaft extends beyond the roof covering other than a fire-isolated stairway or at the bottom of the shaft on a concrete slab laid directly on the ground.

Details showing how to construct shafts in timber-framed construction are shown under Section 5.6.

4.4.3 Complex roof framing intersecting fire-rated walls

An open roof void may allow a fire to pass from one Sole Occupancy Unit to another. To prevent this, the NCC requires that a fire-resisting wall extend to the underside of a non-combustible roof and not to be crossed by combustible construction except for a maximum of 75 x 50 mm roof battens. For many situations, this is not practical, such as where walls intersect valleys or hips ends. In these cases, a ceiling which is Resistant to Incipient Spread of Fire is often a preferred option (see Section 5.5).

4.4.4 Vertical separation of openings in external walls

The prevention of fire spreading, via the external wall, from one floor to the next, is a requirement of the NCC Provision C2.6. It is achieved by addressing the vertical separation of openings. Vertical separation of openings only applies to Type A construction, as there is no requirement for Type B and C construction. It is also not applicable where NCC Specification E1.5 sprinklers are installed through the building, or for opening within the same stairway or where there is no fire-rated floor between openings, such as in a townhouse.

In Type A construction, where there is an opening directly or within 450 mm (measured horizontally) of another opening in the storey below, and the building is not fitted with automatic sprinklers, the NCC requires these openings to be protected a spandrel or horizontal projection (see Figure 14).

Protection can be achieved by a spandrel which is not less than 900 mm in height between the two openings and not less than 600 mm above the upper floor surface. The spandrel must have a Fire Resistance Level of 60/60/60, which in most cases is the requirement of the external wall. The non-combustible construction requirement can be ignored by NCC Specification C1.1 clause 3.10 (a).

Alternatively, horizontal construction projecting at least 1,100 mm from the external face of the wall and extending not less than 450 mm beyond the opening, either side of the wall, is required. Again the construction must have a Fire Resistance Levels of 60/60/60.

Details showing how to construct the two options in timber-framed construction are given in Section 5.7.

Refer to: NCC C2.6.

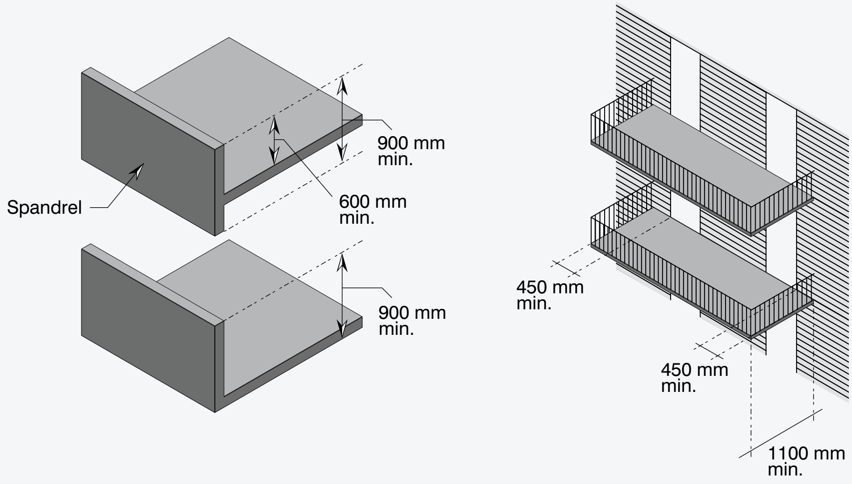


Figure 14: Required dimensions for spandrel panels.

4.4.5 Protection of openings in external walls

The NCC requires openings in an external wall that is required to have a fire-resistance level, and the distance between the fire-source feature, is less than 3 m from a side or rear boundary of the property, or 6 m from the far boundary, if not located in a storey at or near the ground level, or 6 m from another building on the property, except for a Class 10; be constructed with protection to the openings.

Acceptable protection of a doorway is internal or external wall-wetting sprinklers used with a self or automatic closing door, or a self or automatic closing fire door that has a fire resistance of -/60/30. Windows where an internal or external wall-wetting sprinklers are used must have a self or automatic closing or permanently be fixed closed.

4.4.6 Fire- and non-fire-isolated stairs and ramps used as the buildings required exits

Stairs used as exits in buildings are important to allow people to travel past a storey that may be on fire and to enable fire brigade personnel to carry out search and rescue and fire-fighting activities.

The NCC Provision D1.2 requires all Class 2 and 3 buildings less than the effective height of 25 m to have at least one exit from each storey within the building. The exception is where the two-storey Type C construction concession is used, i.e. NCC Provision C1.5, where additional exits may be required.

The NCC sets out construction requirements for two types of stairs termed *fire isolated* and *non-fire isolated*, and their use is dependent on the building's classification and how many storeys the stair or ramp has to go through.

For a Class 2 and 3 building, the NCC Provision D1.3 required only the stairway or ramp used as the required exit to be fire-isolated, if it passes through or passes by more than:

- Class 2 building - three consecutive storeys
- Class 3 building - two consecutive storeys

One extra storey is allowed for each building classification if one of the following is present

- the storey is only used for motor vehicle accommodation
- the entire building has a complying sprinkler system to NCC specification E1.5
- the stair or ramp is not used for the building's access or egress, and is separated from the extra storey by fire-resisting construction that is for loadbearing 90/90/90 and non-loadbearing -/60/60 and no opening is present to allow the passage of smoke or fire.

Stair or ramps that are required exits and do not pass through more than the maximum number of storeys for each building classification discussed above are termed *non-fire isolated*. As this Guide addresses a maximum rise in storey of three, or four if the lowest storey is a car park, then for Class 2 construction, *non-fire isolated stairs* are sufficient. For Class 3 buildings, that have more than two consecutive storeys the required stair travels pass, in this situation, a fire isolated stair may be required.

Construction details for fire isolated and *non-fire isolated stair* or ramps are discussed under Section 5.8.

Refer to: NCC D1.3.

4.4.7 Services penetrating fire-resistant elements

The NCC Specification C1.1 Clause 3.10 and 4.3 requires that where services such as pipes, ducts and electrical cables that penetrate a fire-rated wall, floor or ceiling, such penetration must not affect the fire rating performance of the building element.

Details showing how to meet this requirement are shown in Section 5.6.

4.4.8 Lightweight construction

The NCC provision C1.8 requires elements that have a Fire Resistance Levels, or that form a lift, stair shaft, an external wall bounding a public corridor, non-fire-isolated stairway or ramp, and are made from lightweight materials such as timber framing and plasterboard, must comply with NCC Specification C1.8 as lightweight construction.

NCC Specification C1.8 is an impact test for lightweight construction, as it is more susceptible to damage. In most parts, the impact test is directly related to the performance of the linings used. Manufacturers of lining material should be able to provide appropriate information on compliance with this requirement.

4.5 NCC Concessions

This section discusses the concessions available that may affect the fire resistance design of the building.

4.5.1 Non-combustibility

The NCC Provision C1.9 Non-Combustibility Building Elements and C2.6 Vertical Separation of Opening in External Walls describe where certain elements within a building of Type A and B construction are required to be made from non-combustible materials. These include external and common walls, non-loadbearing internal walls required to be fire-resisting, service shafts, and spandrel and exterior wall horizontal projections. The non-combustibility requirement can be ignored by the concession given under NCC Specification C1.1. Clause 3.10 for Type A construction and Clause 4.1 for Type B construction. For Fire Protected-Timber, another concession deals with this Deemed-to-Satisfy solution and is outside the scope of this Guide.

4.5.2 Sprinklers

Generally, sprinklers are not required for Class 2 and 3 building that have a rise in storeys of three or less. Where a building has a rise in storey of four or more, NCC Specification E1.5a requires Class 2 and 3 buildings to have sprinklers installed. Timber-based Deemed-to-Satisfy solutions must use sprinklers compliant with AS 2118.1, not sprinkler systems that use drinking or hydrant water as the water supply, i.e. FPAA101D or FPAA101H.

Where sprinklers are installed because they are required or are added voluntarily, there are concessions in the fire-resistant level that can be used. Refer to Section 4.3.

4.5.3 Concession for roofs

The NCC has a concession for roofs in Type A for Class 2 and 3 building, removing the need for the roof to be fire-resisting. Refer to Specification C1.1 Clause 3.5. There are no fire-rating requirements for a roof for Type B and C construction.

4.5.5 Ground floor concession

The ground floor is not required to be fire-rated if the ground floor is laid directly on the ground (concrete slab on ground), or the space below the floor is not a storey, or does not accommodate motor vehicles, or is not for storage or work area, or another ancillary purpose. Refer to NCC Specification C1.1 Clause 3.2 for Type A construction and Specification C1.1 Clause 4.1 (i). Also, floors that are contained entirely within the Sole Occupancy Unit are not required to be fire rated. Care is required to ensure that the floor in question is not laterally supporting a fire-rated wall because the NCC Specification Clause 2.2 Fire Protection for a Support of Another Part requires elements that provide lateral or vertical support to a fire-resisting element also need to be fire-rated.

4.5.6 Internal walls and columns storey below roof Type A concession

For the storey immediately below the roof, that does not have a fire-rated roof, refer Section 4.4.3. Internal columns and internal walls required to have a fire-resistance level can be reduced to a fire resistance level of 60/60/60, except for firewalls and walls surrounding shafts. Refer to NCC Specification C1.1 Clause 3.7 for Type A construction and Specification C1.1 Clause 4.1 (i).

4.6 Fires During the Building's Construction

There may be fires on building construction sites due to the nature of the works, such as the result of hot work (cutting and welding), heating equipment or accidental fires. Sometimes malicious arson may be the cause.

Timber-framed construction covered with fire protective linings is a very safe and economical building system. Fire-rated linings play an important role in providing this fire safety but due to the construction sequencing, there may be some time when the timber frame is not lined. This is when timber buildings are at their highest risk from construction fires.

The NCC requires a suitable means of fire-fighting must be installed in a building under construction to allow initial fire suppression by construction workers and then for fire brigade intervention. The NCC specifies that, in a building under construction that is less than 12 m in height, a fire extinguisher to suit Class A, B and C fires and electrical fires must be provided at all times on each storey, adjacent to each exit or temporary stairway or exit.

As the NCC only prescribes minimum levels of compliance, builders and building owners should consider what is actually required for the building site. Wood Solutions Guide #20 provides additional information that applies to the design and planning stages as well as the actual construction phase.

4.7 The Next Step

Having used the information above to obtain a strong understanding of the fire-resistant construction required, the next step is to go to Step 5 – Selecting Timber-Framed Construction that may comply with minimum NCC fire-resisting construction requirements.

5

Step 5 – Select Sound- and Fire-Rated Timber Construction Systems

This step focuses on matching Deemed-to-Satisfy sound-insulation levels ($R_W + C_{tr}$, $L_{n,w}$), Fire Resistance Levels (FRLs) and other necessary requirements with appropriate timber-framed construction. The commentary begins by explaining the fundamental principles used in timber-framed construction to address sound insulation and fire safety needs. These principles are then presented in the form of integrated systems, e.g. timber-framed wall, floor and ceiling systems. Importantly, construction details are provided for each system in terms of fire/sound rated junctions between elements, penetrations in elements, stair construction details, and treatment of service shafts, balconies and similar situations.

5.1 Principles for Achieving Fire Resistance Levels in Timber-Framed Construction

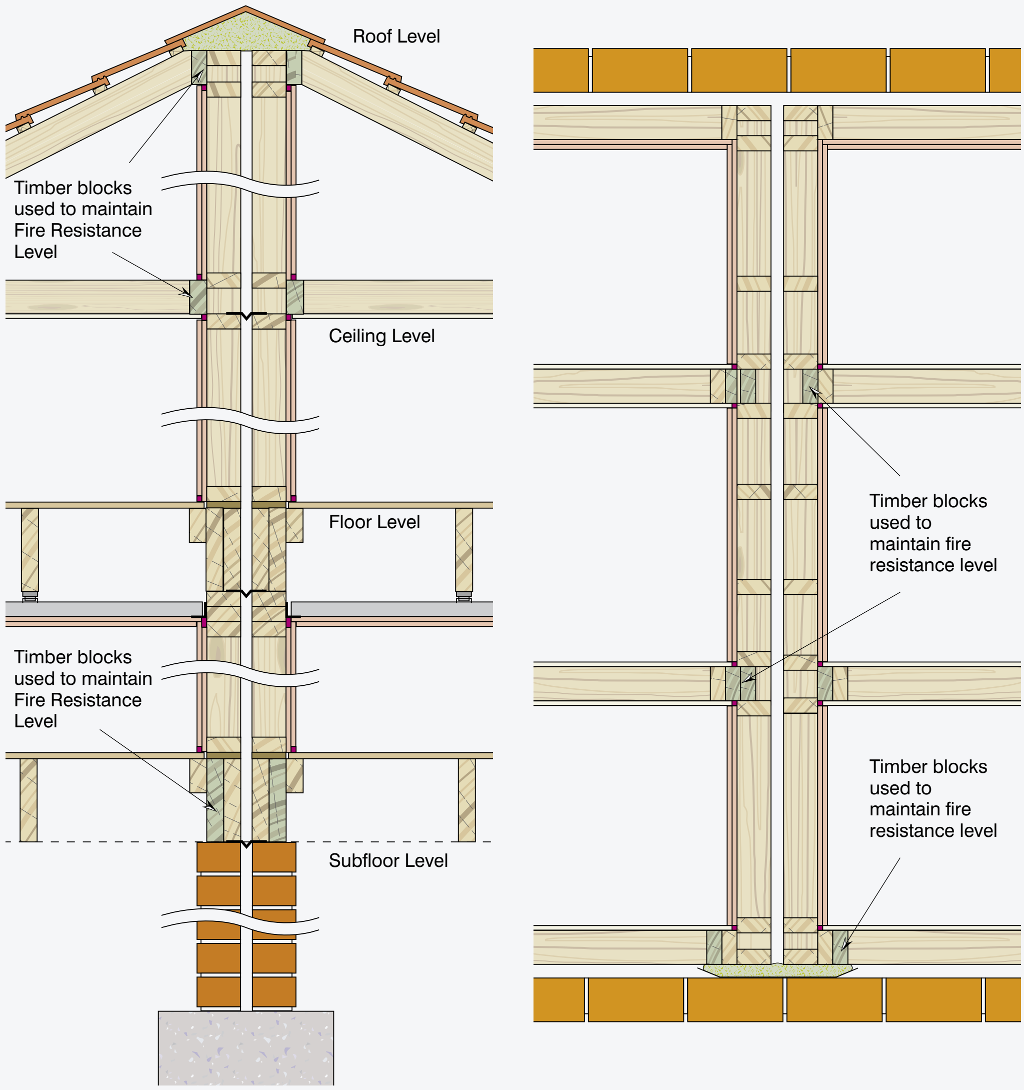
Fire-protective linings (see Appendix D for definition) provide the primary source of protection to timber framing. Generally, the higher the number of layers, the greater the resistance to fire. Additional measures, as discussed in the following paragraphs, are required at weak spots or breaks in the fire-protective linings at intersections between wall, floor and ceiling elements. Particular attention is needed for fire-protective lining's corner laps and exposed edges. Extra consideration is also needed at penetrations, openings and protrusions.

5.1.1 Timber blocks used to replace fire-protective linings

In some situations, solid timber can equate to fire-grade linings.

Owing to the sequencing of trades in lightweight buildings, it is not always possible to provide complete coverage with the fire-protective linings as framing elements often get in the way. Solid timber can be used as an equivalent to fire-protective linings in these situations, and this is mainly used where linings stop at junctions between the wall and floor elements. At these junctions, the width of the timber framework is unprotected by the linings and consequently extra studs, plates or joists are used to provide fire-resistance. This fire protection is possible because the timber of a certain thickness forms an insulating char layer as it burns. This char layer helps protect and slow the burning process for the remaining timber thickness. As a result, it is possible to predictably calculate and determine how long the timber joint may last in a fire. Though this varies according to timber density, in general, the more pieces of solid timber added to the joint, the longer the joint may last. For higher fire resistance, the joint is reinforced with a light-gauge metal angle.

Common locations where solid-timber blocks are used are where building elements that are not fire-rated or have lower fire-resistance intersect with fire-rated elements. These locations include wall, floor, ceilings and roof junctions. Figure 15 shows general locations where timber blocks can be used. It is essential that the extra timber block should not also have a structural propose unless shown otherwise. If the element is required to support a load, then these timber blocks are in addition to timberwork required for structural adequacy.



Elevation view ***Plan View***

Figure 15: Common locations where solid-timber blocks are used to maintain fire-resistance.

Fire stops are fire-protective materials used to close gaps in the construction that occur between fire-resisting materials and where service penetrates the fire-resisting barrier. They restrict heat, smoke and gases from moving beyond a certain point in the construction. There are various situations where such gaps occur, and so various options can be used to act as fire stop materials. Generally, the material and systems used are proprietary, and reference to suppliers of these products is required for application, installation instruction and evidence for certification. Figure 16 illustrates common products used in lightweight timber framing.

Figure 16: Common products used to seal penetrations in fire-rated lightweight timber-framed walls.

5.1.2 Cavity barriers

Cavity barriers are used to restrict the passage of heat, smoke and gasses within a cavity of a fire-rated barrier. Due to acoustic considerations, separation of framing elements in the floors and walls is often used, and this creates an unintentional passageway for the fire to travel within the fire-rated wall or floor elements.

For the NCC Specification C1.1, Clause 3.10 and 4.3 timber framing's fire-resistance Deemed-to-Satisfy concession, cavity barriers are non-mandatory construction in so far as not directly achieving Fire Resistance Levels in wall, floor and ceiling elements. Even so, these barriers have a clear and worthwhile purpose as they limit damage to the building from a fire and also assist in reducing flanking noise as their position in wall cavities also reduces airborne noise travelling along these cavities. For the fire-protected timber NCC Deemed-to-Satisfy solution, cavity barriers mandatory, refer to WoodSolutions Guide #37R.

Key locations where cavity barriers should be installed (see Figure 17):

- Situation 1: A barrier is required where the cavity in a brick veneer wall creates the means for a fire to bypass the fire-resisting wall bounding a Sole Occupancy Unit (see Section 5.11 for construction information).
- Situation 2: A barrier is required where the cavity in a multi-storey wall creates the means for a fire to bypass the fire-resisting floor bounding a Sole Occupancy Unit (see Section 5.11 for construction information).

Though optional, cavity barriers offer many worthwhile benefits.

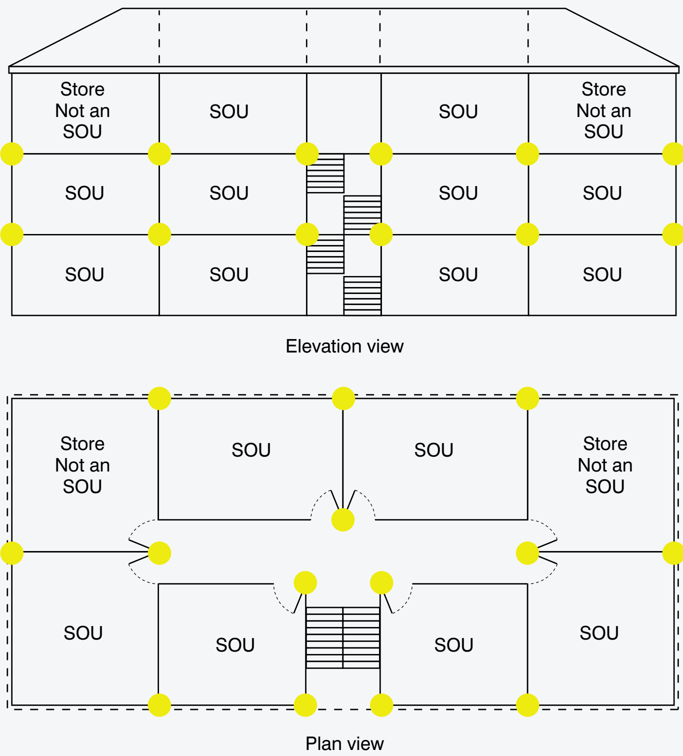


Figure 17: Key locations for cavity barriers.

5.2 Principles for Achieving Sound Insulation in Timber-Framed Construction

In timber-framed construction, airborne and impact sound requirements are primarily achieved using one or more of the following principles:

- **Increasing mass such as increasing the thickness of wall linings.** This can be particularly useful in reducing airborne sound transmission. For instance, like fire-protective linings, the higher the number of layers, the higher the increase in R_w (Note: extra factors are involved in increasing $R_W + C_{tr}$).
- **Isolating one side of a wall from the other** (e.g. using double stud cavity wall construction). This is also known as decoupling and can be useful in reducing both airborne and impact sound. Of note, it serves to limit noise vibration from one side of the element to the other.
- **Avoiding rigid connections between the opposing sides of isolated (decoupled) elements**. This limits the occurrence of sound bridges that would otherwise allow sound to transmit from one side to the other. If required for structural stability, sound-resilient connectors should be used, generally at changes in floor level.
- **Using absorptive materials to fill the wall and floor cavities** (glass fibre or mineral wall) can reduce airborne sound transmission. The NCC requires absorptive material to be non-combustible.
- **Sealing sound leaks** at the periphery of wall and floor elements or where penetrations are made for electrical and plumbing services.
- **Batten out walls in the wet area**. In wet area construction, fire/sound rated walls can be compromised where bath and shower base units need to be recessed into the wall. A simple means of dealing with this is to batten out the wall (after fire/sound resisting linings have been installed) and then provide an additional lining over the top. The bath can then be installed into the batten space without affecting the fire- and sound-rated wall. In such instances, it is best to have at least 35 mm batten space and to place insulation into the cavity (see Figure 18).

Battening wet areas protects fire- and sound-rated walls from compromise due to bath and shower installation.

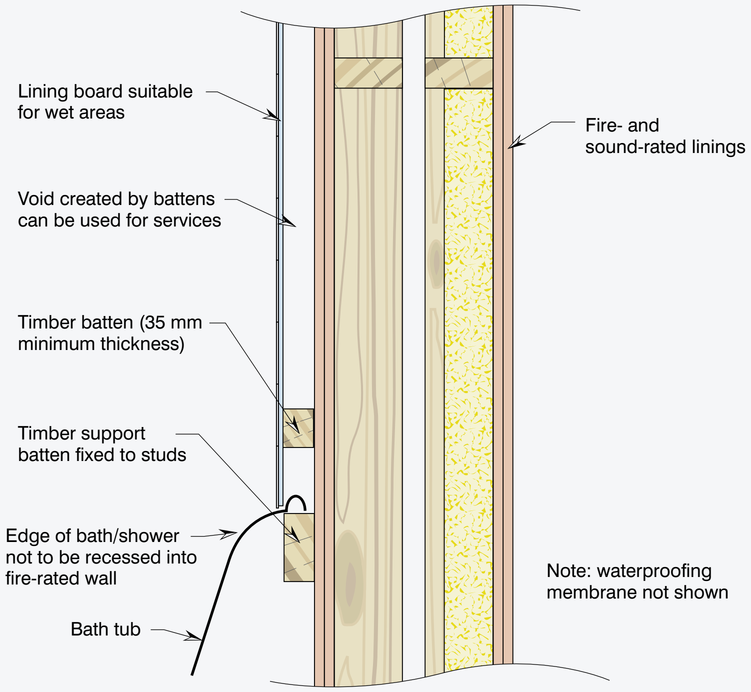


Figure 18: Batten detail for wet area walls – elevation view.

5.2.1 Floors systems

Truncating the floor joist and floor sheet so that they are not continuous over the wall framing may reduce the ability of noise from one Sole Occupancy Unit to transfer via the floor framing and floor sheet to the adjoining Sole Occupancy Unit (see Figure 19). Attention is also necessary to consider the impact on the structural performance of truncating the floor joists and floor sheet. Section 3.4.2 describes locations that have the best impact is reducing flanking noise.

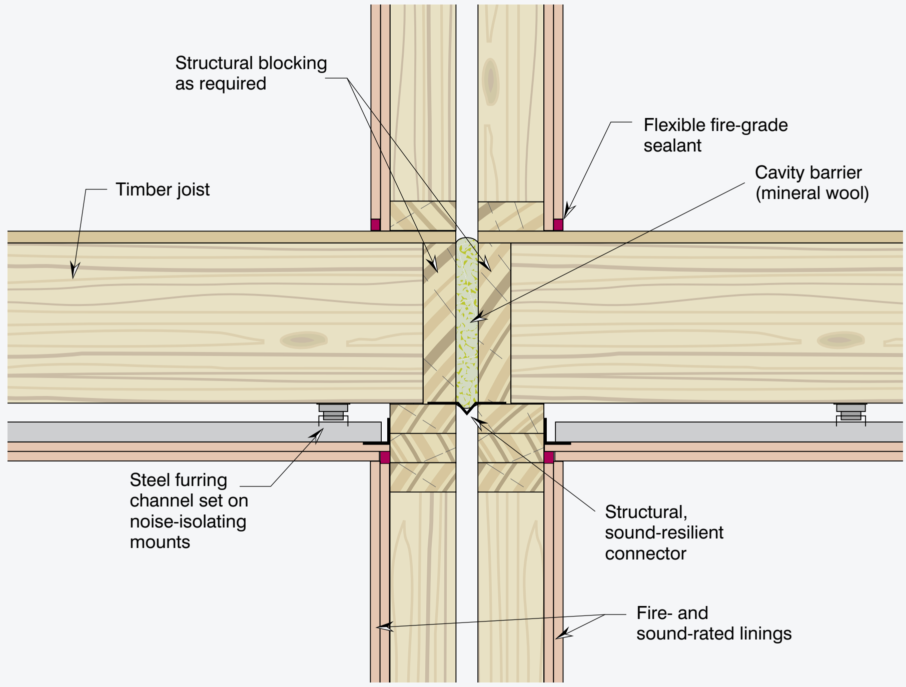


Figure 19: Truncated floor joists and floor sheet to reduce noise transfer.

Time spent choosing the right sound-resistant ceiling mount can pay dividends.

Upgrade sound-resilient ceiling mounts. Ceiling mounts are commonly used to prevent noise that gets into the floor frame coming out through the ceiling below. They help reduce sound transfer between the bottom of the floor joist and the ceiling lining. To further improve performance, some ceiling mounts now provide an isolating and damping effect. They typically force the sound energy through a rubber component that deforms slightly under load, as the sound passes from the joist to ceiling sheet. Therefore, sound-resilient mounts are not all the same; different systems have different performance and investigation is recommended (see Figure 20). Particular care is required to ensure the resilient mount has the correct mass from the ceiling to compress the resilient mount adequately.

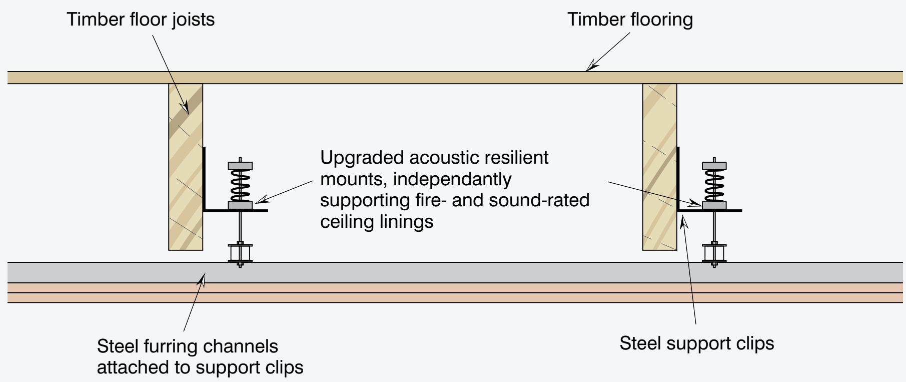


Figure 20: Upgraded sound-resilient ceiling mounts – elevation view.

Increase the mass of the top layer of floor systems. Increasing the mass of the top surface of the acoustic floor system is one of the best ways to improve acoustic performance. There are three common ways to increase mass being – concrete topping, sand/gravel or additional floor sheets.

Quantifying the improvement is difficult as the acoustic performance is aimed at improving the low-frequency performance of the floor, a phenomenon not measured by tested systems. It is suggested that the base floor and ceiling system be designed to comply with the minimum NCC sound requirements, and then additional floor mass is extra.

Few SOU residents would suspect sand in their timber floors.

When height is added to the top of the floor, consideration of the effect this has on other issues such as step up or down to wet areas, balconies, corridors, stairs, doors and windows, is needed at the planning stage.

Sand or gravel used to increase mass in timber floors. Sand or gravel increases the mass of the upper layer of the floor element. The air spaces between the particles help reduce the vibration and energy created by impact sound from footfall.

Typically, this is achieved by placing 45 mm deep battens directly over a standard acoustic floor system at typical 450 or 600 mm centres (depending on floor sheet spanning capacity). A layer of dry sand mixed with sawdust is placed between the battens and levelled just below the surface of the final floor sheet. The final floor sheet is fixed in the usual manner, and floor covering placed on this (see Figure 21).

Further information is available from Forest and Wood Product Australia research project PN04.2005 Maximising impact sound resistance of timber-framed floor/ceiling systems.

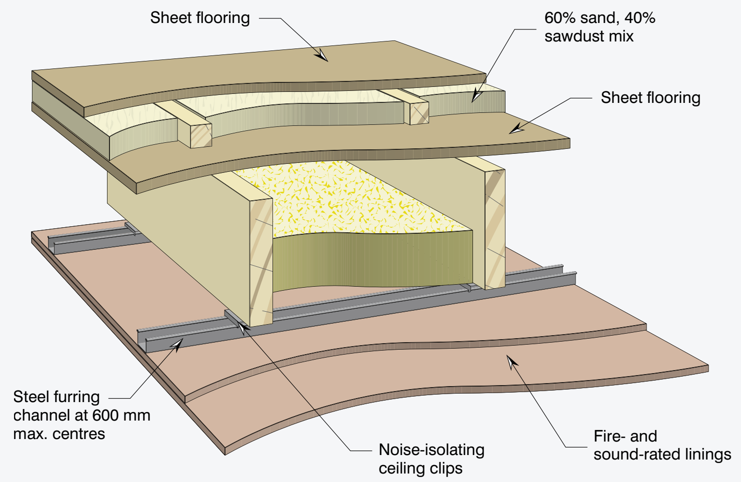


Figure 21: Adding mass to the floor system through the use of a sand/gravel top layer.

Concrete topping. The use of a 35 to 45 mm thick layer of concrete placed over an isolating acoustic mat can increase the sound performance of the floor system. Care is required to turn-up the isolating acoustic mat at the perimeter of the topping adjacent to the wall; otherwise, the effect of the topping is negated (see Figure 22).

There are several concrete toppings available, e.g. sand and cement screed, standard concrete or gypsums based concrete. Each concrete topping has its own performance, and the thickness of the topping depends on the issue, such as preventing cracking and breaking up of the topping, not generally on their acoustic performance. Refer to WoodSolutions Guide #50, Section 4.8, for further information.

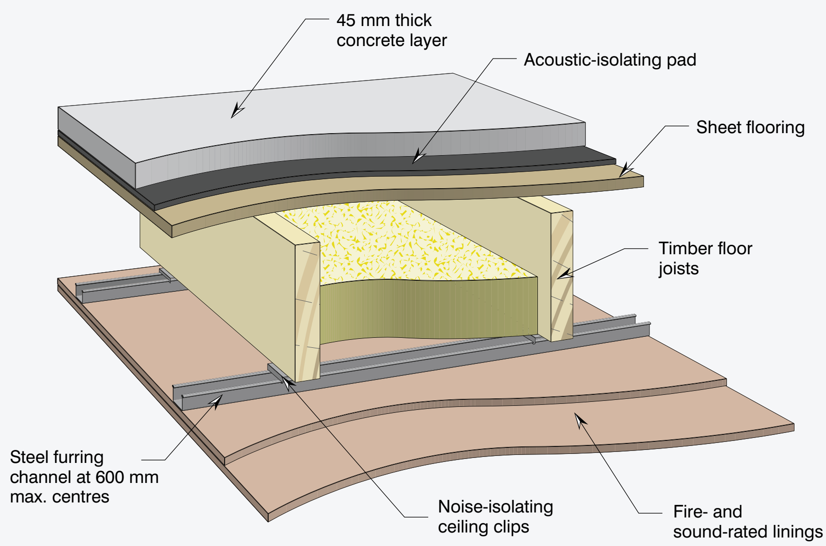


Figure 22: Adding mass to the floor system through the use of concrete topping.

Extra sheet flooring. This method uses standard sheet flooring on an isolating mat. The floor sheets are laid directly onto a resilient mat, usually with two sheets, so that the joints between the sheets can be staggered to minimise issues of movement between sheets. This system does not perform as well as the heavier mass products, sand or concrete (see Figure 23).

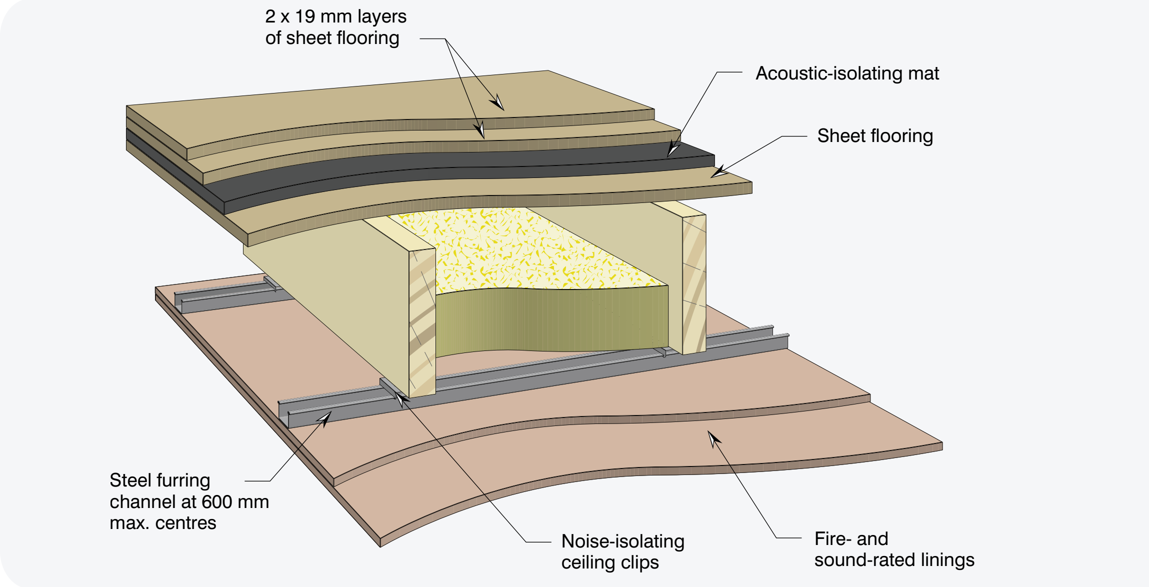


Figure 23: Adding mass to the floor system through the use of additional floor sheets.

Separate floor and ceiling frame. Separation of surfaces so there is no direct link between the surfaces provides the best acoustic performance. By having two sets of joists (separate floor and ceiling joists) which are nested between but not touching each other, it is possible to isolate the two structures, thereby minimising the transference of impact sound through the structure. Even so, care is needed with this approach to prevent flanking noise running along the floor joists and into the walls below. This can be improved by sitting the ceiling joists on strips of isolating mat (see Figure 24).

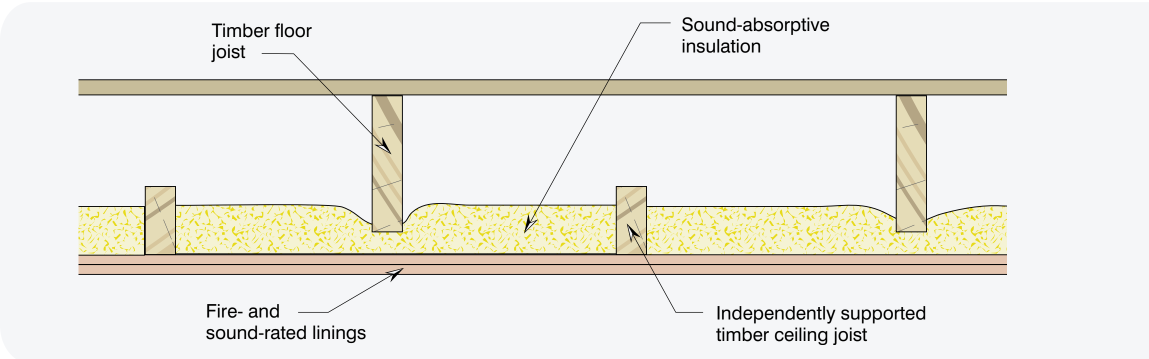


Figure 24: Separate ceiling and floor joist structures.

Isolated support for stairs. Impact sound from stair usage typically vibrates its way into walls dividing Sole Occupancy Units, thus creating a higher likelihood of sound passing across the walls and into adjacent units. The best way to prevent this is by isolating the support for the stair structure. Options include:

- using the stringers to support the stairs (top and bottom) rather than the wall between dwellings (see Figure 25)
- using Newell or independent posts to support the stair structure rather than the wall between dwellings.

Stringers are an elegant way to isolate stairs from dividing walls

Stringers lift and separate!

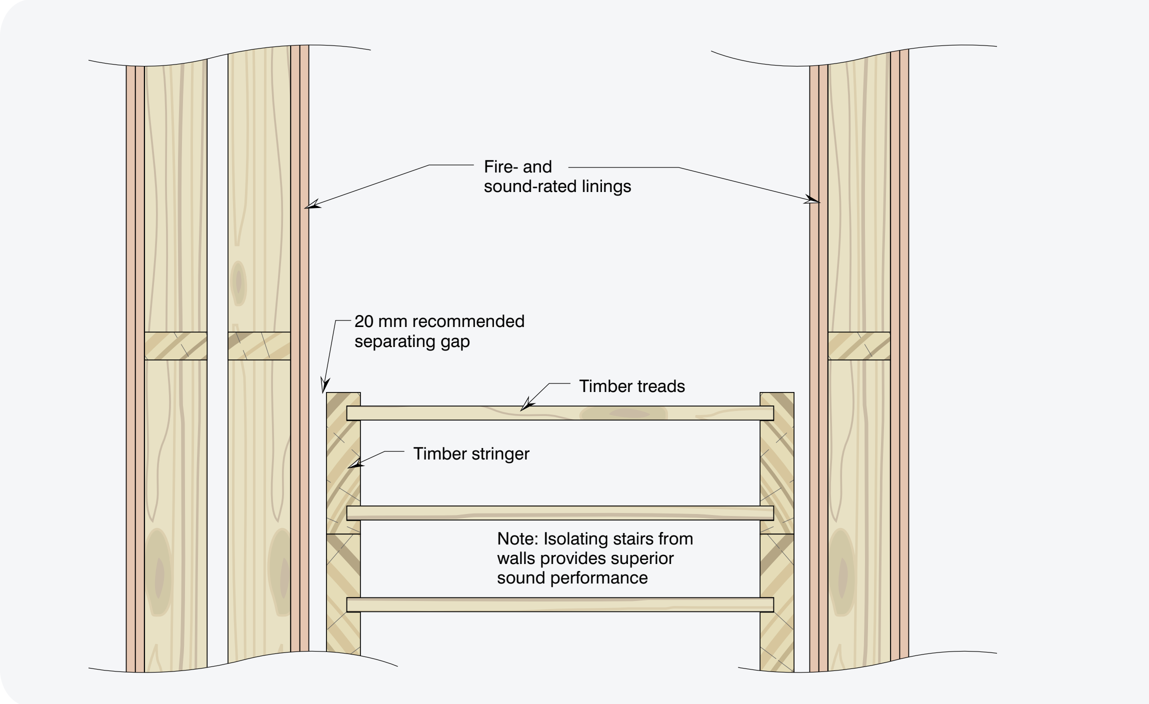


Figure 25: Isolated support for stairs – elevation view.

5.3 Sound- and Fire-Rated Wall Construction Systems

Timber-framed construction can be described in terms of the systems as depicted by the main wall, floor and ceiling elements (see Figure 26).

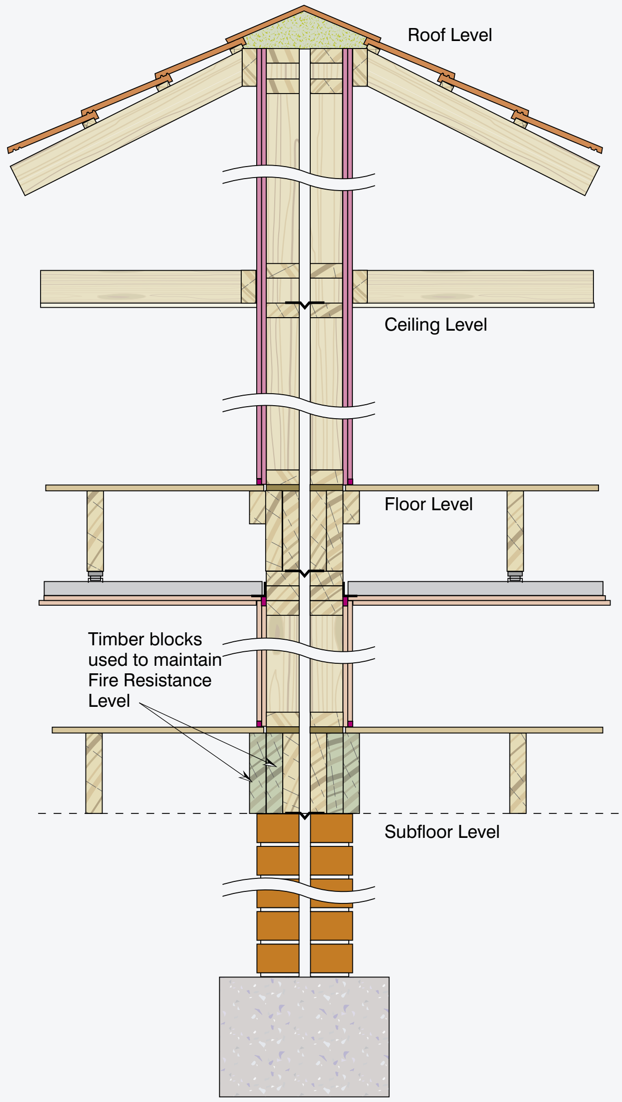


Figure 26: Main elements that make up a fire- and sound-rated timber-framed building – elevation view.

As explained previously, all the elements in Figure 26 rely on multiple layers of linings to attain to fire-protective and sound-insulation levels. Sound-absorptive insulation is also critical in the achievement of sound insulation. Further detail on each individual element in the system is discussed below.

Situation 1: Sound- and fire-resistant double stud wall (see Figure 27), mainly used between Sole Occupancy Units, where discontinuous construction is required.

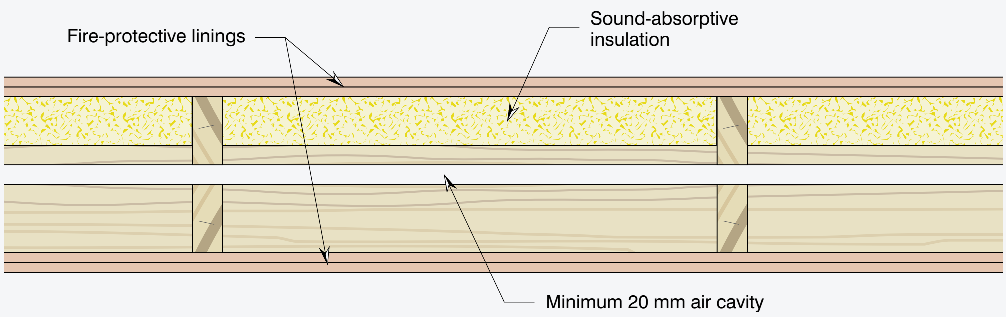


Figure 27: Fire- and sound-rated double stud timber wall – plan view.

Situation 2: Fire-resistant internal single stud wall (see Figure 28), mainly used for supporting fire-rated floors within a Sole Occupancy Unit, as they have no sound-resisting requirements.

Multiple layers + bulk insulation = good sound and fire performance.

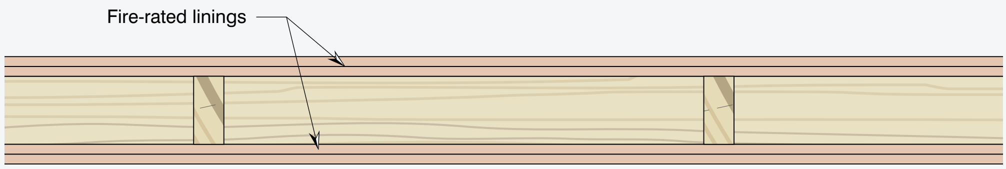


Figure 28: Fire-rated internal timber stud wall – plan view.

Situation 3: Fire-resistant external single stud clad walls (see Figure 29) are used where required to protect against an external fire source, using lightweight wall cladding.

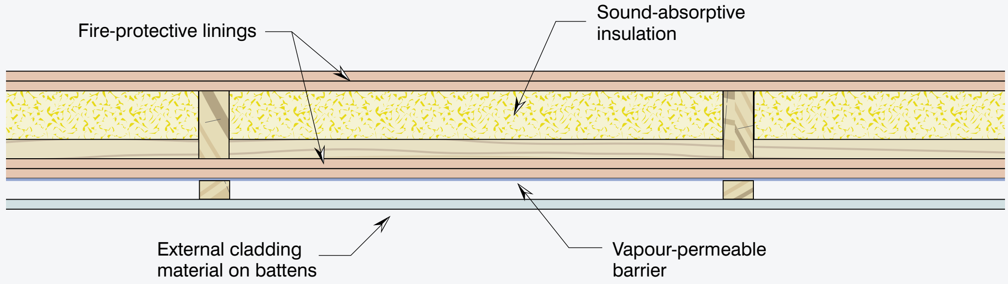


Figure 29: Fire-rated external timber stud wall – plan view.

Situation 4: Fire-resistant brick veneer external walls (see Figure 30) are used where required to protect against an external fire source.

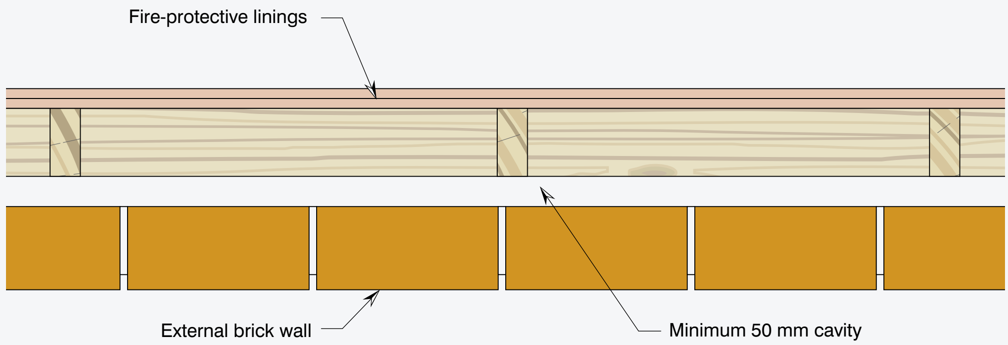


Figure 30: Fire-rated brick veneer wall – plan view.

Situation 5: Sound- and fire-resistant deep joisted floors (see Figure 31) are mainly used between Sole Occupancy Units stacked on top of each other.

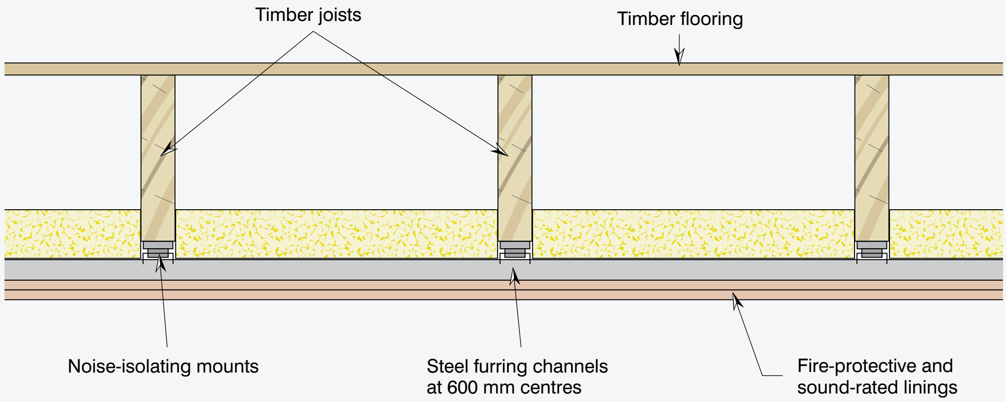


Figure 31: Fire- and sound-rated timber-framed floor – elevation view.

Situation 6: Smoke-proof walls are used to limit long corridors to a maximum length of 40 m. To meet the NCC timber-framed Specification C1.1 Clause 3.10 and 4.3 Deemed-to-Satisfy solutions, the wall and door need to be constructed from non-combustible materials, such as metal framed or masonry wall and metal door frame.

For fire-protected timber construction, the NCC concession Provision C13 allows the substitution of non-combustible construction with fire-protected timber; unfortunately, this concession can't be used for this Deemed-to-Satisfy solution discussed in this Guide. The fire-protected timber concession for smoke-proof walls can only be used if a performance solution is undertaken.

5.4 Construction Joints

The NCC provision C3.16 requires construction joints, spaces and the like in between building elements required to be fire-resisting, with the same Fire Resistance Level as the system they are in. These gaps often occur between fire-grade materials due to sequencing of trades as well as locations of service penetrations. A number of solutions are available, including:

- Fire-resisting mineral wool (see Figure 32)
- Solid-timber blocking (see Figure 32)
- Fire-grade sealant (see Figure 33)
- Or a combination of all the above.

Refer to: NCC C3.16.

'Gaps' in the system must perform as well as the system.

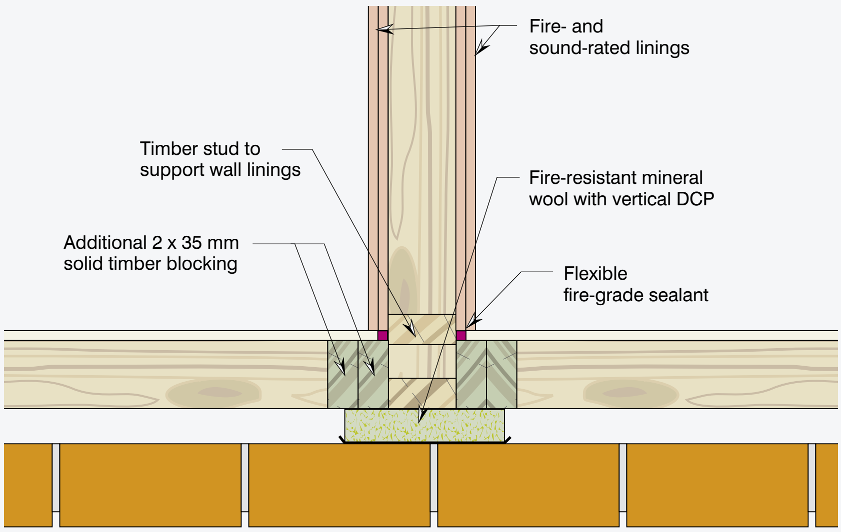


Figure 32: Fire-resistant mineral wool used to close a gap – plan view.

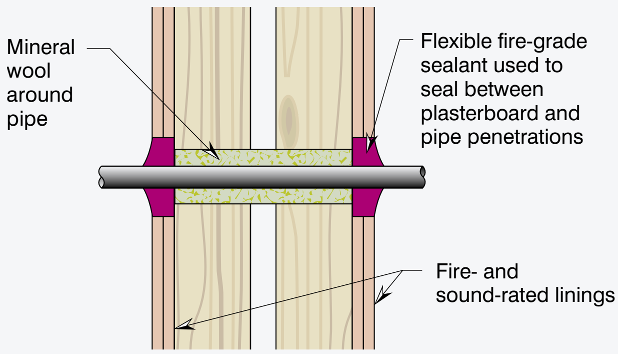


Figure 33: Fire-resistant sealant used to close a gap.

By forming a char layer, some timber elements gain fire resistance as they burn.

5.4.1 Solid Timber Construction Joints

Solid timber can be used as an equivalent to fire-protective linings, due to timber's ability to slowly char, and provide fire protection. Timber of a certain thickness can form an insulating char layer as it burns. This char slows the burning process for the remaining timber thickness and, as a result, it is possible to predictably calculate how long the timber may last in a fire. Research has been conducted to find the equivalent time of protection given by fire-protective linings that continuous solid timber has. This research is support by an assessment discussed in WoodSolutions Guide #6.

Solid timber blocking is mainly used where linings cannot be placed due to construction sequencing or load transferring function. This predominating occurs where non-fire-rated framing, such as internal non-fire-rated partition walls, or floors or roof framing abuts a fire-rated wall. Generally, extra studs, plates or joists are used to provide the required fire-resistance, in addition to the studs, plates or joists used to carry the load.

Solid timber blocks can be any species or engineered timber. They are not required to have a stress grade, but must have a density, measured at 12% moisture content, of 450 kg/m^3 or greater. Figure 34 illustrates a non-fire-rated wall abutting a fire-rated wall, suitable for 60 minutes fire-resistance. Other applications are discussed later in the Guide. Section 5.4.6 discusses a calculation method to determine the minimum thickness of the timber block.

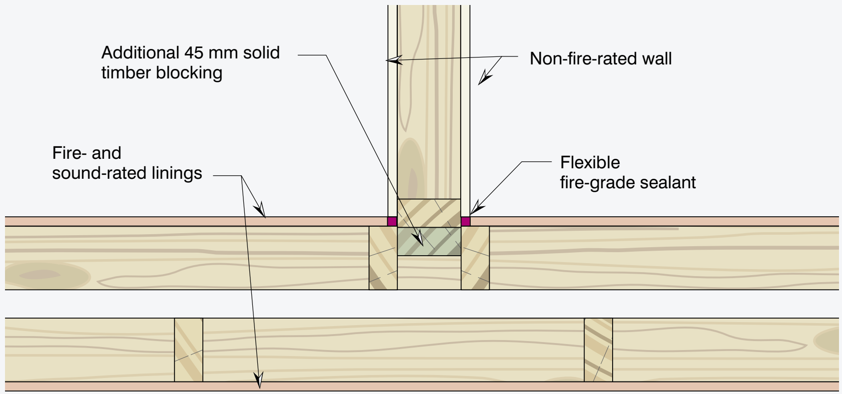


Figure 34: Non-fire-rated wall abutting 60 minutes fire-rated walls using timber blocks – plan view.

For 90 minutes fire-resisting systems, the fire-protective plasterboard adjacent to the timber blocks is required to be supported by thin gauge metal angles, 35 x 35 x 0.7 mm BMT (see Figure 35).

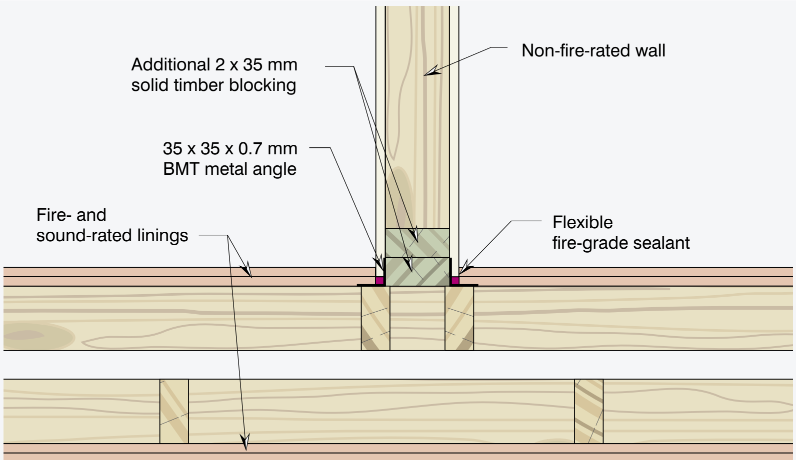


Figure 35: Timber sacrificial blocks used to close a gap for a 90 minutes system – plan view.

The system is limited to fire-resistance of 90 minutes. Where fire-resistance greater than 90 minutes is required, continuous fire-rated linings through the wall junction is recommended.

5.4.2 Common locations for construction joints

Due to the number of building classifications and types of construction covered by this Guide, there are a variety of situations when wall and floor elements may require the maintenance of the fire and sound rating. It can be simplified to the following situations:

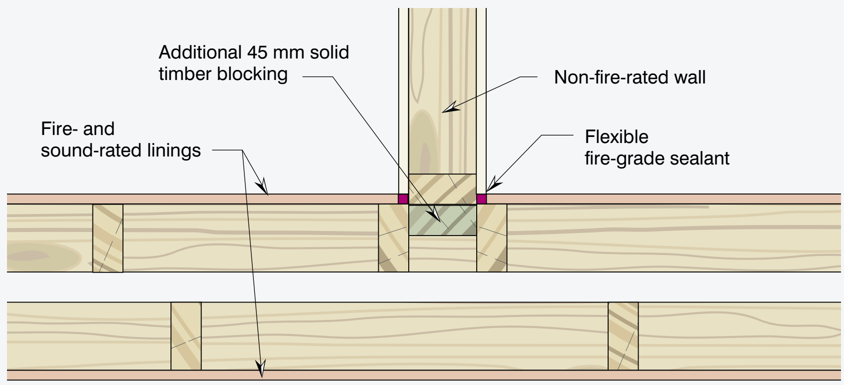
- Non-fire-rated wall, i.e. partitioned wall inside a Sole Occupancy Unit abuts a fire-rated wall element (see Section 5.4.3).
- Non-fire-rated floor, i.e. a mezzanine or floor within the Sole Occupancy Unit abuts a fire-rated wall element (see Section 5.4.3).
- Non-fire-rated roof abuts a fire-rated wall element (see Section 5.4.3).
- Fire-rated wall and floor elements abut, both have fire resistance but one is lower than the other (see Section 5.4.4).
- Fire-rated wall and floor elements abut but have the same Fire Resistance Level (see Section 5.4.5).

As explained in Section 5.1, solid timber is used as an equivalent to fire-protective linings; the more blocks or thicker the block is, the greater the fire resistance achieved. The use of timber blocks is an important means of making fire-resisting joints between wall, floor and ceiling elements in timber-framed construction and is a principle that can be used for situations not covered by this Guide.

Such joints are generally only required where there is a break in the fire-protective lining, and this generally excludes situations where two of the same Fire Resistance Level elements intersect. Instead, the emphasis is on junctions between non-fire-rated elements and fire-rated elements, or lower fire-rated elements meeting more highly fire-rated elements. The systems described later do vary, depending on the fire-resistance required. Generally, this difference is that timber blocks alone only work for a 60 minutes system, while a 90 minutes system requires 2 x 35 mm thick timber blocks as well as being reinforced with a metal angle or flashing. Further information on the principles of this method and reference to an assessment can be found in WoodSolutions Guide #6.

Non-fire-rated wall abutting fire- and sound-rated wall

The system in Figure 36 depends on solid-timber blocks replacing the fire-protective linings and can be used wherever the non-fire-rated wall abuts a fire- and sound-rated wall. The important point is that the addition of the timber blocks is supplementary to the framing required for structural purposes. This system is limited to FRL 60 minutes and requires the addition of 1 x 45 mm block or 2 x 35 mm blocks.



While solid wood blocks can add fire safety, they must be supplementary to structural framing.

Figure 36: Non-fire-rated walls abutting fire- and sound-rated walls using timber blocks – FRL 60 minutes.

Light gauge metal angles do more than reinforce joints.

Systems with an FRL of 90 minutes require the use of 0.7 mm BMT light-gauge metal angle to reinforce the joint (see Figure 37). This is in addition to the 2 x 35 mm solid-timber blocks that are also required.

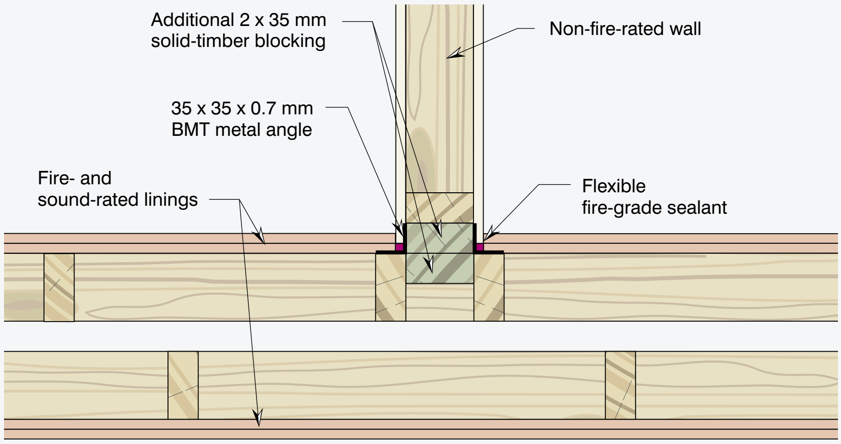


Figure 37: Non-rated wall abutting a fire- and sound-rated wall using metal angles – FRL 90 minutes – plan view.

Non-fire-rated walls abutting fire-rated walls

Non-fire-rated walls abutting fire-rated walls can occur within a Sole Occupancy Unit or where no sound rating is required. The principle is the same: where the fire-protective linings cannot be placed, solid-timber blocks can substitute for the linings. The technique to deal with them is similar to Figure 36. This system is limited to 60 minutes and requires 1 x 45 mm or 2 x 35 mm timber blocks (see Figure 38).

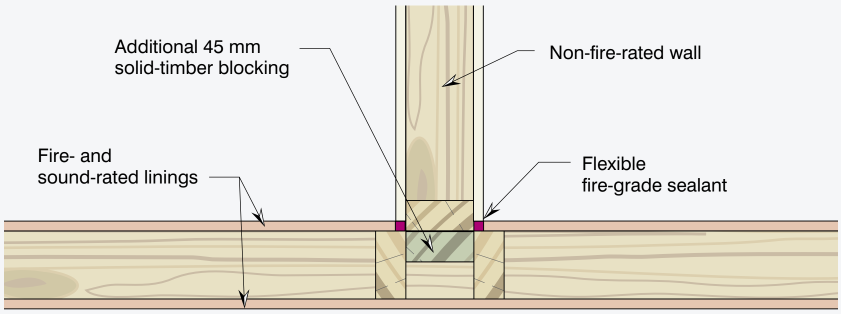


Figure 38: Non-rated wall abutting fire-rated wall using timber blocks – FRL 60 minutes – plan view.

Similarly, for an FRL of 90 minutes, light gauge metal angles and 2 x 35 mm timber blocks are required (see Figure 39).

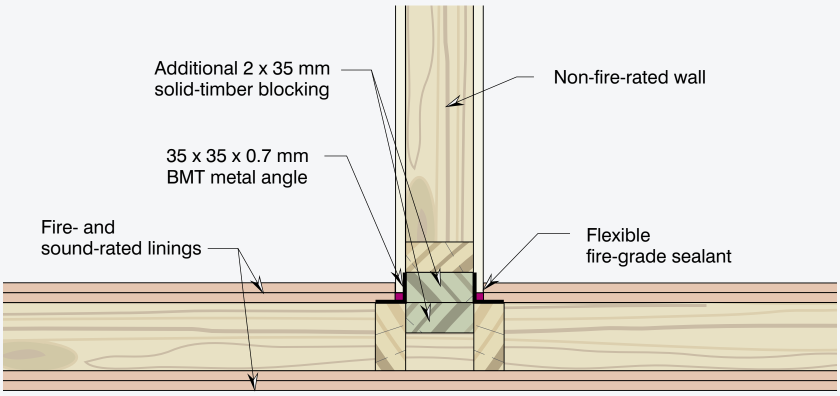


Figure 39: Non-rated wall abutting fire-rated wall using timber blocks and 35 mm metal angle – FRL 90 minutes – plan view.

Internal non-fire-rated floors abutting fire-rated walls

There are times when floors maybe abutting a fire-rated wall but are not fire rated, such as an internal floor to a Sole Occupancy Unit commonly found in Class 2 or 3, two and three-storey townhouse, or mezzanine floors. In these cases, the same principle is used, with timber blocks replacing fire-resistant linings (see Figures 40, 41 and 42 for FRL 60 minutes system and Figures 43, 44 and 45 for FRL 90 minutes). Additional solutions for 60 minutes fire resistance are available in WoodSolutions Guide #1.

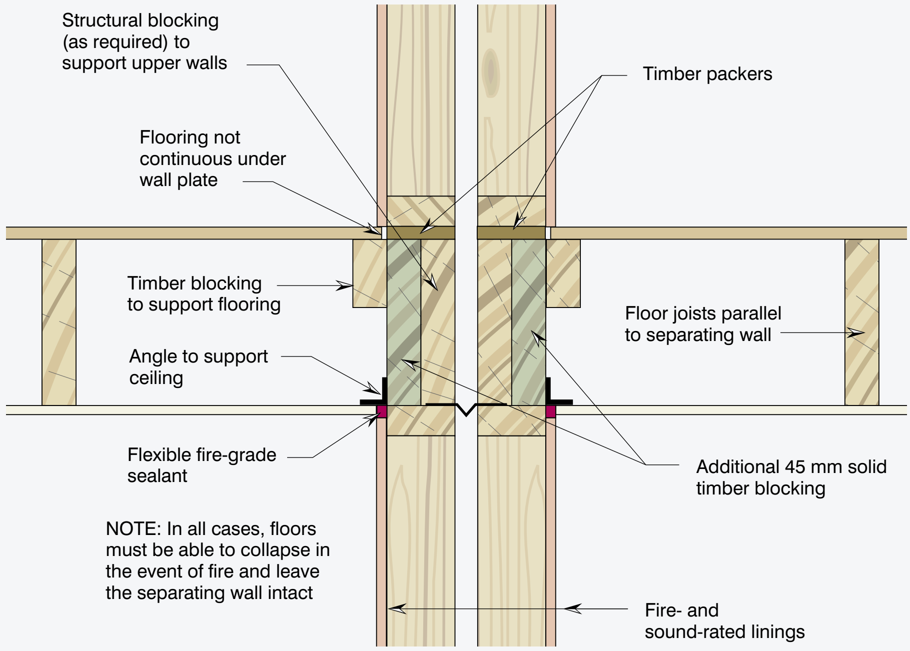


Figure 40: Joist parallel to the wall, wall stud not continuous through junction – FRL 60 minutes – elevation view.

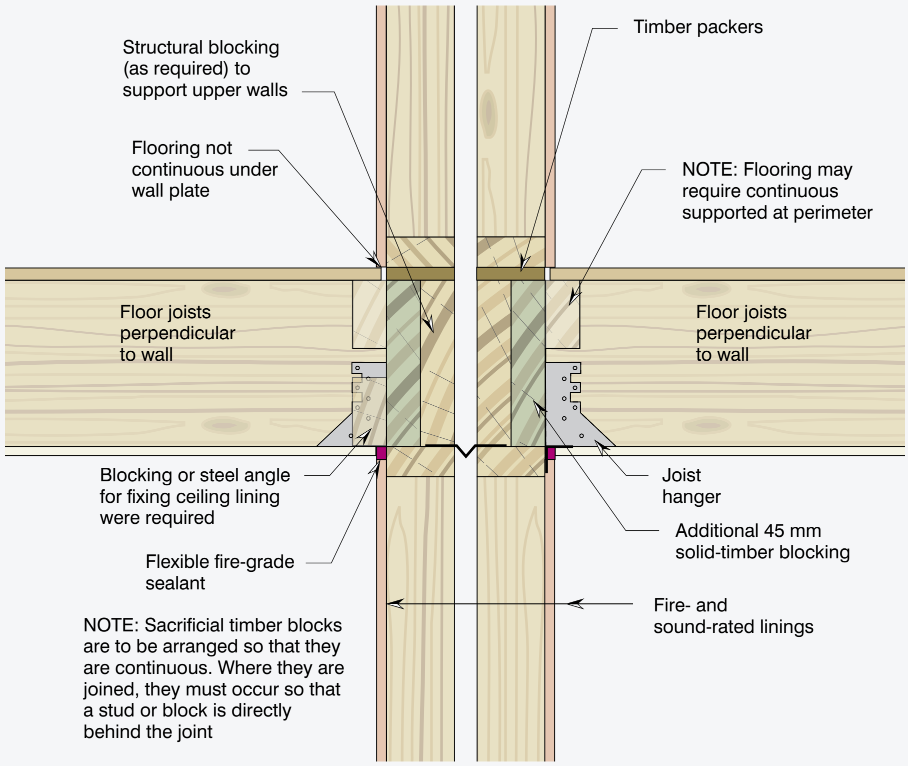


Figure 41: Joist perpendicular to the wall, wall stud not continuous through junction – FRL 60 minutes – elevation view.

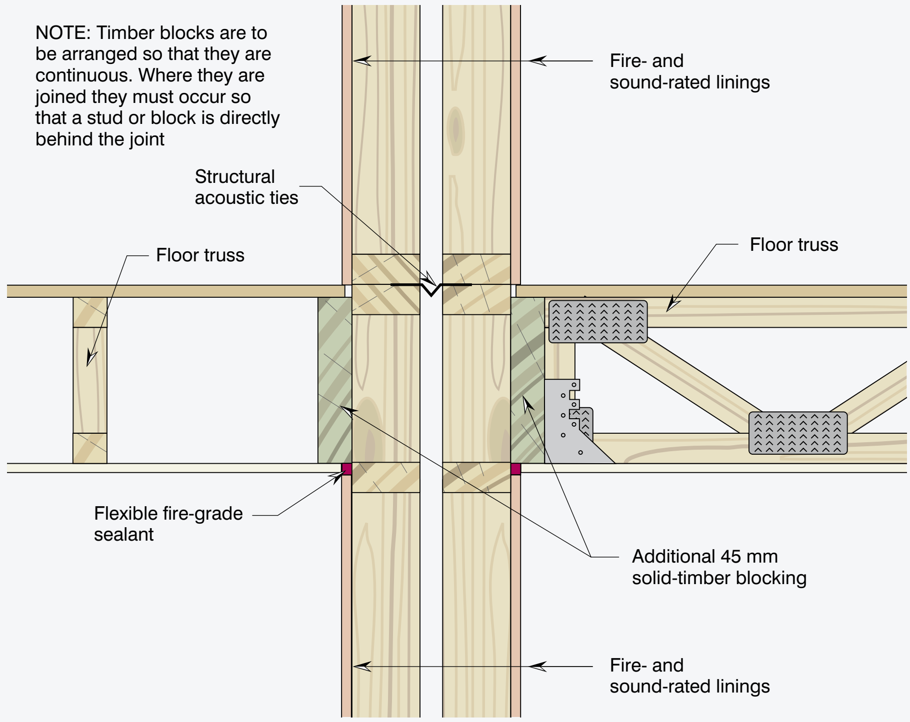


Figure 42: Joist parallel and perpendicular to the wall, wall stud continuous through junction – FRL 60 minutes only – elevation view.

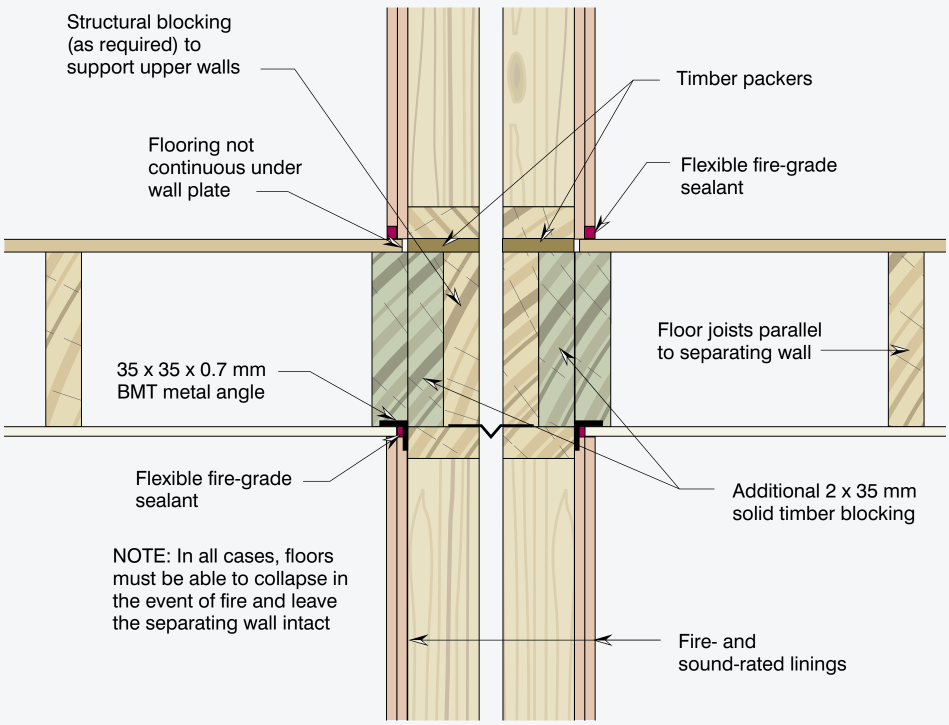


Figure 43: Joist parallel to the wall, wall stud not continuous through junction – FRL 90 minutes – elevation view.

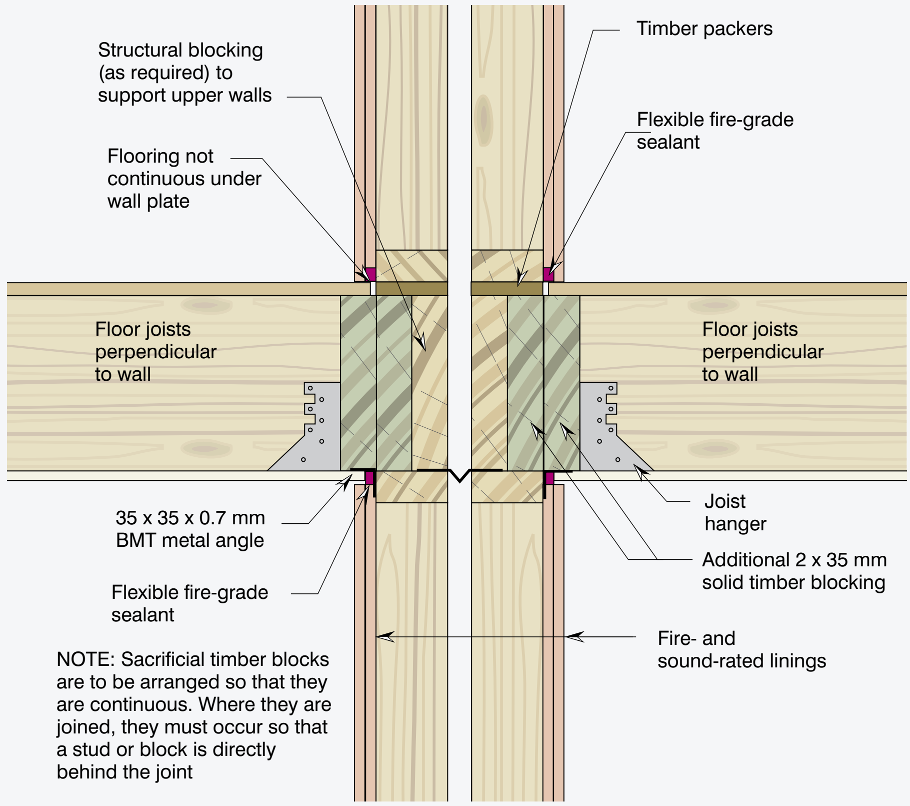


Figure 44: Joist perpendicular to wall, wall stud not continuous through junction – FRL 90 minutes – elevation view.

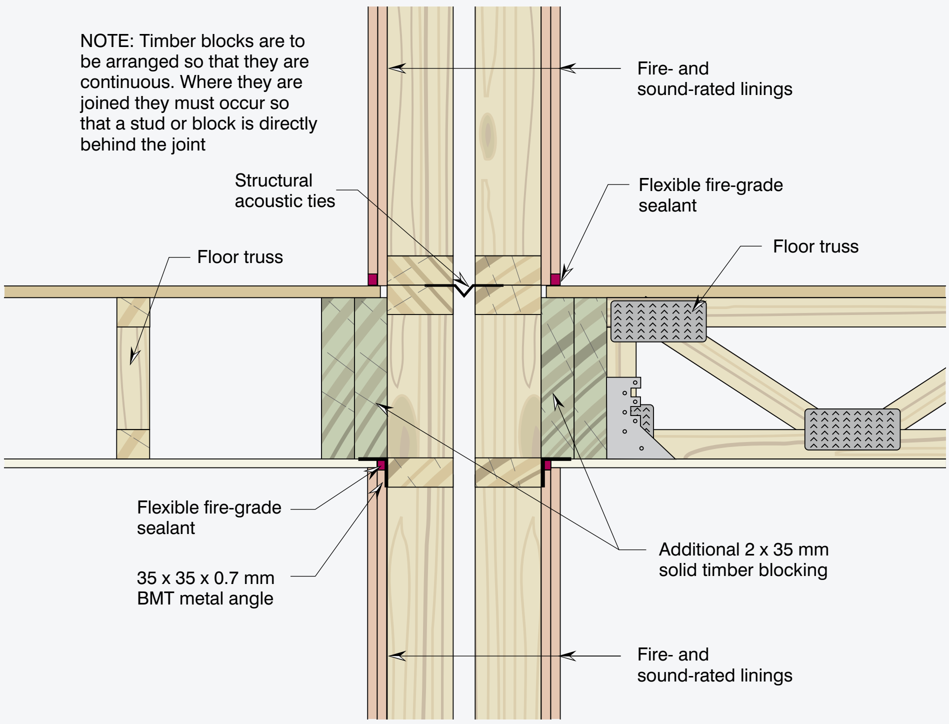


Figure 45: Joist parallel and perpendicular to the wall, wall stud continuous through junction – FRL 90 minutes only – elevation view.

Mineral wool fills many needs and spaces.

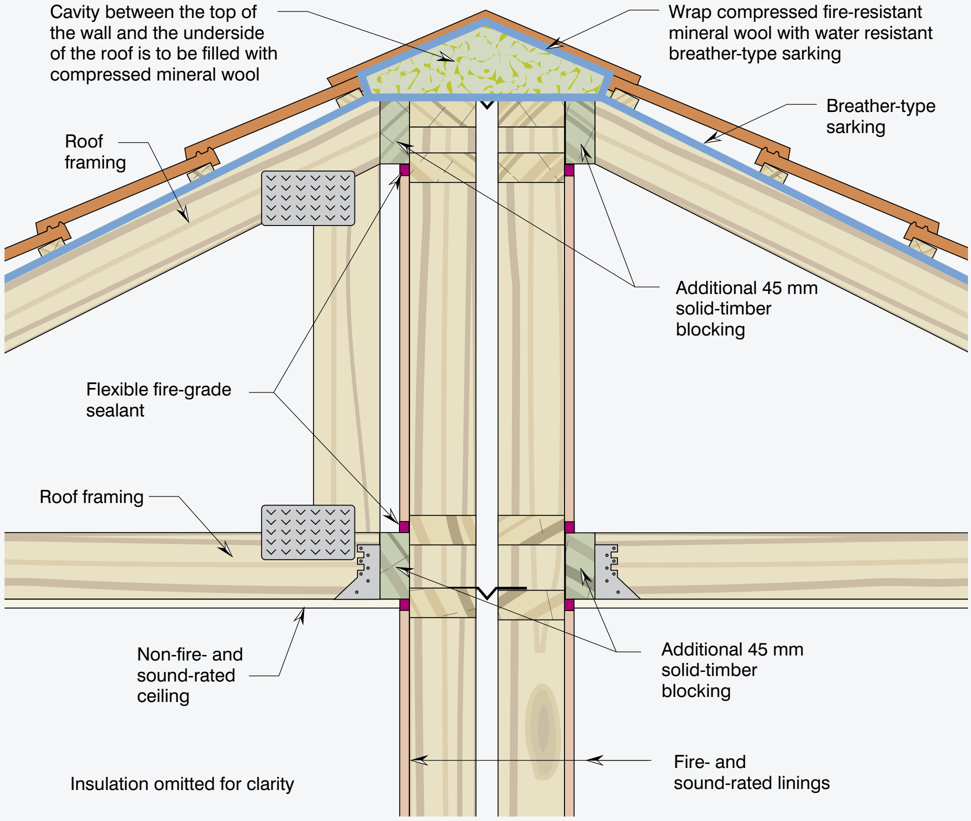


Figure 46: Timber blocks used to maintain fire-resistance – FRL 60 minutes in roof void – elevation view.

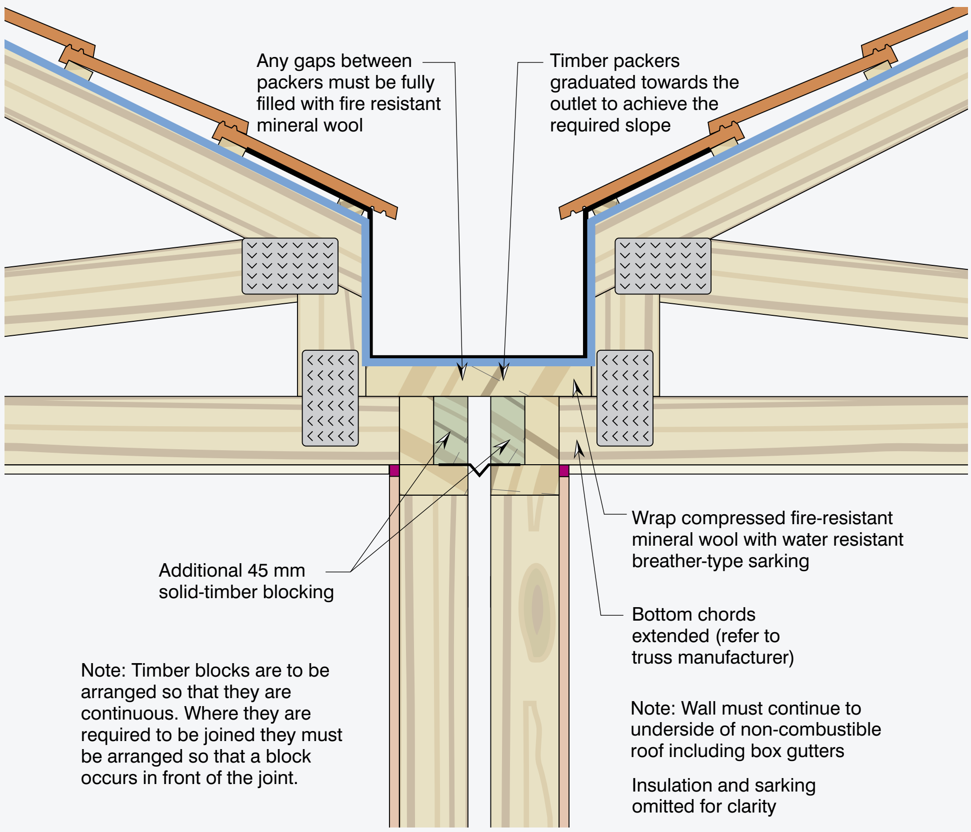


Figure 47: Timber blocks used to maintain fire-resistance – FRL 60 minutes under box gutter – elevation view.

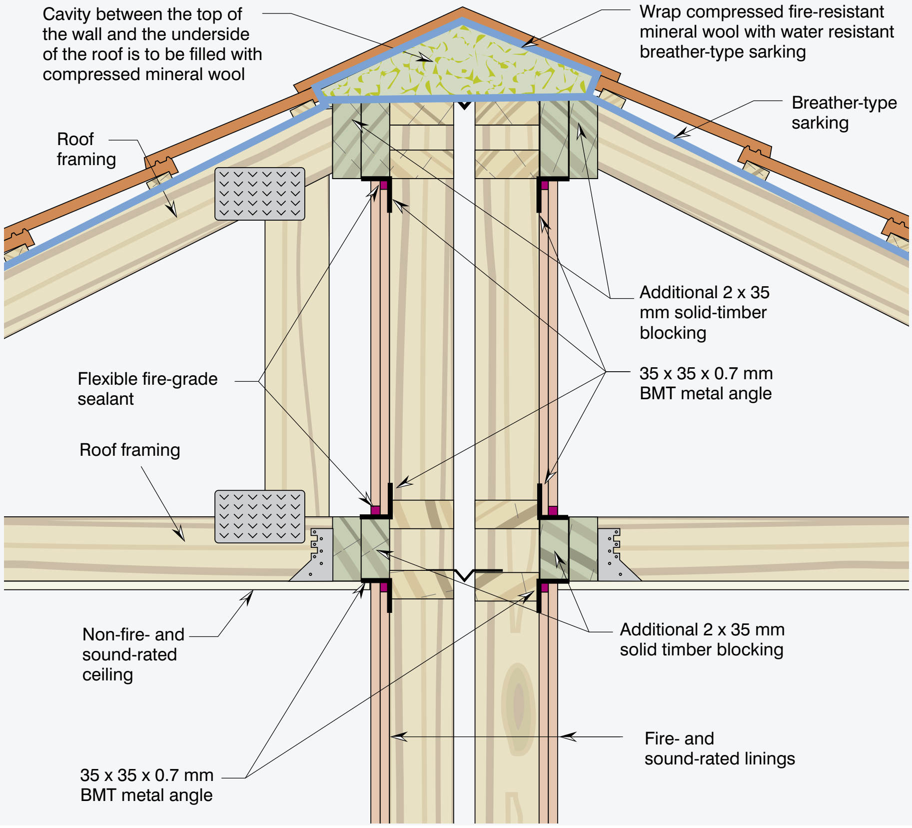


Figure 48: Timber blocks used to maintain fire-resistance – FRL 60 minutes in roof void – elevation view.

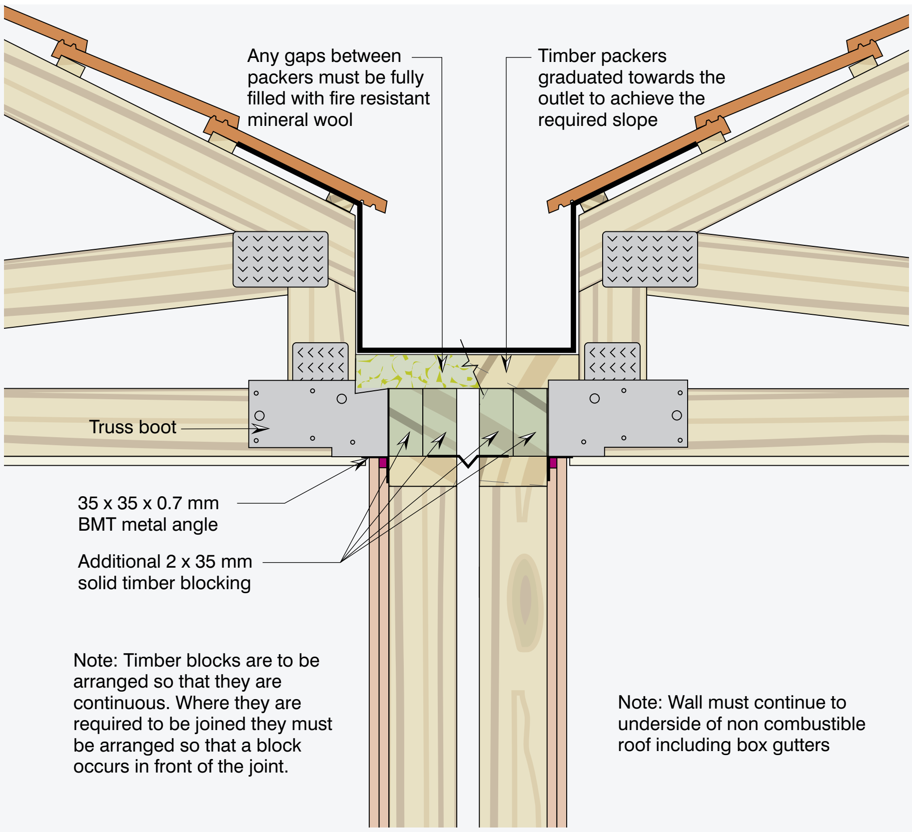


Figure 49: Timber blocks used to maintain fire-resistance – FRL 90 minutes under box gutter – elevation view.

Fire pockets in fire-rated walls

Another method is to create pockets within the fire-rated wall that allow the joists to bear onto the wall. This detail can be achieved by utilising similar techniques discussed previously for double joists. Solid-timber blocking, the same depth as the main joists, forms the inner of the two blocking joists. Where this blocking joist is required to be joined, it must be butted tightly, and the joint must be at least 100 mm from any pocket created.

Floor joists such as solid timber, I-joists or floor trusses, perpendicular to the wall, can be supported on the wall and in the pocket formed, with a minimum bearing depth of 35 mm. Additional solid-timber blocks, the same depth and thickness as the inner packing block, are to be tightly cut-in between the joist. The main floor joists are not to be nailed to the blocking, and any locating nailing is to occur at the base of the joist into the lower wall plate only (see Figures 50 and 51).

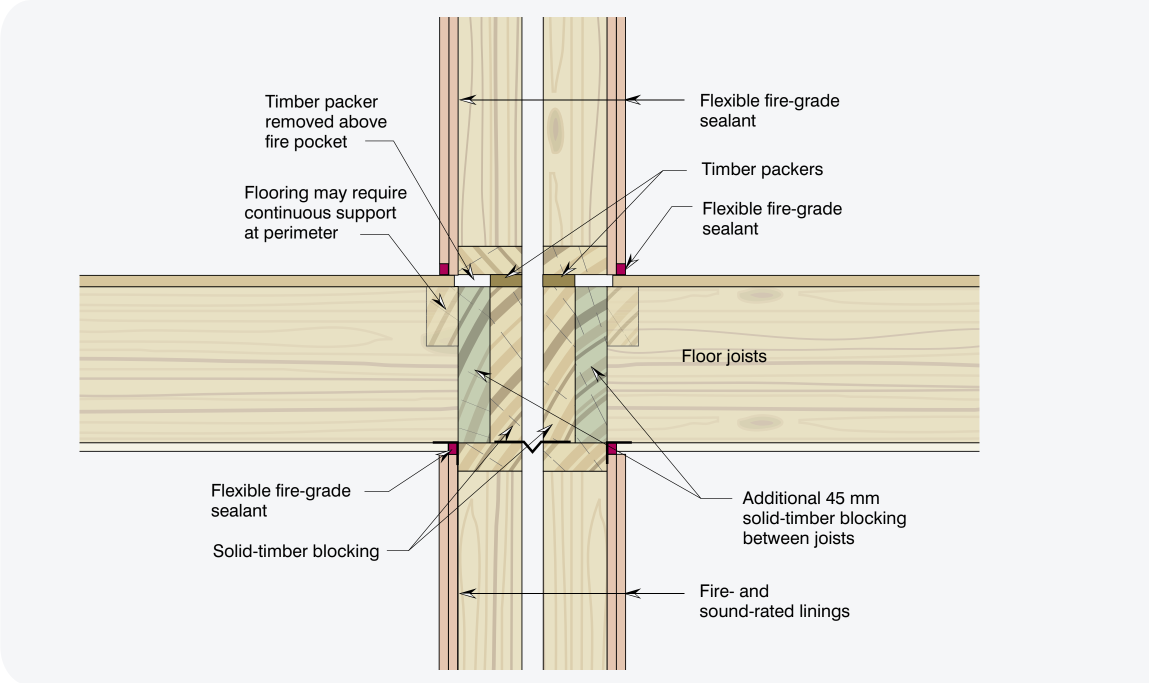


Figure 50: Pockets created in separating wall to accommodate floor joists – FRL 60 minutes only – elevation view.

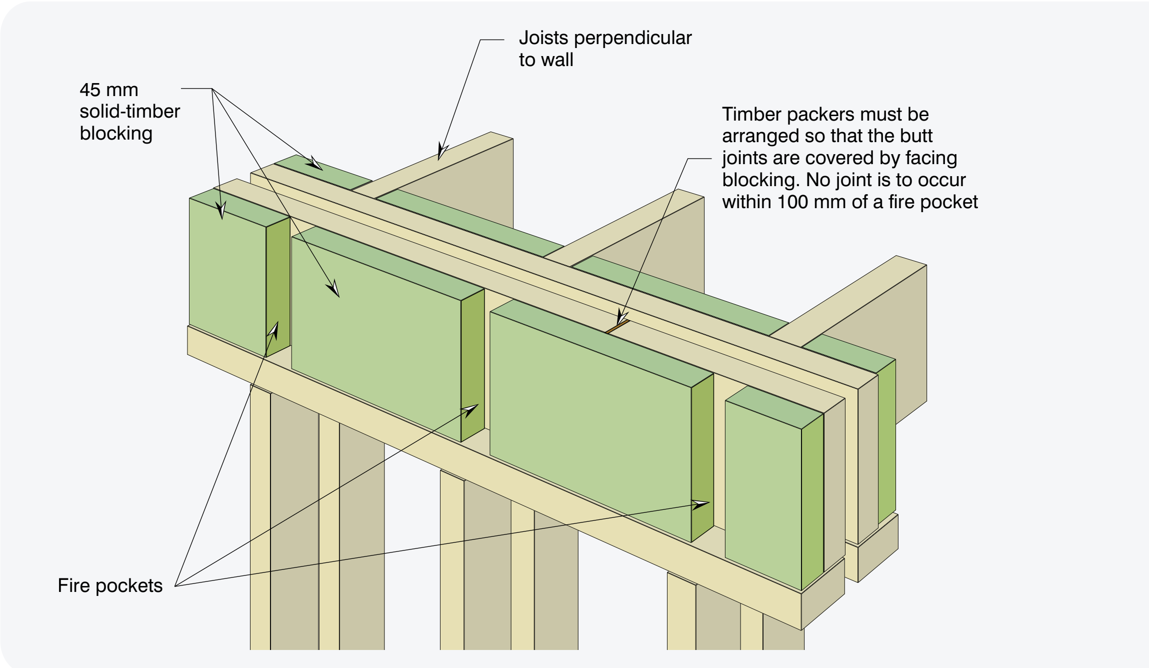


Figure 51: Pockets created in separating wall to accommodate floor joists – FRL 60 minutes only – perspective view.

Top chord support detail for floor trusses

Floor trusses are commonly used as floor joists. This form of floor joist has the unique ability to be supported by the top chord. A similar support mechanism as the pocket described above can be used. Here only the top chord needs to be located in the fire pocket created. Refer to Figures 52, 53 and 54 for two variations on the same solution for an FRL of 60 minutes and Figures 55, and 56 for 90 minutes fire-resistance.

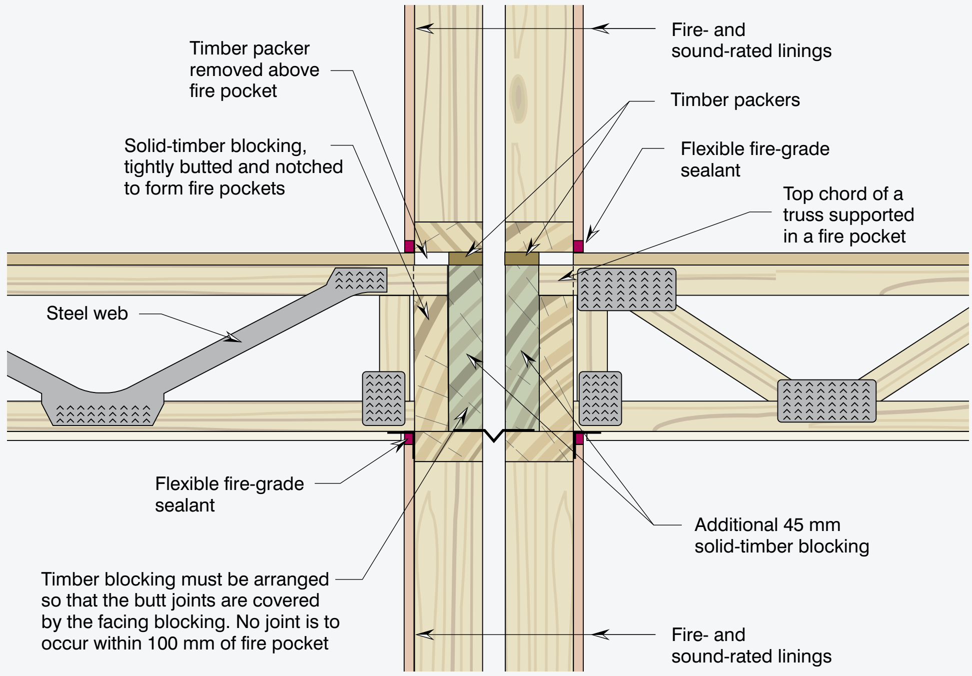


Figure 52: Floor-truss top chord supported in the pocket – FRL 60 minutes – elevation view.

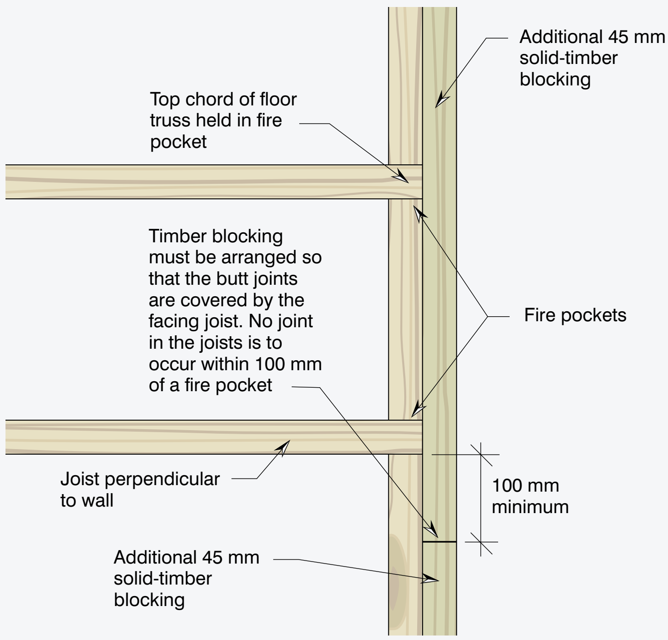


Figure 53: Floor-truss top chord supported in the pocket – FRL 60 minutes – plan view.

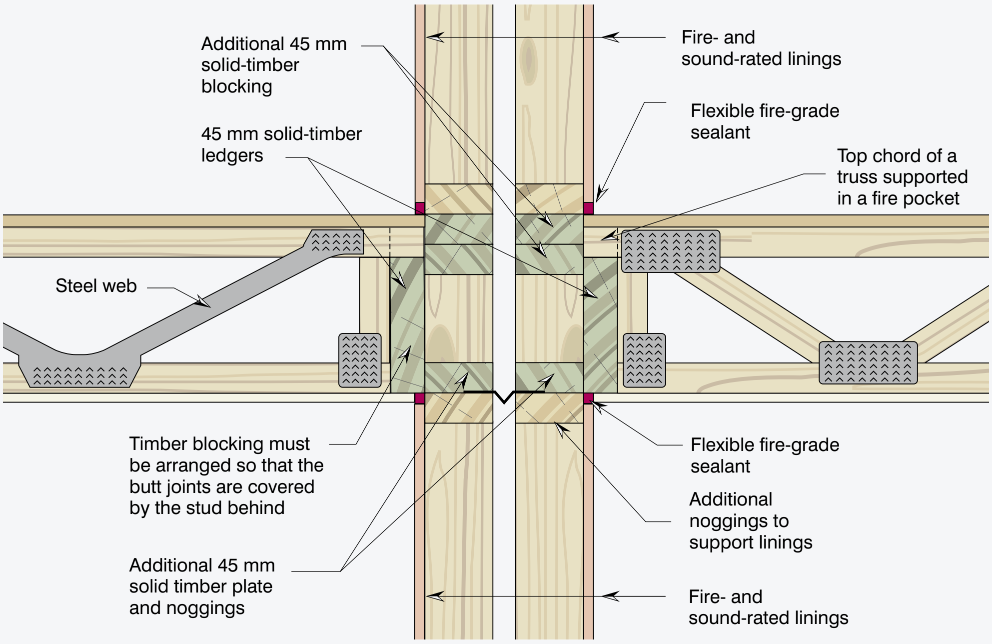


Figure 54: Alternative floor-truss top chord support – FRL 60 minutes – elevation view.

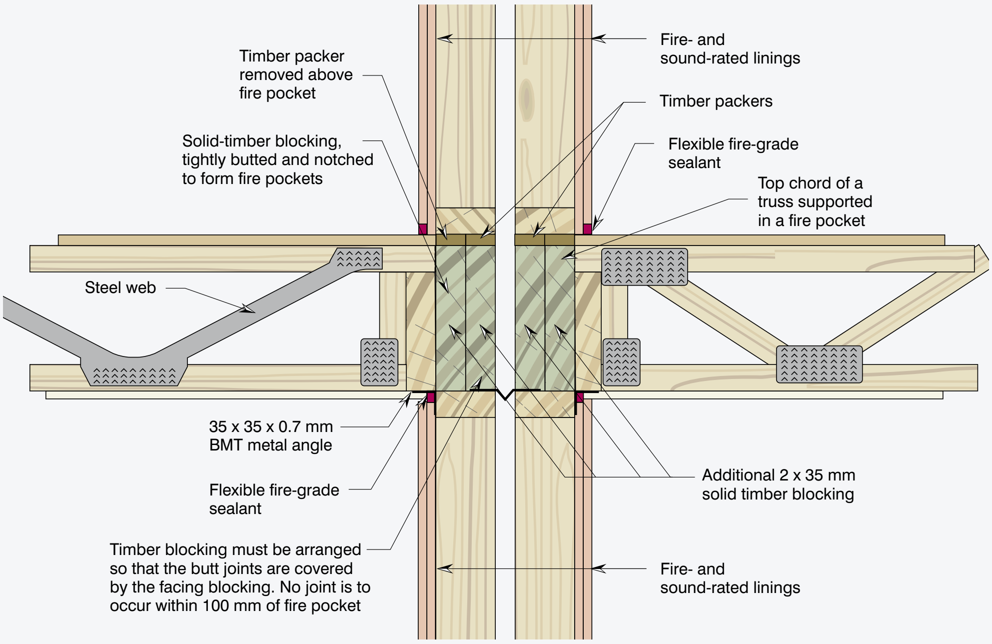


Figure 55: Floor-truss top chord supported in pocket – FRL 90 minutes – elevation view.

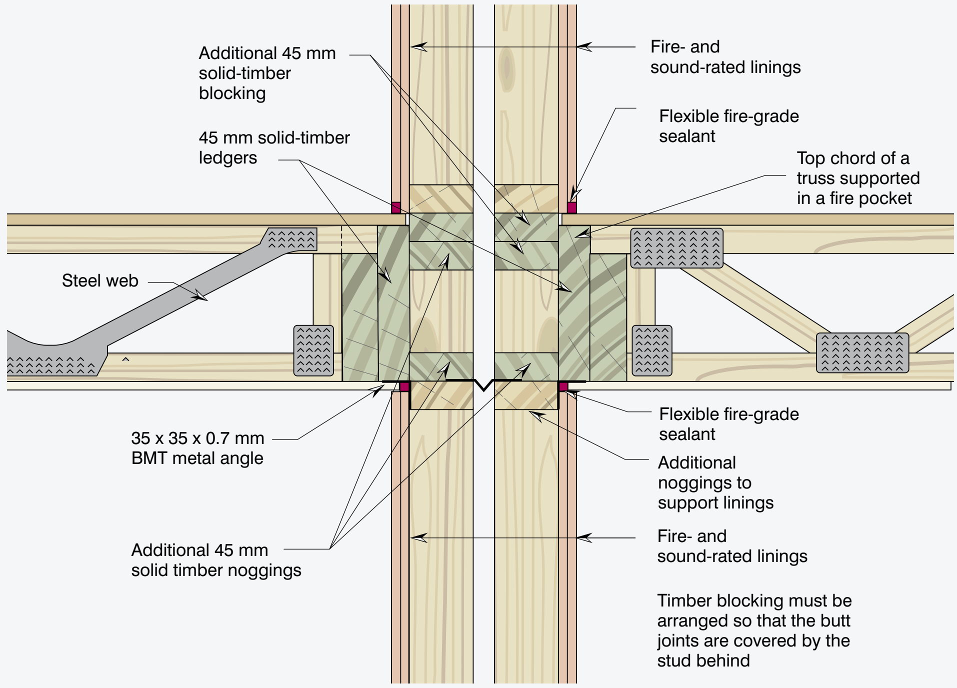


Figure 56: Alternative floor-truss top chord support – FRL 90 minutes – elevation view.

5.4.3 Junction between dissimilar fire-rated elements

There are many instances where lower-rated elements abut higher-rated elements, such as a non-loadbearing Sole Occupancy Unit bounding walls abutting loadbearing Sole Occupancy Unit bounding walls. The NCC allows different Fire Resistance Levels for these elements, and therefore the lower-rated element may be a fire path through the higher-rated element.

The recommended way to treat this is to design both elements to the highest fire rating. By having the walls with the same higher fire resistance removes the need to use timber blocking. In most cases, the sound performance requires more plasterboard sheets than is required for fire resistance, and making use of the lower rating may not necessarily provide project cost savings or the desired performance.

Where the occurrence of mismatched fire-rated elements is unavoidable, the principles of sacrificial timber blocking discussed in Section 5.4.1 can be used. In this case, it is recommended to treat the lower fire-rated element as non-rated and utilise timber blocks or timber blocks and angles, as shown in this Guide.

5.4.4 Support of a fire-rated wall where non-fire-rated floors or roofs abut

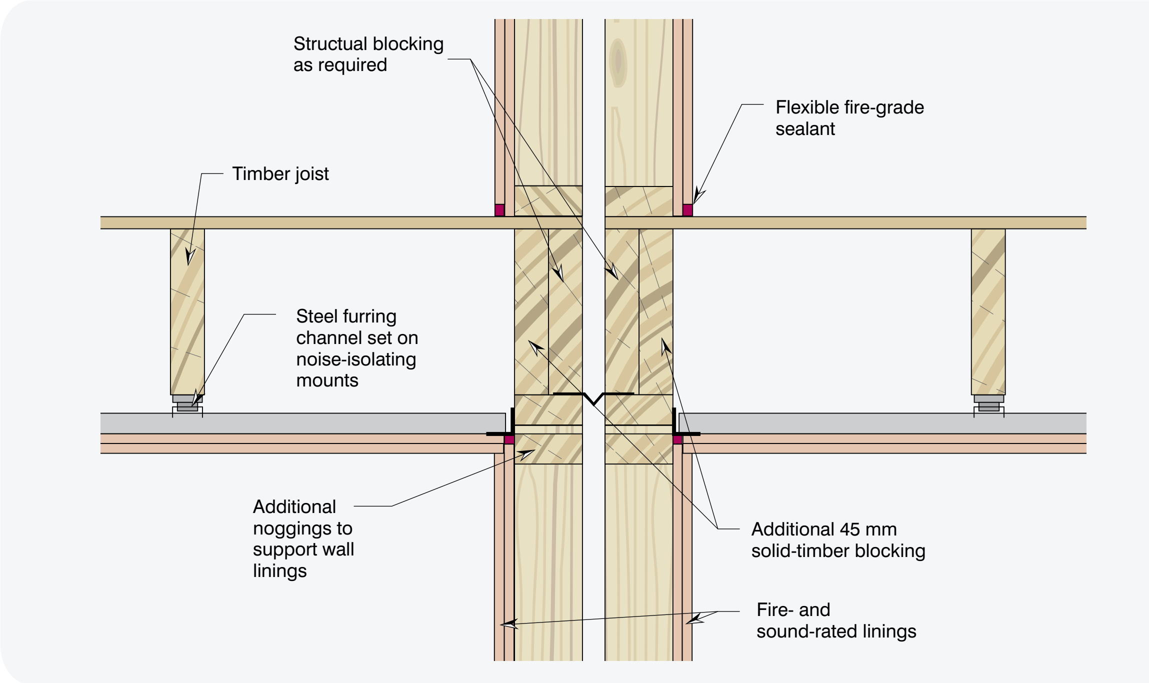
Fire-rated walls generally have height limitations to 3.0 m. Where a non-fire-rated floor that occurs in a Sole Occupancy Unit (i.e. townhouse construction or a mezzanine floor or roof supports the top of a fire-rated wall), NCC Specification C1.1. Clause 2.2 Fire protection for support on another part, requires the vertical and horizontal elements that support the wall to have the same FRL as to the element it supports. The NCC relaxes this requirement for a fire-rated wall supported by the roof (NCC Specification C1.1. Clause 2.2 (b) (iii)).

For non-fire-rated floors, NCC Specification C1.1 Clause 2.2 (b) (v) provides a concession where the fire-resisting wall is supported on both sides of the wall, and if a failure occurs on one side of the wall, it does not affect the fire performance of the wall. For most situations in a timber-framed fire-rated building, there may be a wall on the other side to provide support. Where double stud fire and sound rated walls are used, there needs to be a resilient tie at each floor level between the frames of the wall.

For townhouse construction that has a need for a fire-rated external wall at the end of the row, this is problematic, as there is no neighbouring structure to support the wall. In this case, a fire-rated floor or fire-rated beams may be required to provide lateral support to the external wall.

5.4.5 Junction between elements with the same fire ratings

When elements have the same fire-resistance, there is little required except to ensure that the fire-protective linings are supported, and the board edges interweave with each other. Details for this depend on the lining material used, and reference to lining manufacturers is recommended for any additional requirements they may have. Typical junctions are shown in Figures 57 and 58.



Fire can traverse higher-rated elements via lower-rated elements. The answer? Aim high.

Figure 57: Typical junction of elements with the same FRL – fire-rated floors abutting fire-rated walls – elevation view.

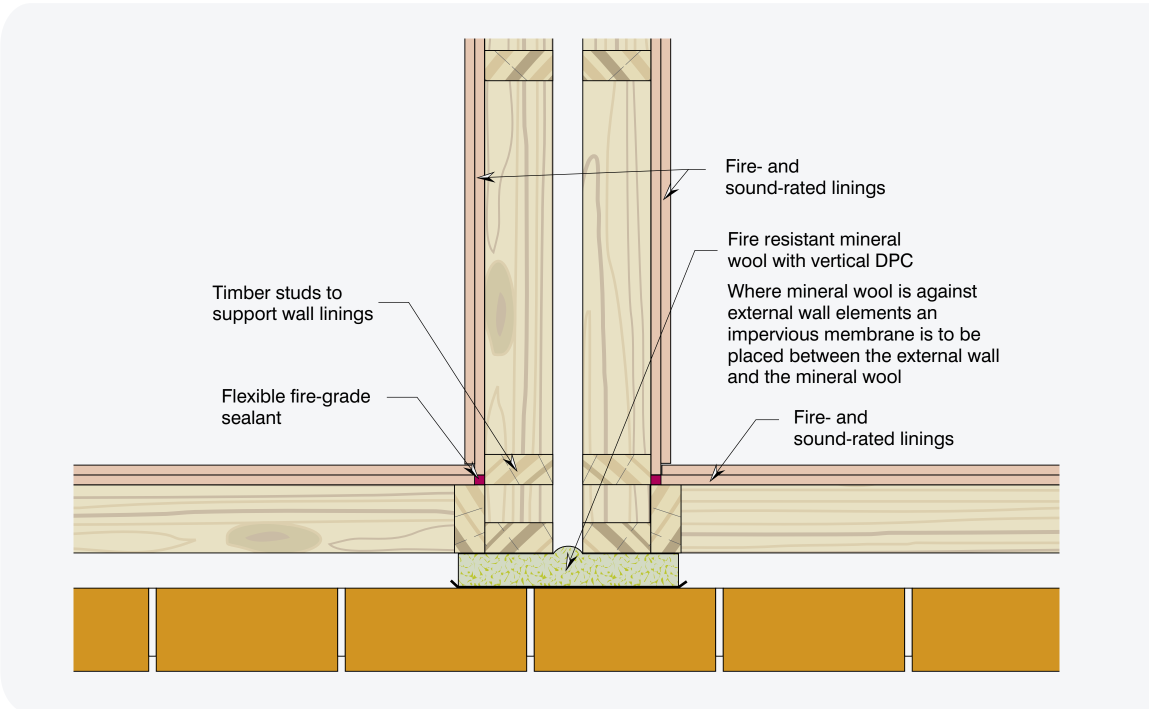


Figure 58: Typical junction of elements with the same FRL – fire-rated bounding wall abutting fire-rated external wall – plan view.

5.4.6 Timber blocks size of alternative thickness or density

Generally, this Guide requires 1 x 45 mm thick timber blocks for Fire Resistance Level of 60 minutes and 2 x 35 mm thick timber blocks for Fire Resistance Level of 90 minutes, with the timber having a minimum density of 470 kg/m^3.

Timber blocks of greater density can substitute the block for either Fire Resistance Level. For the 90 minutes Fire Resistance Level that requires 2 x 35 mm thick timber blocks, these two timber blocks can be substituted by another single piece of timber with a higher density. The thickness of timber required can be calculated from AS/NZS 1720.4, utilising the effective depth of char for a 75 minutes fire-resistance period. The minimum thickness of timber allowed is 45 mm. Therefore, the effective depth of char is

$$d_c = c \, . \, t + 7.0 \text{ mm} \qquad \text{(Eqn 1)}$$

Where

c = notional char rate, found from AS/NZS 1720.4 or common species are repeated in Table 9.

t = 75 minutes

Table 9 provides minimum timber block thickness and density for common timber species used in construction. The timber block thicknesses are represented in minimum dimension required, and they may not be commercially available to this dimension. Where this is the case, the next timber size should be used. Where engineered timber is used, the base timber species' density must be used in the calculation of the effective depth of char, not the density of the engineered timber that may include the weight of the adhesive.

Table 9: Minimum Block Thickness for FRL 90 Minutes Based on AS/NZS 1720.4

Timber Species[1]	Notional Charring Rate	Minimum Block Thickness based on Effective Depth of Char for 75 minutes exposure
Blackbutt	0.5	45
Cypress	0.56	49
Douglas fire	0.65	56
European Spruce	0.65	56
Gum, Spotted	0.46	452
Ironbark, grey	0.46	452
Ironbark, red	0.47	452
Jarrah	0.52	46
Merbau (Kwila)	0.51	45
Radiata pine	0.65	56
Victorian Ash and Tasmanian Oak	0.59	51

Note:
1. The density of other timber species can be found from AS 1720.1 or AS 1720.2.
2. Where the effective depth of char is calculated to be less than 45 mm, the minimum block thickness of 45 is used.

5.5 Treatment of Roof/Ceiling and Eaves Voids

5.5.1 Roof and ceiling Voids

In Class 2 and 3 buildings, there is the opportunity of fire and sound jumping from one Sole Occupancy Unit to another through the roof void. Timber-framed construction needs to prevent this from happening, and there are three options available to prevent this, including:

- continuation of the fire/sound wall through the roof void to the roof covering (see Figure 58)
- continuation of the fire/sound wall through the roof to a parapet wall (see Figure 59)
- stopping the flame passage at ceiling level using a Resistant to Incipient Spread of Fire ceiling (see Figure 60).

The roof void must not let fire jump between SOUs.

Fire- and sound-rated wall through to underside of roof covering

Figure 59 illustrates fire and sound sealing between the top of the fire-rated wall and the underside of the non-combustible roof lining.

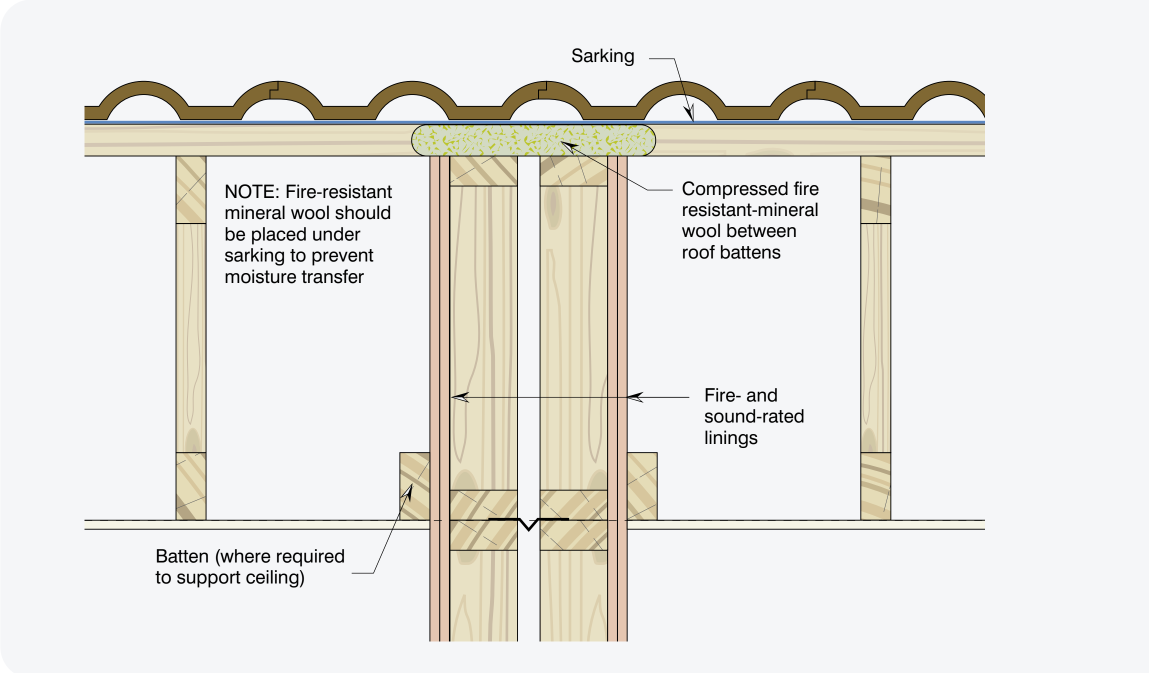


Figure 59: Fire- and sound-rated wall through to the underside of the roof – FRL 90 minutes – elevation view.

Fire- and sound-rated wall through to underside of roof covering

Figure 59 illustrates fire and sound sealing between the top of the fire-rated wall and the underside of the non-combustible roof lining.

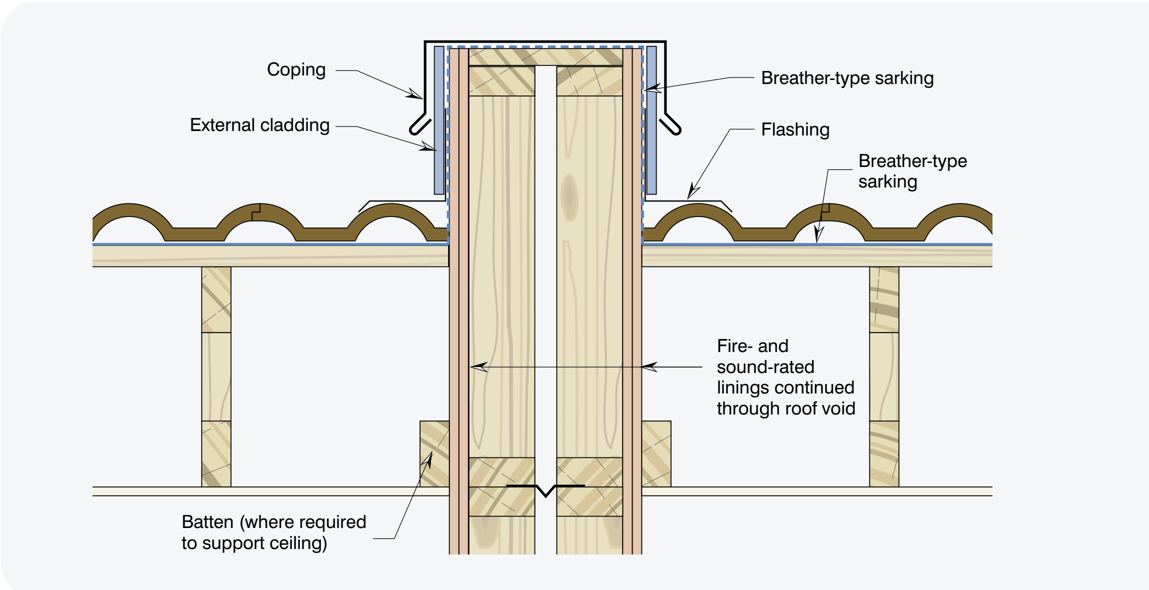


Figure 60: Fire- and Sound-rated wall in the roof void to form parapet – FRL 90 minutes – elevation view.

Fire- and sound-rated wall to underside of Resistant to Incipient Spread of Fire ceiling

This special ceiling is used directly below the roof framing instead of using bounding walls construction built to the underside of the roof. As the NCC does not allow any timber element to cross the bounding wall, except for minimum nominal size, 75 x 50 mm roof battens, this ceiling is useful when dealing with complex roof framing elements.

The ceiling is required to be continuous, and walls below this ceiling must affix to it. In this case, timber block substitution of the linings is not allowed (see Figure 61).

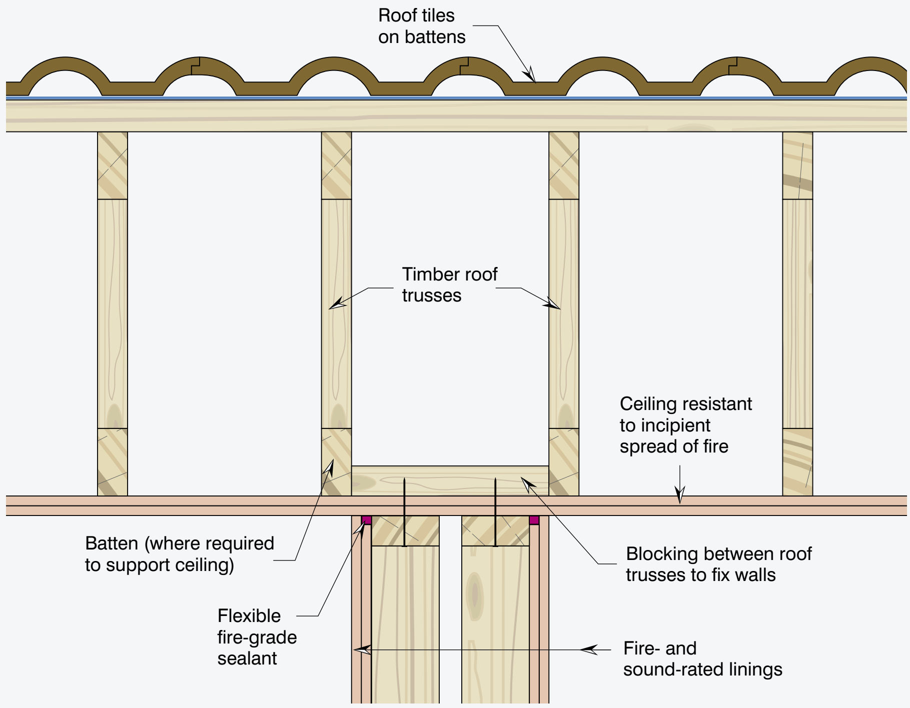


Figure 61: Fire- and sound-rated wall abutting a Resistant to Incipient Spread of Fire ceiling of 60 minutes.

5.5.2 Eaves voids

In addition to the mandatory requirements, there is a non-mandatory but logical need to address the cavity created by a boxed-eave (or similar) that creates the means for a fire to by-pass a fire-resisting wall bounding a Sole Occupancy Unit. This situation often occurs when an external wall is not rated or has a rating less than the bounding walls of the Sole Occupancy Unit. In this case, it is recommended that the eaves void be blocked off to limit fire spread along this path. A construction detail to address this problem is shown in Figures 62 and 63. This construction detail is the same approach to the requirement for Class 1 buildings eaves and separating walls, where for this building classification the NCC requires the eaves void to be blocked.

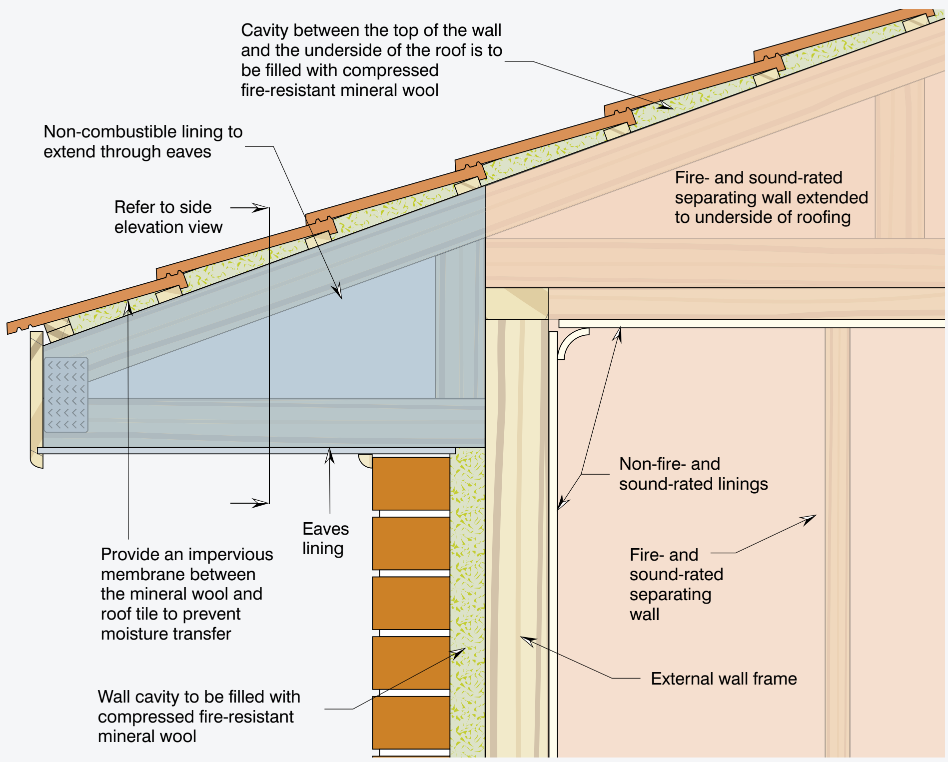


Figure 62: Non-combustible linings blocking off eaves void – front elevation view.

As they lack mandatory requirements, eaves require common sense handling.

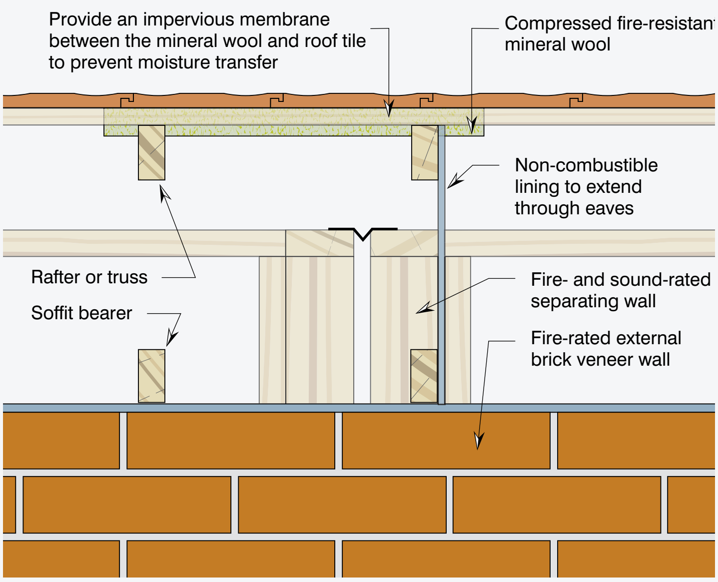


Figure 63: Non-combustible linings blocking off eaves void – side elevation view.

5.6 Shafts and Service Penetrations

5.6.1 Fire-rated service shafts

Service shafts are generally required to have a fire and sound rating. It is best to treat the shaft like an independent compartment (see Figure 64). Care is required to ensure that the sound rating is achieved, as many shaft wall systems are not adequate on their own.

Many wall systems can't handle shafts unaided.

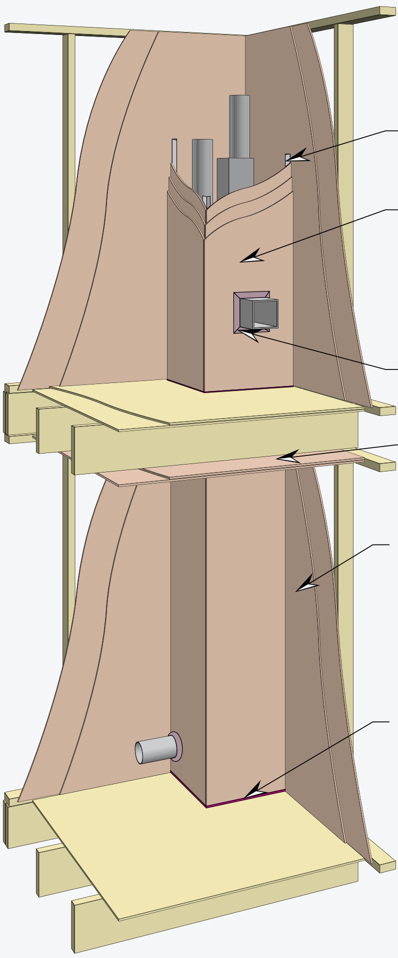


Figure 57: Fire-rated service duct.

Where timber framing is used to support the shaft linings, it must be sheeted with fire- and sound-protective linings on both sides of the shaft, including the part of the shaft that is the bounding wall of the Sole Occupancy Unit.

An alternative approach to using timber framing is to use laminated plasterboard or a proprietary shaft wall system. These systems are exclusively developed by lining manufacturers and reference to their details is required. Figure 65 shows a typical laminated plasterboard shaft wall system.

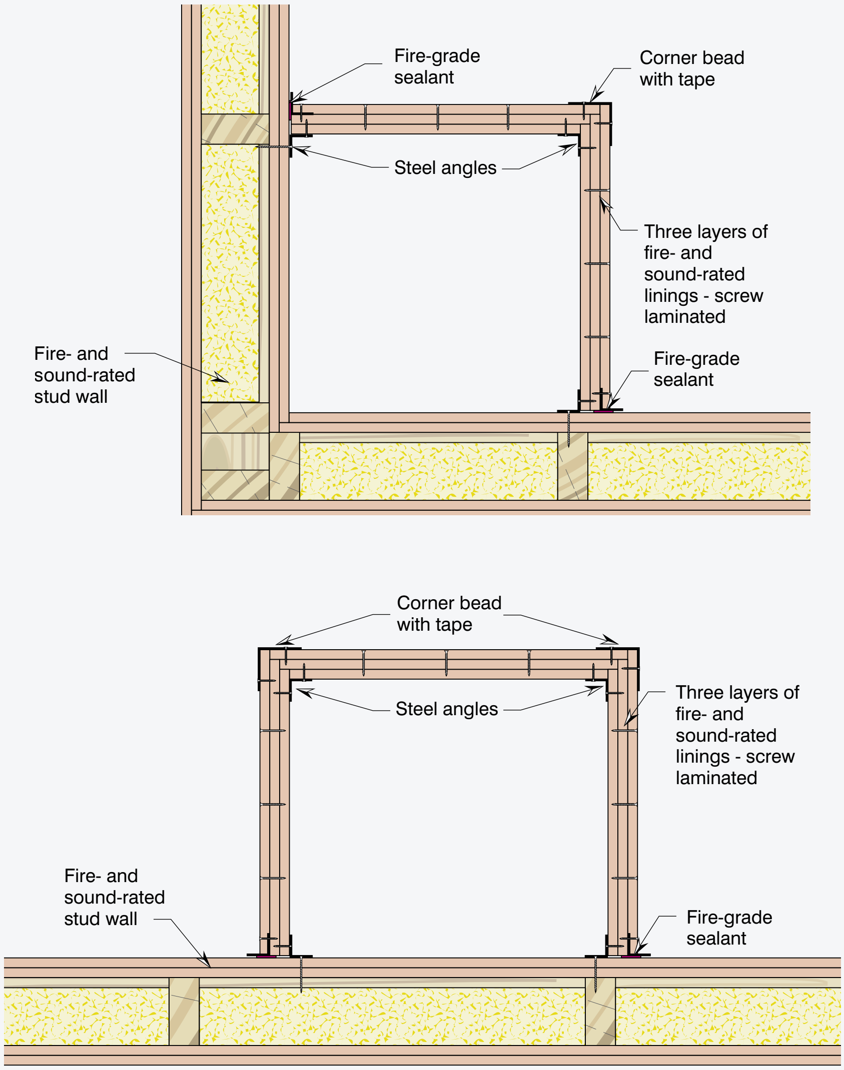


Figure 65: Laminated fire-rated plasterboard used to create a service shaft.

Another approach for Class B and C buildings is to seal the services at the point where they penetrate the fire-rated floor or wall element with the appropriate method of sealing. This sealing removes the need to fire-rated the shaft walls, but in many cases, the service shaft may still require a sound rating (see Section 4.4.2 for further details).

5.6.2 Plumbing, electrical and ventilation services penetrating a fire-rated wall

Where services penetrate a fire-resistant element, the NCC requires the maintenance of the Fire Resistance Level. This maintenance of the Fire Resistance Level necessitates the gaps surrounding service and construction be sealed, and for some services that the element seals off during a fire event.

There are two approaches to satisfy the NCC. The first is to follow the requirements in NCC Specification C3.15 for a system that complies. This method details several elements such as pipes and cables and gives solutions for sealing these penetrations, using fire-stopping materials. The fire-stopping materials are required to be tested in accordance with NCC provision C3.15 (a). In addition, there are limits to metal pipes that are not filled with liquids, to be more 100 mm from timber elements.

The other method is to use a manufacturer's tested system, which involves selecting a system that meets the fire-resistance for integrity and insulation as well as not reducing the acoustic performance required. Tested systems that meet the integrity and insulation criteria also need not comply with the requirement to have metal pipes not filled with liquids, more than 100 mm from timber elements. If the tested system can't meet the integrity criteria, then this 100 mm from timber elements distance requirement is necessary.

As these systems are proprietary, no further details are provided here. Examples of these systems are illustrated in Figures 66 and 67.

In general, all penetrations in fire-rated elements should be fire stopped, kept to a minimum, kept as small as possible and designed in a way that may allow thermal movement as well as shrinkage.

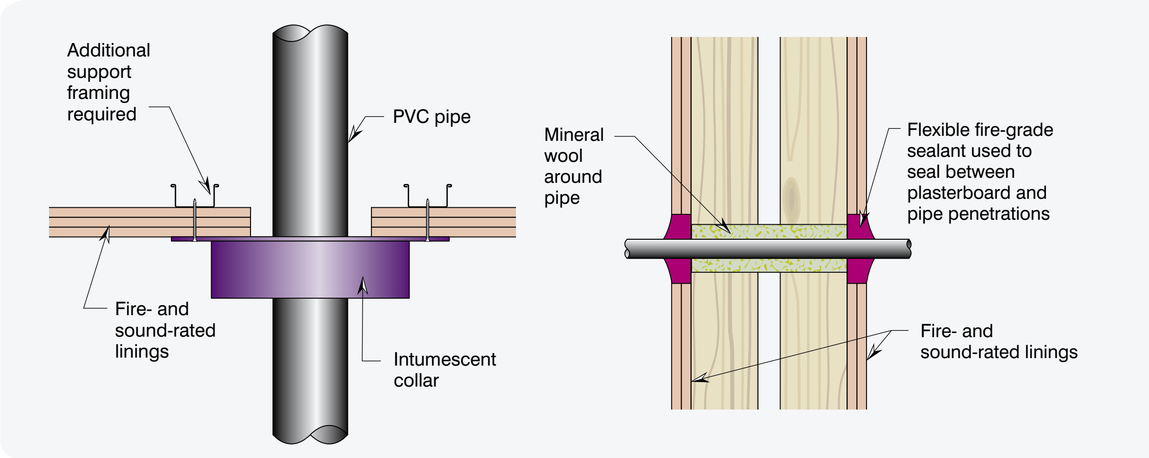


Figure 66: Plumbing service penetration in fire- and sound-rated wall and floor/ceiling – elevation view.

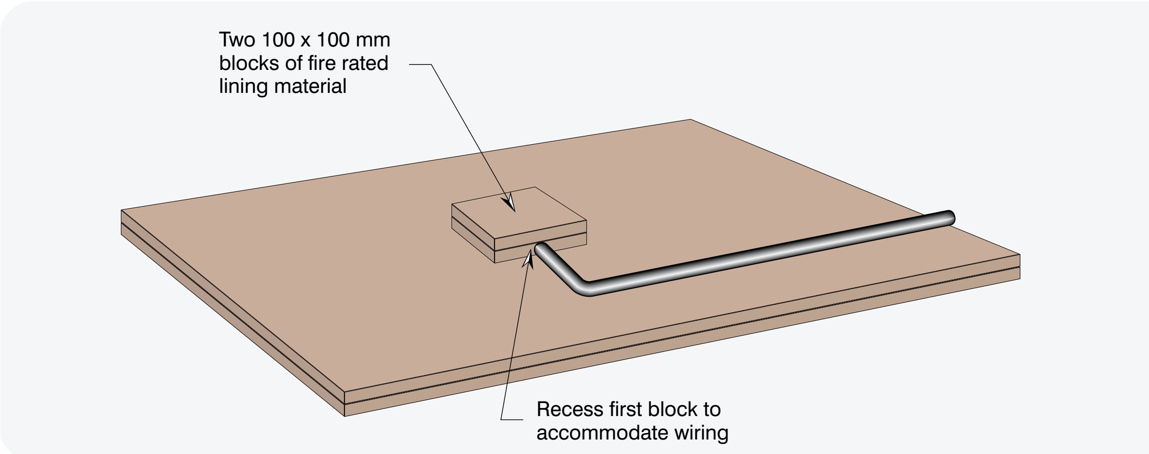


Figure 67: Electrical service penetration in fire- and sound-rated wall and floor/ceiling.

To minimise costs and reduce the chance of compromising the fire resistance of a Sole Occupancy Unit, a strategy that minimises the number of penetrations in a fire-rated element is recommended. Strategies to reducing the number of penetrations that are needed within a fire-rated element can be by not running services within the fire-rated walls or floors, but in interior non-fire-rated walls or false walls, ceilings or boxes/bulkheads over fire-rated elements (see Figures 68 and 69). Furthermore, where services may enter a Sole Occupancy Unit, group the services so that they occur in a shared location, like the bulkhead over the apartment's entrance door.

As 'chinks in the armour' of a fire-rated element, penetrations require careful and comprehensive treatment.

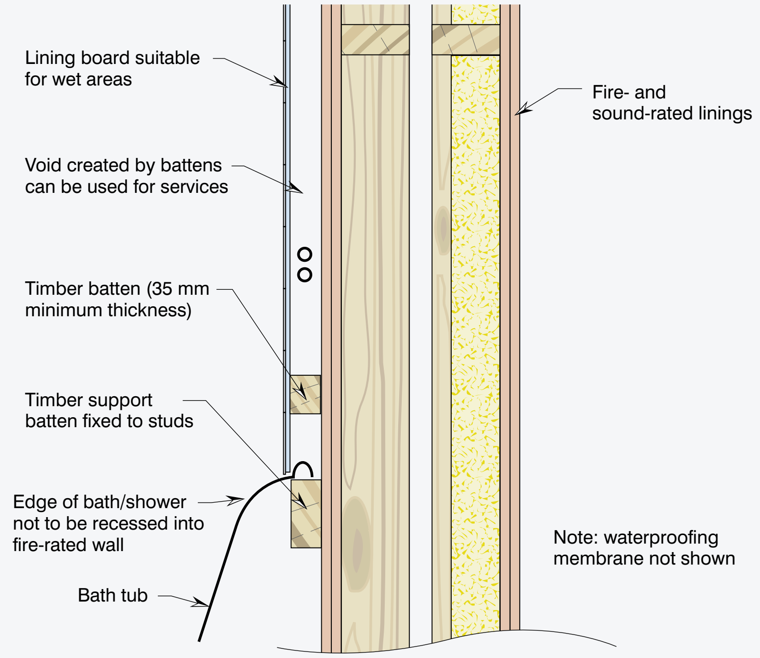


Figure 68: False wall for services (bathroom detail) – elevation view.

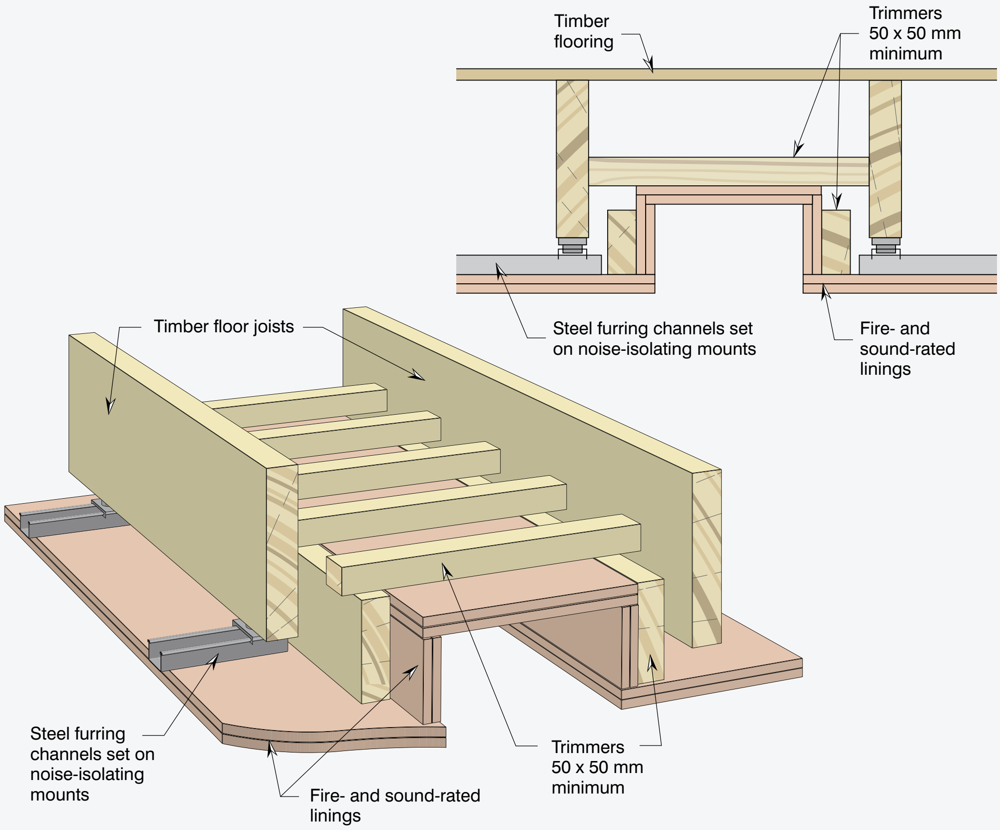


Figure 69: Framing details for recessed light in fire-rated floor/ceiling.

Going around can be simpler (and safer) than going through.

5.7 Vertical Separation in External Walls to Protect Openings from Fire

When using timber-framed construction to create the vertical separation of opening within external walls, it is important to have a clear understanding of the NCC requirements. For instance, there is a requirement for non-combustibility construction in NCC Provision C2.6 of the NCC. However, this requirement can be released by a concession in NCC Specification C1.1 Clause 3.10 (a) which deletes the non-combustibility requirement. Furthermore, for the rise in four storeys residential buildings that require sprinklers, the NCC provision C2.6 (b) (iii) removes the need to provide protection to external wall openings, altogether.

Therefore, where protection of the external wall opening is needed, such as the protection of balcony doors, can be achieved by fire-rating the underside of the balcony floor. Care is required to ensure that the method of fire rating is not affected by moisture or the outdoor environment. In many cases a waterproof deck structure is required, including a covering over the fire rating for its weather protection (see Figure 70).

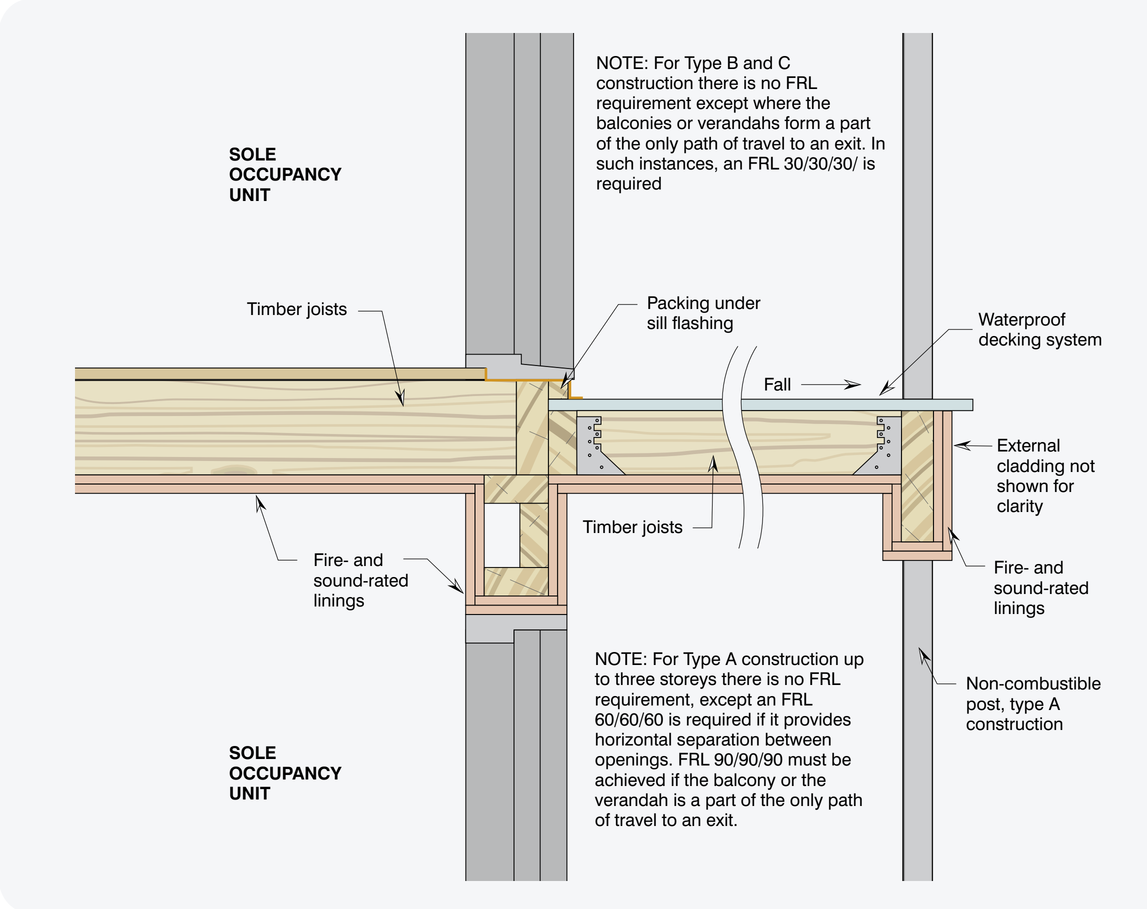


Figure 70: Protection of openings in external walls – elevation view.

5.8 Required Exits Stairways and Ramps

Section 4.4.6 discusses where the NCC has construction controls on exits that are stairways or ramps. These stairways or ramps are termed fire-isolated or non-fire isolated and each has particular construction requirements. The construction requirements are discussed in more details in the following sections.

5.8.1 Non-fire-isolated stairway and ramps

Where timber is used for the construction of a non-fire-isolated stairway and ramps (NCC provision D2.3), the timber must have:

- a finished thickness of not less than 44 mm
- an average density of 800 kg/m^3 at 12% MC
- if made from laminated timber, the adhesives must be resorcinol formaldehyde or resorcinol phenol-formaldehyde.

Thinner timber, lower density or laminated products using different adhesives may be used via the Performance Solution path. Some successful Performance Solution applications in the past have used fire protective linings, as required for the floor systems under the stairs, as an offset for the less fire-resistant Deemed-to-Satisfy construction solution (see Figure 71).

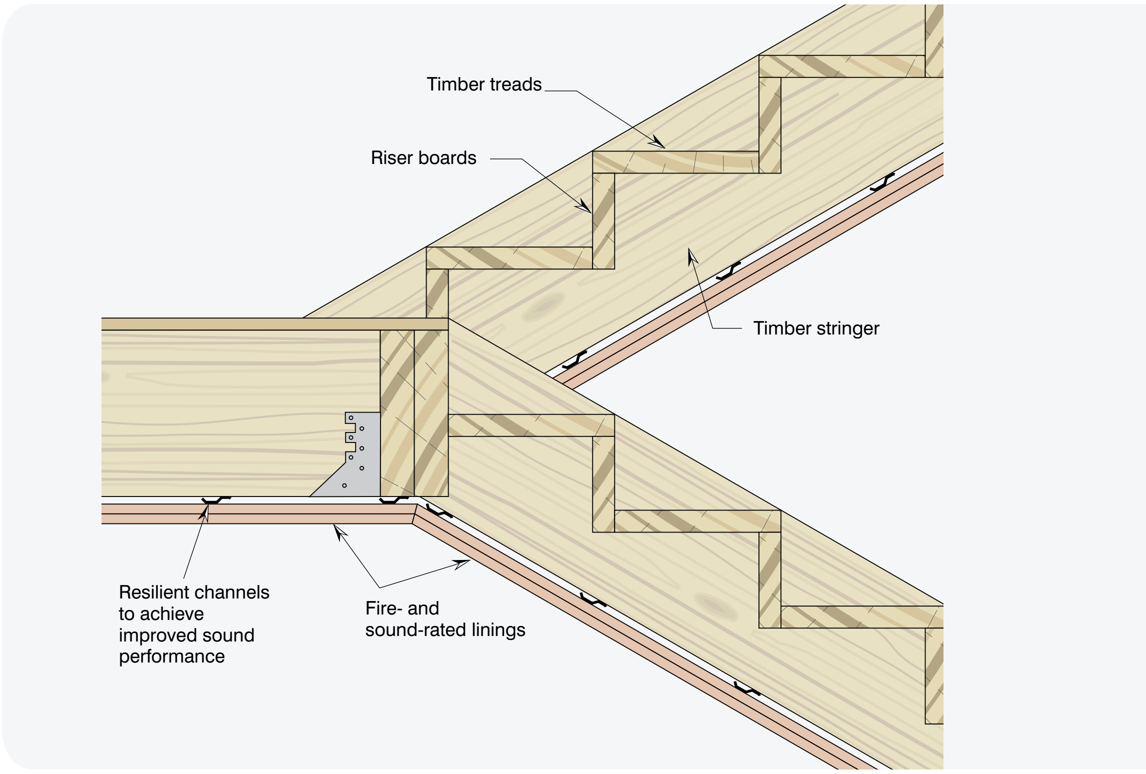


Figure 71: Fire-resistant linings used as Performance Solution for stairs.

5.8.2 Fire-isolated stairs NCC Provision D2.2

NCC provision D2.2 requires any fire-isolated stairway or ramp, including any landings, to be within a fire-resisting shaft and be constructed from non-combustible materials. In addition, the structure needs to be designed so that if there is a likelihood of local failure, the local failure must not cause structural damage to, or impair the fire-resistance of, the shaft. For this situation, often steel stair or ramp are used. Alternatively, an all-timber solution is possible via the Performance Solution compliance pathway.

5.9 Archways, Windows and Doors

There are many instances where a window, door or similar construction may penetrate through the fire- and sound-rated walls. Examples include windows or doors or through external walls, entrance doors, or a door or opening in a fire-rated internal wall.

5.9.1 Fire-rated window and doors in external walls

Where window and door in external fire-rated walls are required to be fire-rated, then the fire-rated window or door is required to be a tested or assessed system. The test or assessed system requires consideration of the type of wall that it is in. In these cases, follow the manufacturer's recommendation.

5.9.2 Non-fire-rated window or door in fire-rated internal and external walls

This situation often occurs in Type B and C buildings where there is no fire-resistance requirement for the actual window and door. In these situations, it is recommended that the wall linings used to protect the fire-rated wall be used to enclose the opening in the timber framing caused by the non-fire-rated window or door (see Figure 72).

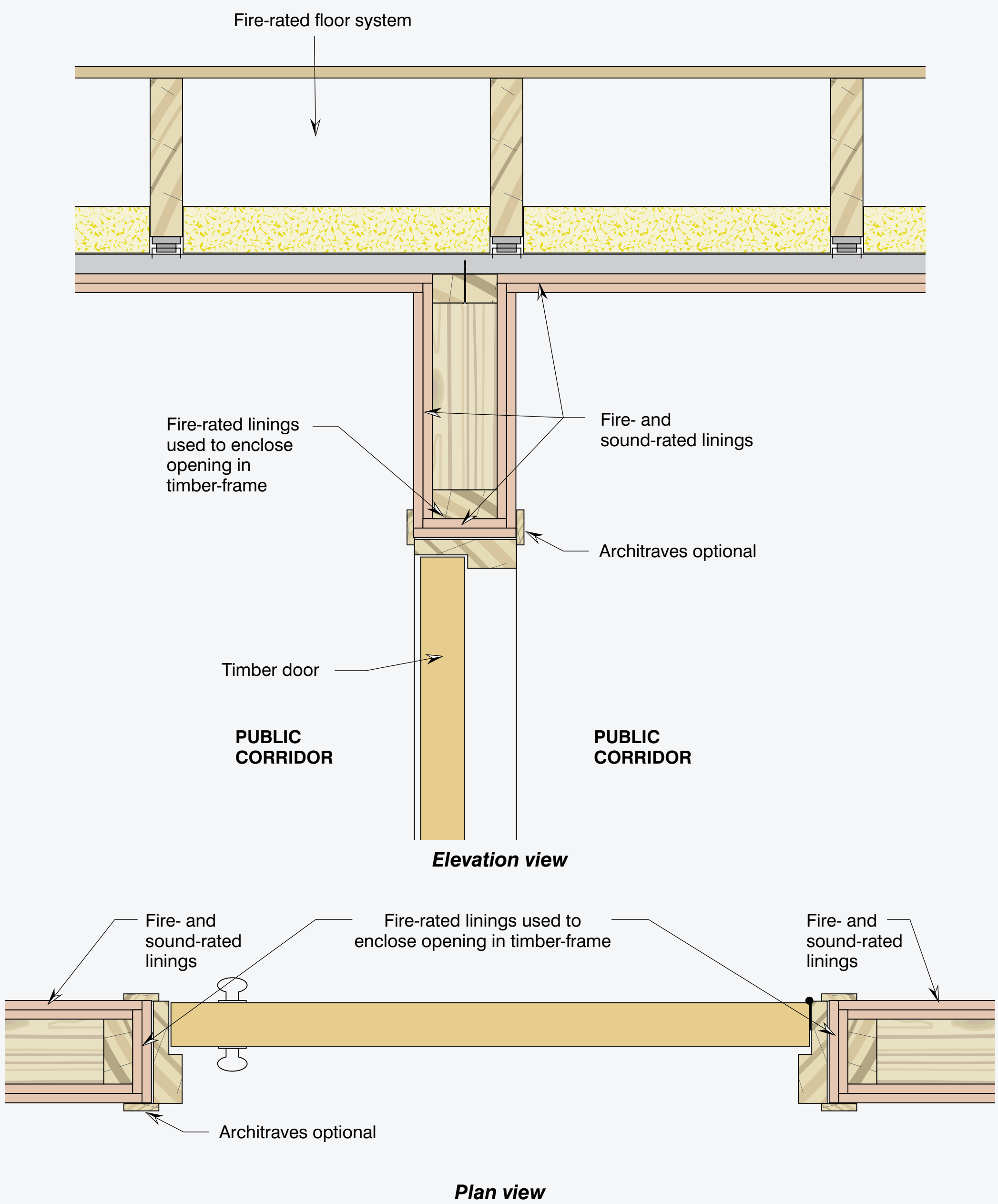


Figure 72: Door openings in fire-rated walls.

5.10 Cavity barriers

Cavity barriers are obstructions placed in concealed air spaces in fire-rated systems that in the event of a fire, limit the spread of smoke and hot gases to other parts of the building, and reduce airborne flanking noise. They are not mandatory under this Deemed-to-Satisfy solution within the NCC but are recommended practice.

Cavity barriers can be made out of many building products used in fire- and sound-rated timber-framed construction, and in many cases are extensions of materials already being used. Solid timber, plywood, particleboard, plasterboard, mineral wools or metal flashing can be used. The cavity barrier must extend continuously across the voids.

5.10.1 Cavity barrier location

Generally, cavity barriers should be placed at the corners of each compartment, i.e. at the intersection of floors and bounding walls, and bounding walls to bounding walls (see Figure 16). The following are typical locations where cavity barriers should be installed:

- The junction between the fire-rated floor and fire-rated internal bounding wall (see Figure 73).
- The junction between the fire-rated floor and the fire-rated external walls. Note there is two option, one using mineral wool and the other using a metal flashing (see Figure 74).
- The junction between the internal fire-rated bounding wall and external wall (see Figures 75 and 76).

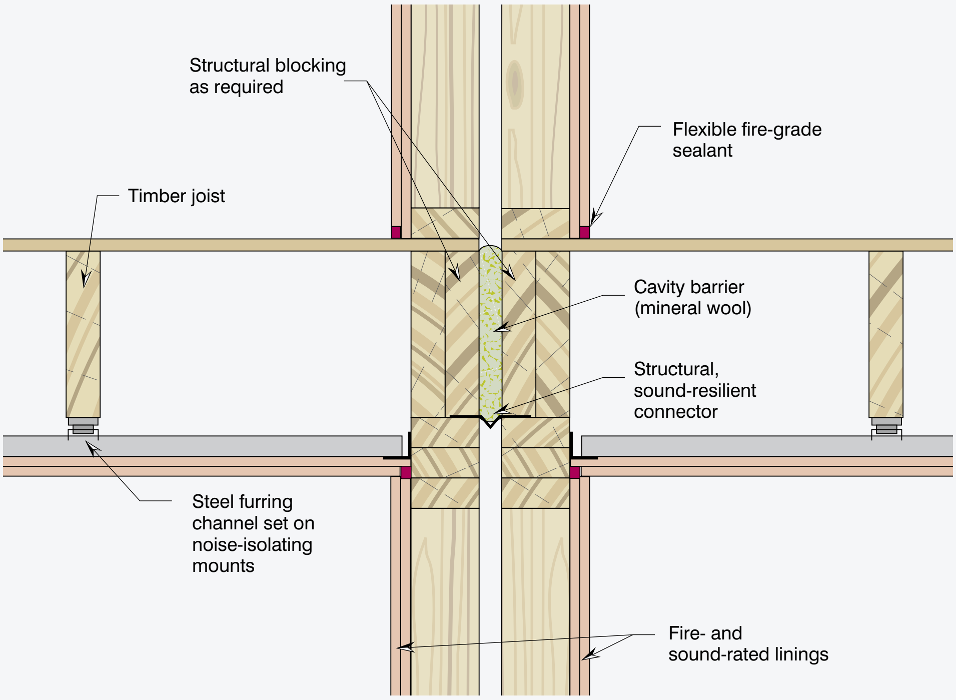


Figure 73: Cavity barrier at the junction of fire-rated floor and fire-rated wall – elevation view.

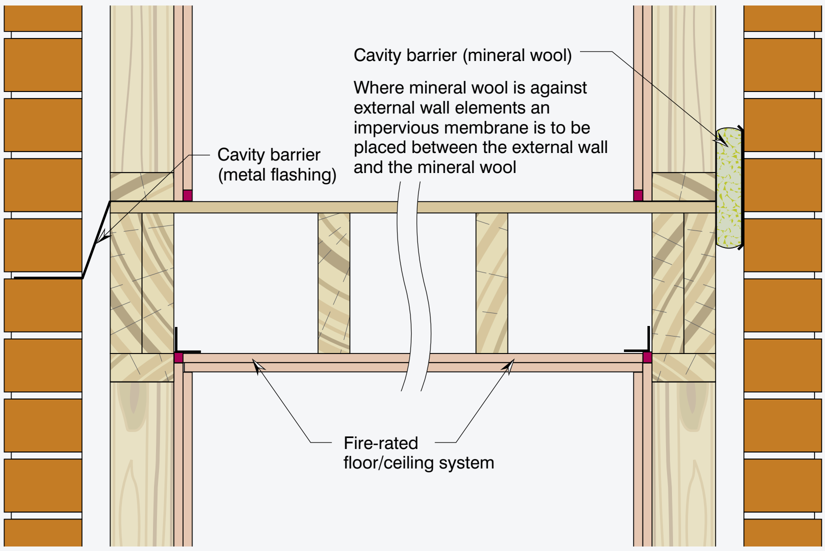


Figure 74: Junction between fire-rated floor and fire-rated external walls – elevation view.

Proprietary systems, if correctly specified, can save building from scratch.

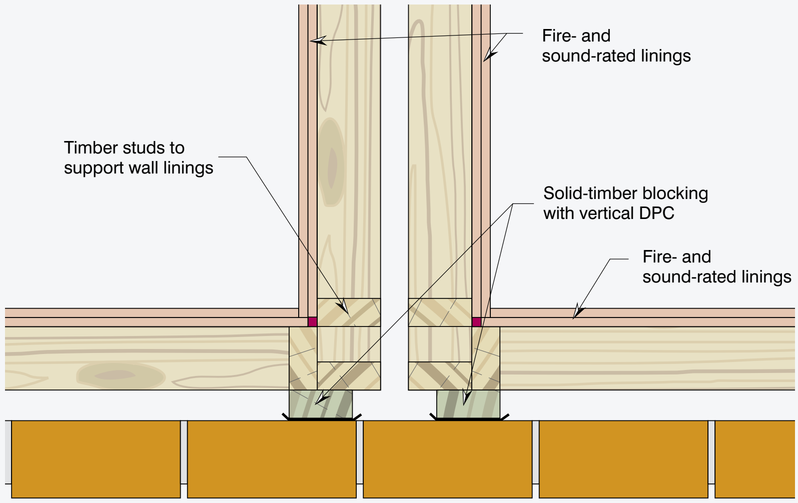


Figure 75: Cavity barrier (using timber blocking) at the junction of fire-rated bounding wall and external wall – plan view.

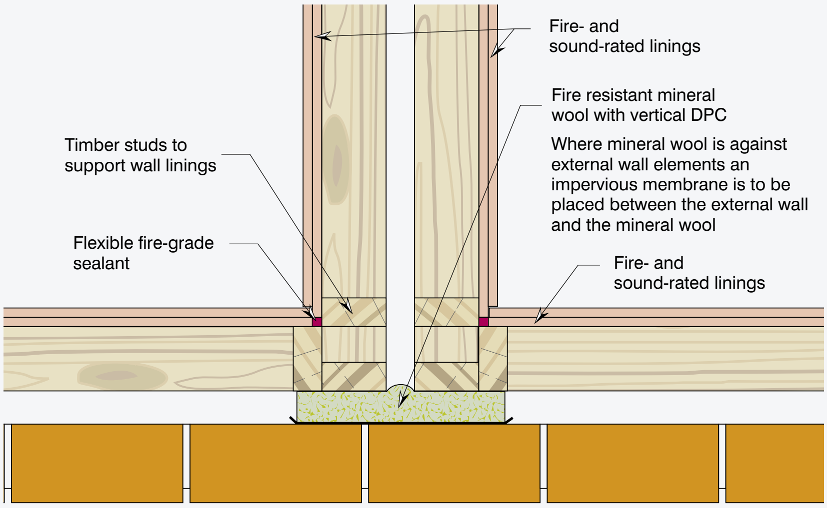


Figure 76: Cavity barrier (using mineral wool) at the junction of fire-rated bounding wall and external wall – plan view.

6

Further Design Assistance

The previous Steps in the Guide require consideration of additional information on topics closely linked to the design of fire and sound construction. The following appendices cover structural design considerations, Deemed to Satisfy fire requirements not covered by this Guide, other design references and a Glossary.

A

Appendix A – Resolving Structural Design Considerations

The following issues should be taken into account in the structural design of Class 2 and 3 buildings:

- Lighter mass than masonry construction – greater attention needs to be given to resistance against overturning.
- The more significant effect of wind loads than expected for traditional timber-framed detached houses. This more significant effect is due to the larger height-to-width ratio, resulting in a need for attention to resistance to overturning.
- Greater imposed loads than timber-framed detached houses because of the extra loads associated with the fire and acoustic-rated wall and floor elements.
- Need to accommodate a larger number of people than detached housing, resulting in higher applied loads.
- Must be constructed using specific methods for attachment of linings to achieve fire ratings.
- More significant potential for shrinkage in taller timber buildings. Shrinkage can be minimised by:
  - using seasoned timber or engineered timber
  - constructing bearers and joists in the same plane
  - detailing to avoid differential shrinkage between dissimilar materials, e.g. steel to timber; timber to masonry
  - allowing for shrinkage with respect to plumbing.

It is recommended that a professional structural engineer is employed to address the above issues and structural performance in general. Call upon the following Standards and Guidelines for assistance:

- AS 1170.0 – Structural design actions – General Principles.
- AS 1170.1 – Structural design actions – permanent, imposed and other actions provide the basis for determination of appropriate dead, live design loads and loads combinations.
- AS 1170.2 – Structural design actions – wind actions – which provides the basis for wind loads.
- AS 1170.4 – Structural design actions – Earthquake actions in Australia – which provides guidance and design procedures for earthquake forces.
- AS 1684 – Residential timber-framed construction - Although written for Class 1 buildings, the Standard can be used as a general guide for construction practices, and some design of members in buildings up to two storeys provided the appropriate adjustments are made to the relevant criteria including: permanent, imposed and wind loads. Common practices include allowable notching into framing members. More specific engineering design of members is required for three and four-storey buildings.
- AS 1720.1 – Timber structures – design methods.
- AS/NZS 1720.4 – Fire resistance of timber elements – alternative method to assign fire resistance levels to timber elements.
- WoodSolutions Guide #50 – although aimed at mid-rise timber structure, i.e. above a rise of four storeys, many of the principles discussed in this guide are explained in more details within #50.

In addition to the above:

- Select details that minimise the effects of shrinkage (especially since differential shrinkage may have an adverse impact on the function of the fire-rated wall and floor elements).
- Check that double-stud walls bounding Sole Occupancy Units are capable of supporting multistorey load paths from above. Enlist internal walls if required.
- Check that any elements supporting loads (including bracing elements) are treated as fire-resistant construction and designed accordingly. This usually includes all the external walls of the building.
- Where required, solid timber without protective fire-protective linings can be designed to perform as a fire-resistant element by allowing for an extra charring layer. A calculation method is available to assist in determining the correct size, available from AS/NZS 1720.4.

B

Appendix B – Deemed-to-Satisfy Fire Requirements Not Covered by this Guide

This publication aims to assist users wanting to use timber-framed construction under of the NCC's Deemed-to-Satisfy fire-resistance provisions. Even so, many of these provisions extend beyond the scope of this publication. To help users obtain a more holistic understanding of NCC requirements, checklists are provided in Tables B1, B2 and B3.

These lists cover the main issues raised in Parts C1, C2 and C3 of the NCC (being the three key parts contributing to the Deemed-to-Satisfy Provisions). The checklists aim to inform readers of what is and is not covered in this Guide. By knowing this, users can confidently speak with construction certifiers, regulatory bodies, designers, head contractors and subcontractors about the role of timber-framed construction in complying with the NCC's Deemed-to-Satisfy Provisions. For further guidance, refer to NCC Guide to Volume One.

Table B1: Checklist for NCC Part C1: Fire-Resistance and Stability.

NCC Clause	Issue	Is assistance on this issue provided in this publication
C1.0	Deemed-to-Satisfy Provisions	Yes, general information on relevant clauses required to be considered for a design
C1.1	Type of Construction	Yes, refer Section 4.2
C1.2	Calculating the 'rise in storeys'	No, refer to NCC Guide to Volume One
C1.3	Buildings of multiple classifications	No, refer to NCC Guide to Volume One
C1.4	Mixed types of construction	No, refer to NCC Guide to Volume One
C1.5	Two storey Class 2 and 3 buildings	Yes, refer Section 4.2.1
C1.6	Class 4 parts of buildings	No, refer to NCC Guide to Volume One
C1.7	Open spectator stands and indoor sports stadiums	Not applicable
C1.8	Lightweight construction	Yes, but only for the timber parts of lightweight construction. Requirements for fire-protective linings and other components are the responsibility of suppliers.
C1.09	Non-combustible building elements	Yes, refer Section 4.5.1
C1.10	Fire hazard properties	No, advice on suitable species and application can be found on www.woodsolutions.com.au
C1.11	Performance of external walls in the fire	No, this item only applies to concrete external walls
C1.12	There is no requirement in the NCC	Not applicable

Table B2: Checklist for NCC Part C2: Compartmentalisation and Separation.

NCC Clause	Issue	Is assistance on this issue provided in this publication
C2.0	Deemed-to-Satisfy Provisions	Yes, general information on relevant clauses required to be considered for a design
C2.1	Application of Part	No, not relevant
C2.2	General floor area and volume limitations	No, not relevant
C2.3	Large isolated buildings	No, not relevant
C2.4	Requirements for open spaces and vehicular access	No, not relevant
C2.5	Class 9a and 9c buildings	No, not relevant
C2.6	Vertical separation of openings in external walls	Yes, refer to Section 5.7
C2.7	Separation by firewalls	No, designer to interpret relevance then if required, select an appropriately rated timber detail.
C2.8	Separation of classifications in the same storey	No, refer to NCC Guide to Volume One if relevant.
C2.9	Separation of classifications in different stories	No, refer to NCC Guide to Volume One if relevant.
C2.10	Separation of lift shafts	Yes, refer to Section 5.6
C2.11	Stairways and lifts in one shaft	No, refer to NCC Guide to Volume One if relevant.
C2.12	Separation of equipment	No, refer to NCC Guide to Volume One if relevant.
C2.13	Electricity supply system	No, refer to NCC Guide to Volume One if relevant.
C2.14	Public corridors in Class 2 and 3 of buildings	Yes, go to Section 4.4.1

Table B3: Checklist for NCC Part C3: Protection of Openings.

NCC Clause	Issue	Is assistance on this issue provided in this publication
C3.0	Deemed-to-Satisfy Provisions	Yes, general information on relevant clauses required to be considered for a design
C3.1	Application of Part	No, general information on relevant clauses required to be considered for a design
C3.2	Protection of openings in the external wall	Yes Section 4.4.5
C3.3	Separation of external walls and associated openings in different fire compartments	No, but maybe relevant to a building design
C3.4	Acceptable methods of protection	No, but relevant to a building design
C3.5	Doorways in firewalls	No, but maybe relevant to a building design
C3.6	Sliding fire door	No, but maybe relevant to a building design
C3.7	Protection of doorways in horizontal exits	No, but relevant to a building design
C3.8	Openings in fire–isolated exits	No, but maybe relevant to a building design
C3.9	Service penetrations in fire-isolated exits	Yes, refer to Section 5.8
C3.10	Openings in fire-isolated lift shafts	Yes, refer to Section 5.8
C3.11	Bounding construction: Class 2, 3 and 4 buildings	Yes, refer to Section 5.9
C3.12	Openings in floors and ceilings for services	Yes, refer to Sections 5.6.2
C3.13	Opening in shafts	Yes, refer to Section 5.6.2
C3.14	There is no requirements in NCC	No
C3.15	Openings for services installation	No, but relevant to a building design
C3.16	Construction joints	Yes, refer to Sections 5.4
C3.17	Columns protected with lightweight construction to achieve an FRL	No, but maybe relevant to a building design

C

Appendix C – Design References

Association of Australian Acoustical Consultants

- Guideline of Apartment and Townhouse Acoustic Rating.

Australian Building Codes Board

- National Construction Code Series Volume 1, Building Code of Australia (BCA) Class 2 to Class 9 buildings
- National Construction Code Guide to Volume One.

Australian Standards

- AS/NZS ISO 717.1 – Acoustics - Rating of sound insulation in buildings and of building elements Airborne Sound insulation
- AS ISO 717.2 – Acoustics - Rating of sound insulation in buildings and of building elements Impact Sound insulation
- AS 1530.4 – Methods for fire tests on building materials, components and structures – Fire-resistance tests on elements of construction.
- AS 1684 – Residential Timber Framed Construction Standard
- AS/NZS 2908.2 – Cellulose cement products – Flat sheets
- AS 4072.1 – Components for the protection of openings in fire-resistant separating elements – Service penetration and control joints.

WoodSolutions

The following publications are available as free downloads at www.woodsolutions.com.au:

- #01 Timber-Framed Construction for Townhouse Buildings Class 1 – Design and construction guide for NCC compliant sound – and fire-rated construction.
- #06 Timber-framed Construction Sacrificial Timber Construction Joint
- #11 Timber Framed Systems for External Noise
- #17 Alternative Solution Fire Compliance: Timber Structures
- #18 Alternative Solution Fire Compliance: Facades
- #19 Alternative Solution Fire Compliance: Linings
- #20 Fire Precautions During Construction of Large Buildings
- #37R Mid-rise Timber Buildings Multi-residential Class 2 and 3
- #50 Mid-rise Timber Building Structural Engineering.

Test and Assessment Reports

Bodycote Warringtonfire (Aus)

- 22567A Assessment Report: The likely fire resistance performance of timber-framed walls lined with plasterboard if tested in accordance with AS 1530.4
- 22567B Assessment Report: The likely fire resistance performance of MRTFC wall floor junctions if tested in accordance with AS 1530.4
- RIR 22567B Regulatory Information Report: The likely fire resistance performance of MRTFC wall floor junctions if tested in accordance with AS 1530.4
- 2256701 Test Report: Fire resistance test of a timber wall floor junction in general accordance with AS 1530.4
- 2256702 Test Report: Fire resistance test of a wall beam junction when tested in general accordance with AS 1530.4.

Exova Warringtonfire Australia

- 2365300 Test Report: Fire resistance test of floor junctions incorporating timber and plasterboard in general accordance with AS 1530.4
- 2365400 Test Report: Fire resistance test of floor junctions incorporating timber and plasterboard in general accordance with AS 1530.4
- 2365500 Test Report: Fire resistance test of floor junctions incorporating timber and plasterboard in general accordance with AS 1530.4
- 22221A-00 Assessment Report: The likely fire resistance performance of various MRTFC roof and wall junctions in fire-resistant wall construction if tested in accordance with AS1530.4

Forest and Wood Products Australia

- PN04.2005 Maximising impact sound resistance of timber-framed floor/ceiling systems.

D

Appendix D – Glossary

BCA: Building Code of Australia – Volume 1 – Class 2 to 9 Buildings.

Cavity barrier (relationship to NCC Specification C1.1 Clause 3.10 and 4.3 only): A non-mandatory obstruction installed in concealed cavities within fire-rated wall or floor/ceiling systems.

Discontinuous construction: A wall system having a minimum of 20 mm cavity between two separate wall frames (leaves) with no mechanical linkage between the frames except at the periphery, i.e. top and bottom plates.

Construction joint: Discontinuities of building elements and gaps in fire-rated construction required by the NCC to maintain fire resistance. Refer to Deemed-to-Satisfy Provision C3.16, Volume 1, NCC.

Exit: Includes any of the following if they provide egress to a road or open space:

- an internal or external stairway
- a ramp complying with Section D of the NCC
- a doorway opening to a road or open space.

Fire-protective lining: Either fire-protective plasterboard, fibre-cement or a combination of both, used to provide the required Fire Resistance Level (FRL) for walls or floor/ceiling systems. Individual linings manufacturers should be contacted to determine the extent to which a given lining material provides fire-resisting properties.

Fire-isolated stair or ramp: A stair or ramp construction of non-combustible materials that is within a fire-resisting shaft or enclosure.

Fire-isolated passageway: A corridor or hallway of fire-resisting construction that provides egress to a fire-isolated stairway or ramp.

Fire-protective covering:

- 3 mm fire-protective plasterboard; or
- 2 mm cellulose fibre-reinforced cement sheeting complying with AS 2908.2; or
- 2 mm fibrous plaster reinforced with 13 mm x 13 mm x 0.7 mm galvanized steel wire mesh located not more than 6 mm from the exposed face; or
- Other material not less fire-protective than 13 mm fire-protective plasterboard.

Note: Fire-protective covering must be fixed in accordance with normal trade practice (e.g. joints sealed).

Fire Resistance Level (FRL)

The period of time in minutes, determine in accordance with Specification A2.3 (of the NCC) for the following:

- structural adequacy
- integrity
- insulation.

Fire-resisting mineral wool: Compressible, non-combustible, fire-resisting material used to fill cavities and maintain fire resistance or restrict the passage of smoke and gases at gaps between other fire-resisting materials.

NOTE: The mineral wool to be used in all applications in this Guide must be fire-resisting and therefore must have a fusion temperature in excess of 1160°C. ‘Rockwool’ type products generally meet these requirements, while ‘glasswool’ products do not.

Fire-resisting (fire-rated): As applied to a building element means, having the FRL required by the NCC for that element.

Fire-resisting construction: Construction that satisfies Volume 2 of the NCC.

Fire-resisting junction: The intersection between a fire-rated wall or floor/ceiling system and/or another rated or non-rated system that maintains the fire resistance at the intersection.

Fire-resisting sealant: Fire-grade material used to fill gaps at joints and intersections in fire-protective linings to maintain Fire Resistance Levels. Note: The material should also be flexible to allow for movement and where required waterproof as well.

Fire-source feature: Either:

- the far boundary of a road adjoining the allotment; or
- a side or rear boundary of the allotment; or
- an external wall or another building on the allotment which is not of Class 10.

Habitable room: A room for normal domestic activities and includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room and sunroom, but excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, clothes drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.

Internal walls: Walls within, between or bounding separating walls but excluding walls that make up the exterior fabric of the building. Note: Firewalls or common walls between separate buildings or classifications are NOT internal walls.

Lightweight construction: Construction which incorporates or comprises sheet or board material, plaster, render, sprayed application, or other material similarly susceptible to damage by impact, pressure or abrasion.

Non-combustible: Applied to a material not deemed combustible under AS 1530.1 – Combustibility Tests for Materials; and applied to construction or part of a building – constructed wholly of materials that are not deemed combustible.

Performance Requirements: The objectives, functional statements and requirements in the Building Code of Australia that describe the level of performance expected from the building, building element or material.

R_w: Refer to Weighted Sound reduction index.

Weighted Sound reduction index (R_w): The rating of Sound insulation in a building or building element as described in AS/NZS ISO 717.1.

Free resources are available at woodsolutions.com.au