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Timber-framed Construction for Townhouse Buildings Class 1a

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

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Introduction

This Guide covers fire and sound.

Fire and sound are important issues in residential construction. Sound insulation tends to govern the choice of construction system because of its daily impact on the building occupants' quality of life, while fire-resisting construction is important for protecting against extreme events.

This Guide aims to assist in both areas and is specifically written for use by designers, specifiers, builders and certifying authorities. It is set-out according to a simple step-by-step process shown in Table 1. The steps are then used as the basis for headings throughout the rest of the document. Details on the scope and other important aspects of the Guide are detailed below.

Scope

For timber-framed construction, this Guide demonstrates compliance with targeted fire safety and sound-insulation Performance Requirements in the Building Code of Australia for Class 1a attached buildings and associated Class 10a buildings. Specific areas of performance addressed include:

- Providing sound insulation in walls between dwellings.
- Protection against spread of fire both between dwellings and on external walls (where required).

It does not deal with fire detection and early warning in buildings (including smoke alarms), heating appliance issues, bushfires or fire in alpine areas.

This Guide provides certified construction details by utilising the BCA's Deemed to Satisfy Provisions. In addition, guidance beyond BCA minimum requirements is provided for those wanting to improve and upgrade sound performance.

Although national, some BCA 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 BCA requirements. From time to time State-based BCA amendments may vary requirements. Users of this Guide should make themselves aware of these differences and should develop a full understanding of the resulting implications. Only on this basis should this Guide be used.

Taking a step-by-step approach reduces complex designs to manageable elements.

Table 1: Design process for sound- and fire-resistant timber-framed construction

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 separating walls between dwellings

Step 2 – Define BCA Sound Design Requirements

- Utilise the Deemed to Satisfy Provisions for sound design
- Determine sound-insulation requirements for separating

Step 3 – Improve and Upgrade Sound Performance

- Attention to building design (space and
- 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 Fire Resistance Levels of wall

Step 5 – Sound- and Fire-Rated Timber Construction

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

Step 6 – Further Design Assistance (Appendices)

- Structural considerations, other BCA requirements, references,

Taking a step-by-step approach reduces complex designs to manageable elements.

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Step 1 – High-Level BCA Design Issues

This Guide covers BCA Class 1a and 10a buildings. It's also relevant to Class 1b structures.

The BCA 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 decision making to be made on a building project. A selection of high-level design issues relating to fire-resisting and sound-insulation construction are addressed in this section of the Guide.

1.1 Determine the Class of Building

The Building Code of Australia (BCA) contains mandatory Performance Requirements which apply to 10 primary classes of building. These classes are determined according to the purpose for which a given building will be used. The classes relevant to this Guide are:

- Class 1a attached dwellings each being a building separated by a fire-resisting wall including row houses, terrace houses, townhouses or villa units.
- Class 10a non-habitable buildings that are attached or in some way associated with the above Class 1a buildings including private garages, carports and sheds.

These classes are dealt with in Volume 2 of the BCA and so all future references to the BCA are made with relevance to this Volume. Other Class 1 buildings not specifically dealt with in this Guide, but which may still benefit from specific information contained within, include:

- Class 1a detached dwellings.
- Class 1b boarding houses, guest houses, hostels and similar buildings (Note: Class 1b buildings are defined as having a total floor area up to 300 m^2 and would not ordinarily have more than 12 people as residents).
- Both these types of building have no specific sound Performance Requirements in the BCA and only require fire-resisting construction where exterior walls have close proximity to an allotment boundary or close proximity to an adjacent building (refer BCA 3.7.1.3).

Care is required to ensure that Class 1a buildings do not inadvertently have their building classification changed. Common causes of this are:

- Two or more dwellings sharing a common garage.
- Two or more dwelling sharing a common entrance.
- One dwelling construction overlapping onto another below.

1.2 BCA Compliance – Deemed to Satisfy Provisions or Alternative Solutions

Refer BCA 1.0.9 and 1.2.2 to 1.2.4.

BCA Performance Requirements can be achieved for the above building classes in two different ways:

- Deemed to Satisfy Provisions – a specific type of construction which is acknowledged as complying with the BCA's Performance Requirements. This includes Acceptable Construction Practices for fire and sound, as detailed in Volume 2 of the BCA.
- Alternative Solutions – this means a solution not dealt with under Deemed to Satisfy Provisions and must be proven to satisfy BCA Performance Requirements. Suitable assessment methods are identified in the BCA.

The construction systems and details in this Guide comply with the Deemed to Satisfy Provisions by utilising the Acceptable Construction Practices in Volume 2. This part of the BCA directs the level of fire-resisting and sound-insulation construction that timber-framed construction must achieve in order to meet minimum BCA Performance Requirements. Approved BCA methods of assessment are then used to ensure that the timber-framed construction systems shown in this Guide comply with the levels required.

Two clear BCA conditions make it straightforward to deem external walls.

1.3 Fire and Sound Separation in Buildings

In order to prevent the spread of fire and provide sound insulation between buildings, there are key concepts used in the BCA's Acceptable Construction Practices including:

Separating Walls – Such walls separate the effects of fire and sound on adjoining Class 1a buildings by virtue of a common wall. The wall commences at the lowest floor level (or possibly ground level where a raised floor is involved) and finishes at either the underside of the roofing material or in some instances a set distance above the roof line (Figures 1 and 2). More specific conditions concerning separating walls are discussed later in this Guide.

External Walls – Such walls are important in protecting a building against spread of fire from external fire sources (Figures 1 and 2). These walls are deemed to occur where:

- 900 mm or less from an allotment boundary other than the boundary adjoining a road alignment or other public space; or
- 1.8 m or less from another building on the same allotment other than a Class 10 building or a detached part of the same Class 1 building.

More specific conditions concerning external walls are discussed later in this Guide.

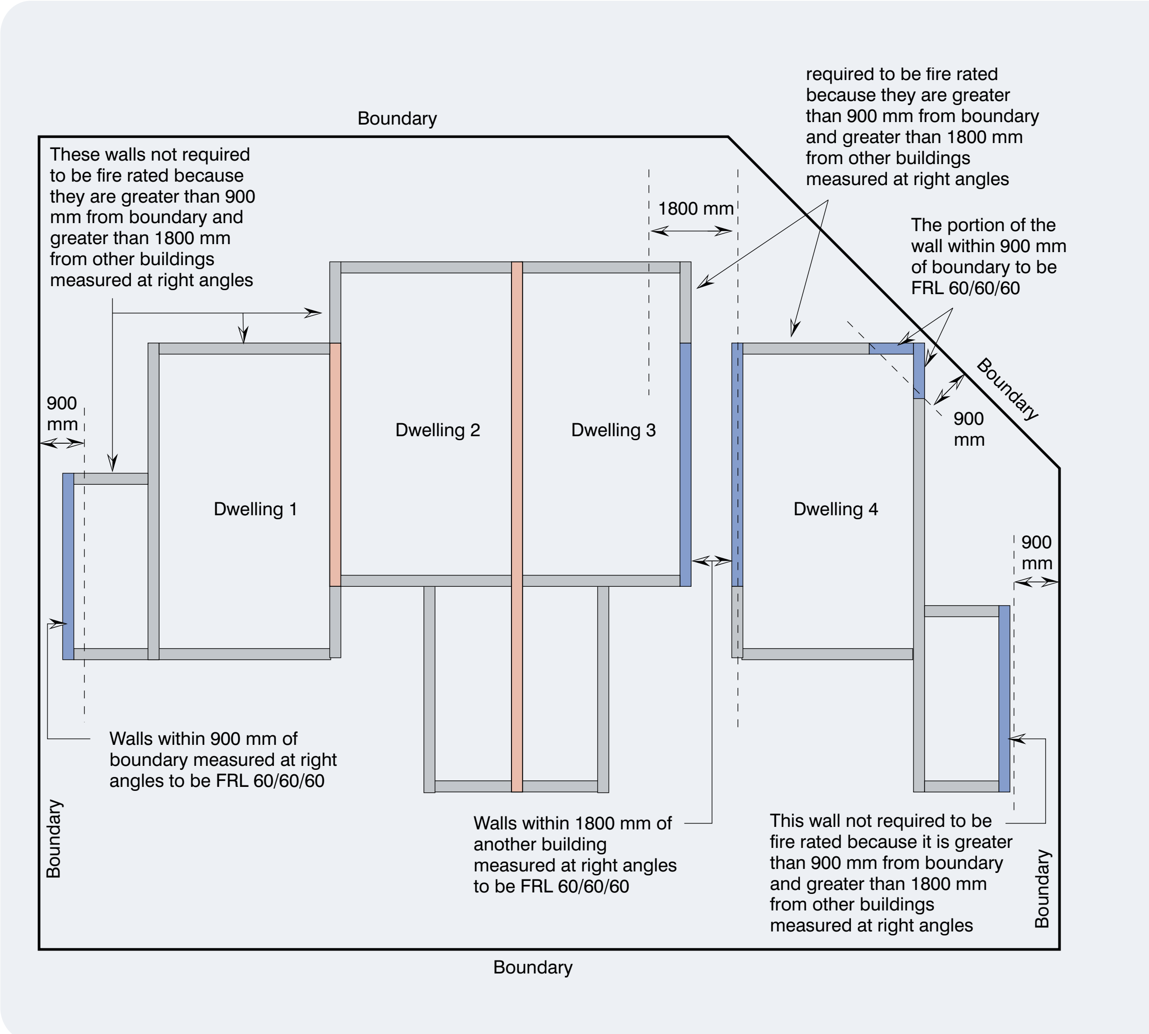

Figure 1: Examples of a separating walls and external walls – plan view.

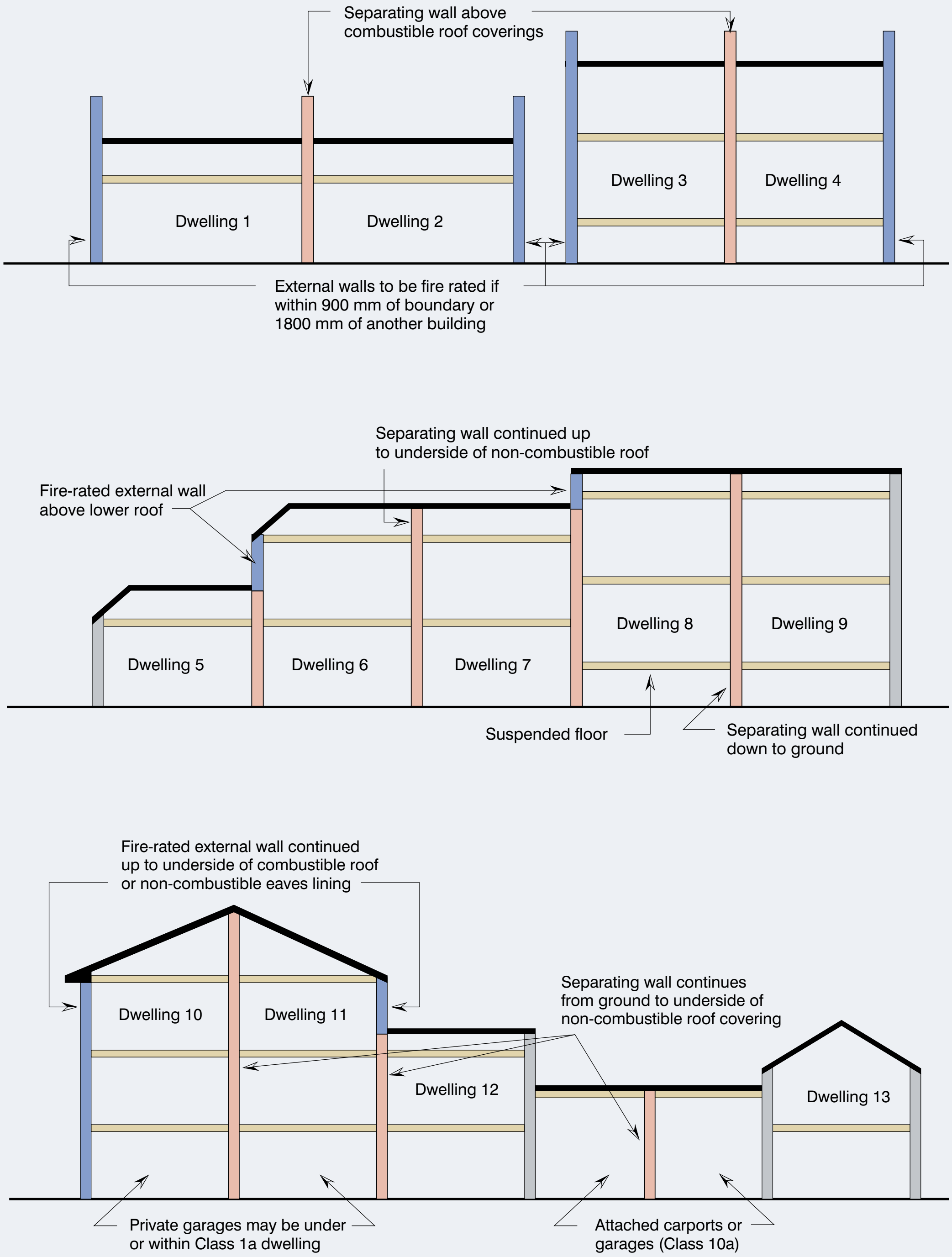

Figure 2: Examples of a separating walls and external walls – elevation view.

2

Step 2 – Define BCA Sound-Design Requirements

Addressing multiple sound sources is even more important in light of today's trend towards medium density housing.

Designing sound-insulated construction involves a process of understanding how the BCA's Performance Requirements translate into objective design parameters, as contained in the BCA's Deemed to Satisfy Provisions (i.e. acceptable construction practice). This is then used as the basis for selecting appropriate timber-framed construction. Key issues determining sound design requirements are discussed in this Section of the Guide.

2.1 Utilising the Deemed to Satisfy Provisions for Sound Design

The BCA's Performance Requirements for sound insulation concern the use of separating walls between dwellings to sufficiently insulate against airborne sound transmission and impact noise. In order to understand these requirements it is important to differentiate between airborne and impact sound as shown in Figure 3.

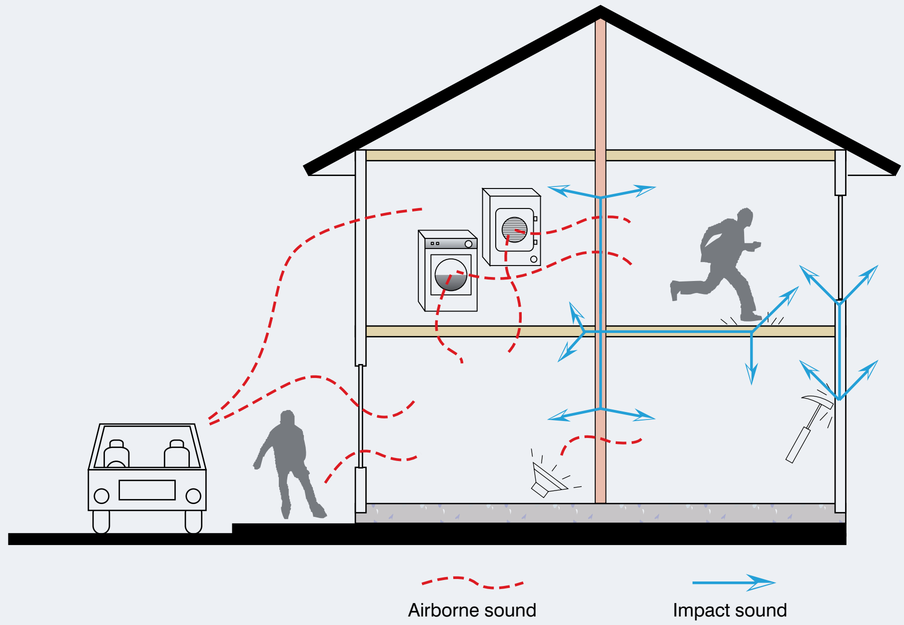

Figure 3: Examples of impact and airborne sound.

2.1.1 Airborne Sound Transmission

Airborne sound transmission refers to sound waves that travel through the air and cause a building element to vibrate, radiating out on the other side of the wall. Methods used to reduce transmitted airborne sound generally use cavity (isolated) construction with bulk insulations to absorb the vibration.

Deemed to Satisfy construction that meets the above Performance Requirements is provided in the Acceptable Construction Practices part of the BCA (BCA 3.8.6).

2.1.2 Impact Sound Transmission

Impact sound refers to the sound arising from the impact of an object on a building element causing both sides of the building element to vibrate and generates sound waves. The primary method used to reduce impact noise is isolation from any adjoining building elements.

Generally, the BCA considers impact sound for walls separating a bathroom, sanitary compartment, laundry or kitchen in one dwelling from a habitable room (other than a kitchen) in an adjoining dwelling. Sound leakage at penetrations from service elements may compromise the performance of

Proper sound insulation isn't 'bolted on'. It starts at the bottom and permeates every level of construction.

walls. This requirement is generally achieved with discontinuous construction. Refer to Appendix C for a definition of discontinuous construction.

It is also important to understand how each type of sound is measured in order to select sound-insulated separating walls. The nomenclature used in the BCA's Acceptable Construction Practice is explained in Figure 4.

Airborne sound is measured using the Weighted Sound Reduction Index which is expressed as R_w (e.g. 50 R_w)

- The higher the number the better the performance
- It can be used on its own or modified using a C_{tr} factor (see below)

A C_{tr}. modification factor can be added to the R_w measurement to bias the overall measurement to take greater account of low frequency bass noise.

C_{tr} is usually a negative number and so even though it is added to the R_w value, the net result is a lower number than the R_w value on its own. It is therefore significantly harder to achieve 50 R_w + C_{tr} than 50 R_w on its own

Applying the above, involves finding out the minimum stated R_w or R_w +C_{tr} for a separating wall, then selecting timber-framed construction that suits.

Figure 4: Methods of measuring airborne sound.

2.2 Determine Sound-Insulation Requirements In Separating Walls

Given the previous definitions, the required airborne and impact sound insulation levels, as interpreted from the BCA for Class 1a buildings, are provided in Table 2. In addition to these requirements, there are general installation requirements in the BCA (refer BCA 3.8.6.3). A key issue here is that to achieve the required sound levels, walls must be sealed at junctions between the sound-insulated separating wall and any perimeter walls or roof covering. In addition, timber studs and perimeter members must be installed as follows:

- Studs must be fixed to top and bottom plates of sufficient depth to permit secure fixing of the plasterboard.
- Noggings and like members must not bridge between studs supporting different wall leaves.
- All timber members at the perimeter of the wall must be securely fixed to the adjoining structure and bedded in resilient compound or the joints must be caulked so there are no voids between the timber members and the wall, refer to lining manufacturer's installation recommendations.

Note: BCA requirements for timber-compatible material such as plasterboard should be viewed separately in the BCA (refer BCA 3.8.6.3) and/or proprietary installation manuals.

Table 2: Minimum sound insulation requirements for separating walls.

SEPARATING WALL – Location and Penetrations	**Discontinuous Construction Required**	**R_w + C_{tr}**
Between a bathroom, sanitary compartment, laundry or kitchen and a habitable room (other than a kitchen) in an adjoining Class 1 building	YES	50
In all other cases, includes roof void and subfloor areas	NO	50
Duct, soil, waste and water supply pipes and storm water pipes that pass through a separating wall between Class 1 buildings:		
• if the adjacent room is habitable (other than kitchen)	NO	40
• if the room is a kitchen or any other room.	NO	25

2.3 Treatment of Services Relevant to Timber-Framed Construction

If a duct, soil, waste, water supply or storm water pipe serves or passes through a separating wall or is located in a separating wall, then the following conditions apply:

- A door or panel providing access to a duct or pipe required to be separated must not open into any habitable room other than a kitchen. In any other part, the door or panel must be firmly fixed so as to overlap the frame or rebate of the frame by not less than 10 mm and be constructed of:
  - – wood, plasterboard or blockboard not less than 33 mm thick; or
  - – compressed fibre-cement sheeting not less than 9 mm thick; or
  - – other suitable material with a mass per unit area not less than 24.4 kg/m^2.
- If it is a water supply pipe, it must:
  - – only be installed in discontinuous construction (double stud walls); and
  - – in the case of a water supply pipe that serves one dwelling, not be fixed to the wall leaf on the side of any other dwelling and have a clearance not less than 10 mm to the other wall leaf.

Electrical outlets must be offset from each other in timber framing not less than 300 mm.

2.4 The Next Step

Having used the previous information to obtain a strong understanding of the minimum sound insulation requirements for separating walls, the next step is to either:

- Go to Step 3 to improve and/or upgrade sound performance, or
- Go to Step 4 find out about the BCA fire-resisting construction requirements.

3

Step 3 – Improve and Upgrade Sound Performance

Sound performance can often be improved by simple attention to the form and spatial arrangement of the building design. In addition, many end users of dwellings often want higher sound performance than the minimum levels required in the BCA. As a result, this Step of the Guide focuses on ways of improving and upgrading sound performance.

3.1 Checking and Adjusting the Building Design to Reduce Sound Transmission

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

There are many aspects of Class 1a buildings that can reduce sound transmission by simply paying attention to thoughtful sound design (Figure 5).

3.1.1 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 therefore best for the service rooms in one dwelling to back onto the same rooms in an adjoining dwelling and should not back onto habitable rooms. Also, try to ensure entrances to dwellings are an appropriate distance from attached or adjacent dwellings.

3.1.2 Windows

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

Windows normally have lower sound insulation than the walls they are located within. As a result, high sound rated wall systems may become ineffective by virtue of poorly sound-insulated windows. Where noise is unavoidable, 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 dwellings.
- 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 the openable sashes and the window frame.

3.1.3 Doors

As with windows, doors tend to be the weak link in sound rated walls. Where sound-control is desired, solid core doors should be used. The top and sides of doors should have soft acoustic gaskets. Threshold closers at the bottom of the door or air seals will also reduce sound transmission. Sliding doors should be avoided where optimum sound-control is desired.

3.1.4 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 separating walls 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.

Combined sound insulation strategies generally yield better results than stand-alone measures.

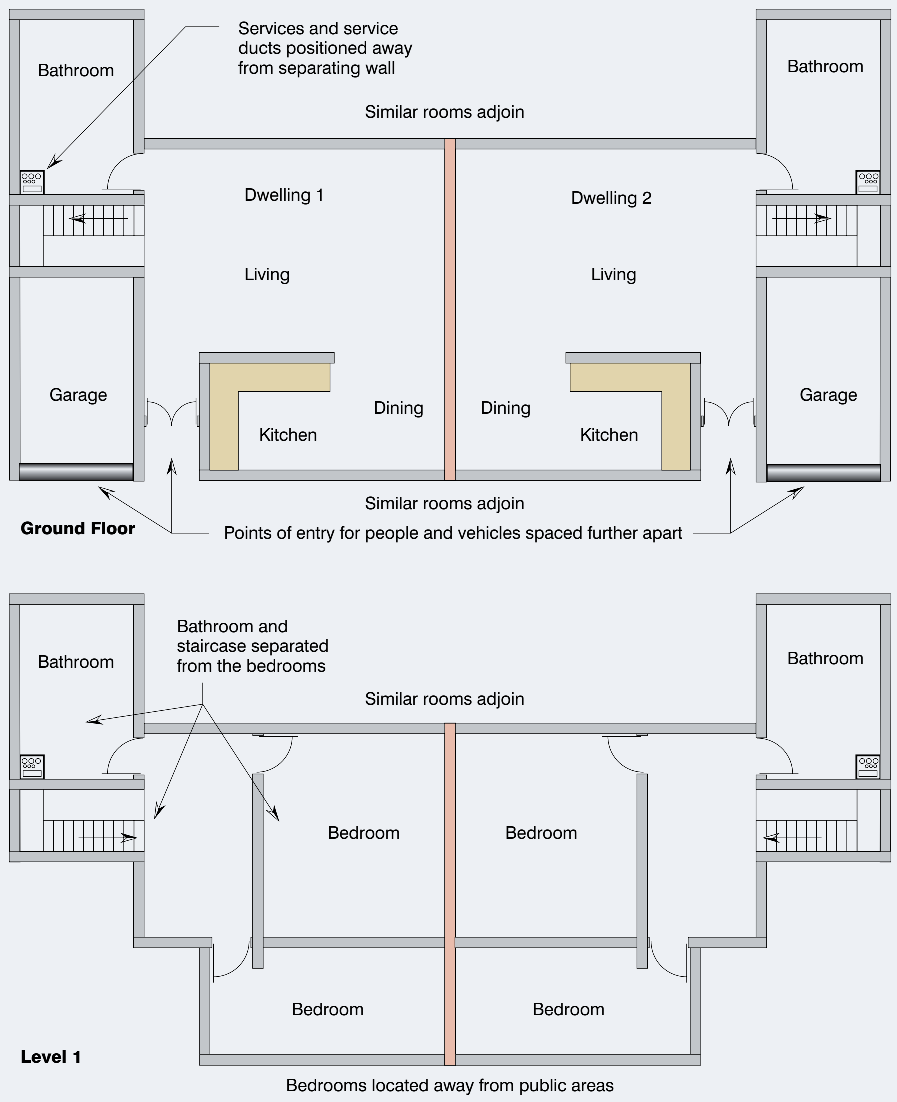

Figure 5: Sound design practices in building layout.

3.1.5 Flanking Noise

Flanking noise is best addressed by:

- isolating of forming discontinuous elements from each other, i.e. resilient acoustic ties and discontinuous flooring, and
- placing absorptive material within sound rated cavities, or near floor/ceiling and wall junctions.

3.2 Strategies for Improving Sound Performance in Construction

The following strategies can be used to improve the sound insulation. Generally, it is not the use of one but a combination of strategies that gives the most economical solution.

Extra mass on the wall – the addition of mass is a simple yet important means of improving sound performance in timber-framed construction. At its simplest, this involves adding extra layers of material such as plasterboard or fibre-cement sheet to the separating wall system.

Use a wider wall (90 mm wall studs) – The wider the wall, the better its sound performance. This is particularly the case when trying to improve C_{tr} scores (being the modification factor for low frequency bass noise applied to R_w scores). The simplest way to do this is to use 90 mm wide studs instead of, say, 70 mm wide studs in a double stud wall system.

Upgrade batts in the wall – There are many different types and grades of insulation batts available. Sound-insulation specific batts are best, and in addition, higher density materials tend to outperform low density materials but as a minimum, batts with densities of 10 kg/m^3 or greater are recommended.

Floor joists parallel to separating walls – By running floor joists parallel rather than transverse to the separating wall, less impact sound from the floor will go into the separating wall and subsequently less impact sound will transfer across the wall to the attached building (Figure 6).

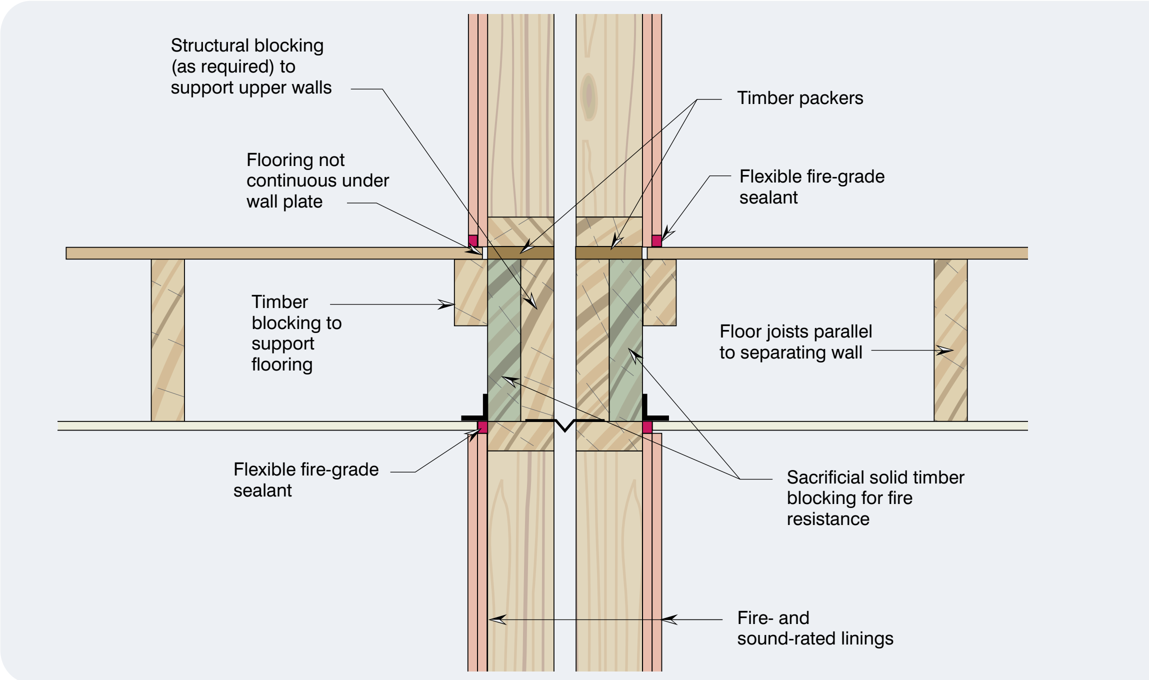

Figure 6: Joists parallel to separating wall – elevation view.

Batts do much more than save energy.

Batts in the floor at the wall/floor junction – Where the parallel joist layout (Figure 6) cannot be achieved, it is good practice to place extra sound-insulation batts between joists running along the separating wall (Figure 7). Much the same can be done at wall and ceiling intersections, but is only required where such insulation is not already provided across the entire ceiling area, such as for energy efficiency.

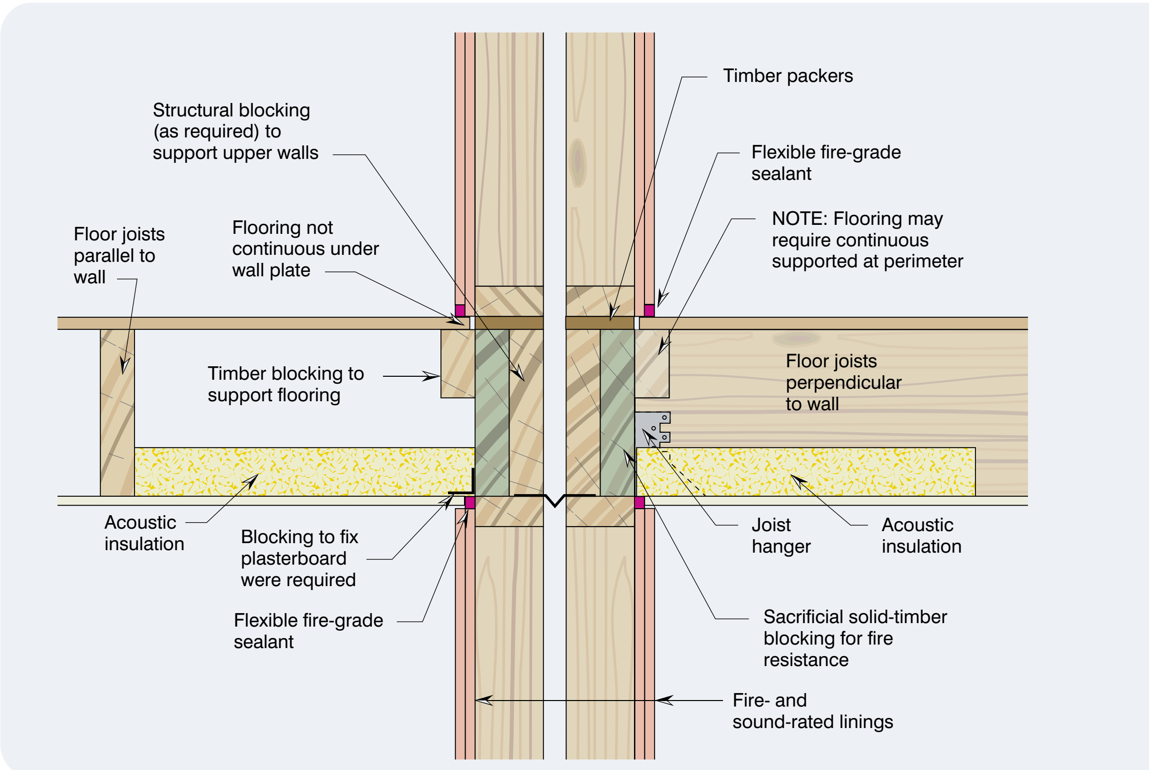

Figure 7: Sound insulation batts at floor and wall intersection – elevation view.

Isolated support for stairs – Impact sound from stair usage typically vibrates its way into separating walls, creating a greater likelihood of sound passing across the wall into attached dwellings. The best way to prevent this is by isolating the support for the stair structure (Figure 8). Options include:

- using the stringers to support the stairs, at each floor level, without intermediate support from the separating wall in between, i.e. free standing
- using Newell posts rather than the separating wall to support the stair structure.

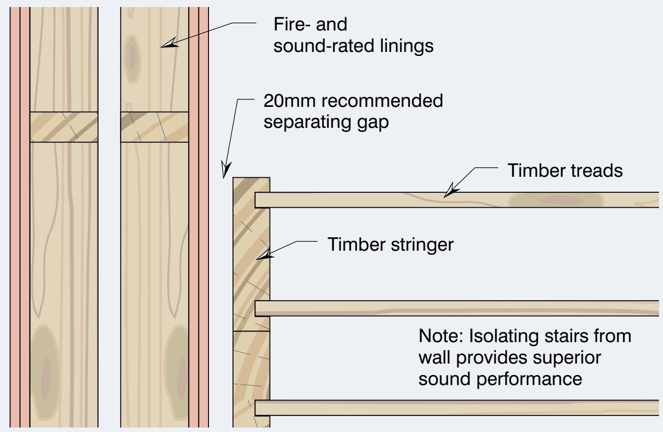

Figure 8: Isolating stair structure from separating wall – elevation view.

Batten out separating walls in 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 separating wall (after fire essential linings have been applied) and then providing an additional lining over the top (Figure 9). The bath can then be installed into the batten space without affecting the fire- and sound-rated wall.

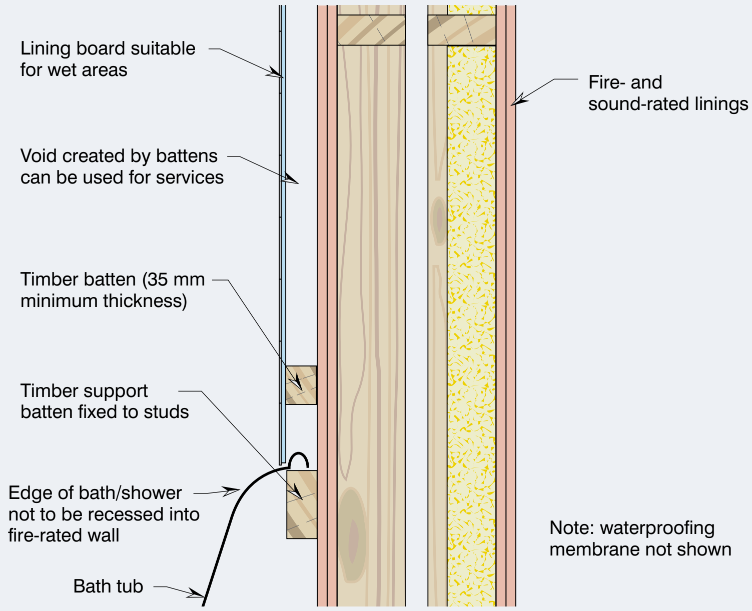

Figure 9: Batten out false wall for services – elevation view.

3.3 The Next Step

The strategies and methods shown in this Step of the Guide 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, or
- go to Step 4 to find out about BCA fire-resisting construction requirements.

4

Step 4 – Define Fire-Design Requirements

Like sound, designing fire-resisting construction involves a process of understanding how the BCA's Performance Requirements translate into objective design parameters, as contained in the BCA's Deemed to Satisfy Provisions (i.e. acceptable construction practices). This is then used as the basis for selecting appropriate timber-framed construction. Key issues are discussed in this section of the Guide.

4.1 Utilising the Deemed to Satisfy Provisions for Fire Design

Refer BCA 3.7.1

As discussed previously, this Guide focuses on meeting Performance Requirements concerning protection against the spread of fire between Class 1a buildings (adjacent to each other) and associated Class 10a buildings. Acceptable construction practices that are Deemed to Satisfy these requirements and of relevance to timber-framed construction, are set out in Part 3.7.1 of the BCA. It provides Fire Resistance Levels and associated construction details for external walls and separating walls. Fire Resistance Levels represent a key requirement when selecting appropriate timber-framed construction systems for fire separation and therefore form the basis for ongoing discussion.

Recent bushfire seasons have made fire resistance a hot issue even for urban building projects.

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

- Structural adequacy (ability to withstand loads);
- Integrity (in terms of containing smoke, flames and gases); and
- 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 an FRL is expressed is: 60/60/60. Another example where not all components are required is: –/60/–. Application of this and related aspects of construction are discussed under the following headings.

4.2 Fire Resistance Levels of Wall Elements

4.2.1 External Walls

External walls are used to protect Class 1a buildings from external fire sources (Figures 1 and 2). Specific requirements pertaining to this include:

- Must have walls with an FRL of not less than 60/60/60 when tested from the outside.
- Must have walls that extend to the underside of a non-combustible roof covering or non-combustible eaves lining.
- Must have openings in walls:
  - – protected by non-openable fire window or other construction with an FRL of not less than –/60/–
  - – protected by self-closing solid core doors not less than 35 mm thick.

Additional Notes:

Refer BCA 3.7.1.7

Certain construction is allowed to encroach on the 900 mm space between an external wall and the allotment boundary or 1800 mm space between the external walls of two buildings on the same allotment (refer BCA 3.7.1.7 for details). Conditions apply as defined in BCA 3.7.1.7 but of relevance to timber-framed construction is the allowable encroachment of non-combustible eaves construction.

Certain concessions exist for windows in non-habitable rooms. Windows that face the boundary of an adjoining allotment may be used if not less than 600 mm from that boundary or, windows that face another building on the same allotment may be used if not less than 1200 mm from the building. Conditions concerning the measurement of distances, the openable area of windows and other features are detailed in BCA 3.7.14 and 3.7.1.5d.

Sub-floor vents, roof vents, weepholes, control joints, construction joints and penetrations for pipes, conduits are not considered as openings, refer BCA 3.7.1.2 (c).

4.2.2 External Walls where Class 10A Buildings are Involved

Refer BCA 3.7.1.6.

Garages and other Class 10a buildings can affect wall designation. The BCA shows the way.

The issue of external walls becomes more complicated where Class 10a buildings (such as garages) have an intervening influence between the fire source and the Class 1a building (refer BCA 3.7.1.6 for illustration of this). This potentially causes a redesignation of (fire-resisting) external wall location. Situations affected include where:

- a Class 10a building occurs between a Class 1a building and the allotment boundary;
- a Class 10a building occurs between a Class 1a building and other buildings on an allotment; and
- Class 10a buildings must be separated on an allotment because of ramifications on attached or adjacent Class 1a buildings.

The BCA gives quite a detailed description of the many options available and reference to this is recommended.

4.2.3 Separating Walls

Separating walls are used to provide fire-resistance and sound insulation between attached Class 1a buildings (Figures 1 and 2). Specific requirements pertaining to this include:

- Must have walls with an Fire Resistance Level of not less than 60/60/60.
- Must commence at the footings or ground slab and extend up according to one of the following scenarios:

    – For a non-combustible roof covering the wall must extend to the underside of the roof (Figure 2). The wall must not be crossed by timber members (or other combustible building elements) other than roof battens (maximum 75 x 50 mm) or sarking. Voids between the top of wall and underside of roofing (i.e. between battens) must be filled with solid timber 75 mm thick (min), mineral wool or other suitable fire-resisting material.

    – For a combustible roof the wall must extend 450 mm above the roof as shown in Figure 2.

- Must address potential spread of fire that can potentially occur where the end of a separating wall intersects with a masonry veneer wall and the cavity of the latter walls acts as passage for fire. Here, the cavity must be no greater than 50 mm wide and packed at the wall intersection with fire-resistant mineral wool or other suitable fire-resisting material. The packing must be detailed to meet weatherproofing requirements and further details are given in Step 5 of this Guide.
- Eaves, verandahs and similar spaces that are open to the roof space and are common to more than one Class 1a dwelling must be separated by a non-combustible vertical lining.
- For electrical cables, wires, switches, outlets, sockets or the like penetrating a separating wall, the wall at the penetration must achieve an Fire Resistance Level of 60/60/60 and must be tested in accordance with AS 4072.1 and AS1530.4.
- Other conditions also apply including the spacing between certain penetrations; the accuracy of installation; the treatment of residual gaps between the wall and electrical fitments/cables; the treatment of cavity spaces behind electrical fitments with fire-resisting materials. These aspects are addressed in Step 5 of this Guide.

4.2.4 Combined External and Separating Wall

In the situation where adjoining Class 1a buildings are stepped in height, there comes a situation where there is confusion over which part of the wall is a separation wall and which is an external wall (Figure 10). In these circumstances the BCA is silent and it is recommended that the wall above the lower roof line is treated as a fire-rated external wall.

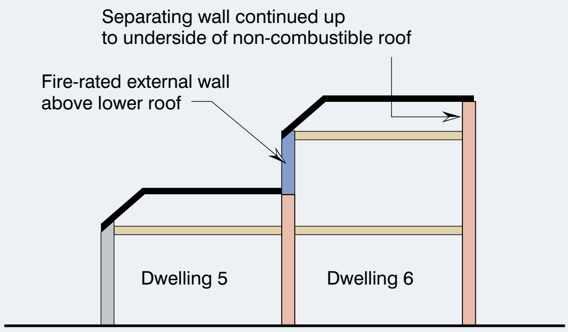

Figure 10: Stepped roof line in Class 1a buildings.

4.3 The Next Step

Having used the previous information to obtain a strong understanding of fire-resisting construction requirements in the BCA, go to Step 5 to select complying timber-framed construction.

5

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

This Step focuses on matching the previously discussed Acceptable Construction Practices for both sound (e.g. $R_W + C_{tr}$) and fire (e.g. FRLs) with appropriate timber-framed construction. This Step begins by explaining key principles used in timber-framed construction to address sound and fire 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, treatment of services and similar situations.

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

5.1.1 Fire-Grade Linings Provide the Primary Source of Protection to Fire-Rated Timber-Framed Walls

The greater the number of layers, the greater the resistance to fire. This is evident when viewing the main fire-resistant timber framing systems described and shown in Section 5.2. Additional measures, as detailed below, are required at weak spots or breaks in the fire-grade linings that occur at intersections between wall, floor and ceiling elements. Corner laps and exposed edges in lining sheets present another area of concern. Extra attention is also needed at penetrations, openings and protrusions.

5.1.2 Construction Joints

In relationship to fire-resistance only Construction Joints are fire-grade materials used to close gaps in the construction that occur between fire-grade materials and at service penetrations. 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, including:

- fire-resisting mineral wool as shown in Figure 11
- fire-resisting sealant as shown in Figure 12.

More layers = better fire resistance.

Laps, edges, penetrations, openings and protrusions have the opposite effect.

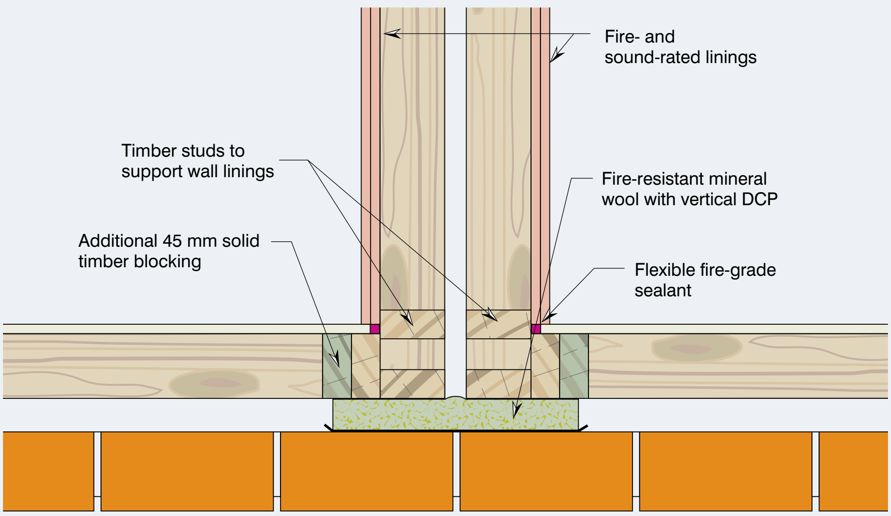

Figure 11: Fire-resisting mineral wool – plan view.

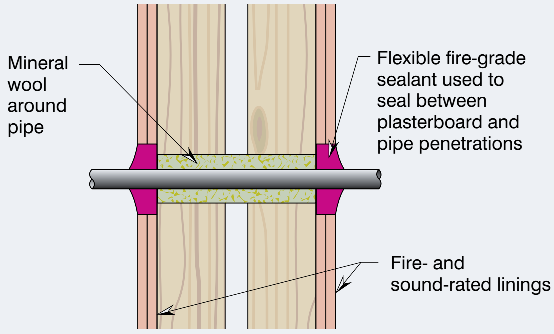

Figure 12: Fire-resistant sealant – elevation view.

By forming a char layer when it burns, solid timer can achieve the fire resistance of fire-grade linings.

Solid timber can be used as construction joints as they can achieve the equivalent fire resistance as fire-grade linings. This is mainly used where linings stop at junctions between wall and/or floor elements. At these junctions, the width of the timber framework is unprotected by the linings and so extra studs, plates or joists are used to provide fire-resistance. This is possible because timber of a certain thickness forms an insulating char layer as it burns. This 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 will last in a fire. Though this varies according to timber density and species, in general, the more pieces of solid timber added to the joint, the longer the joint will last. Common locations where solid timber is used include wall junctions and floor junctions (Figure 13).

For information on the details of this joints in common location, refer to Section 5.4.

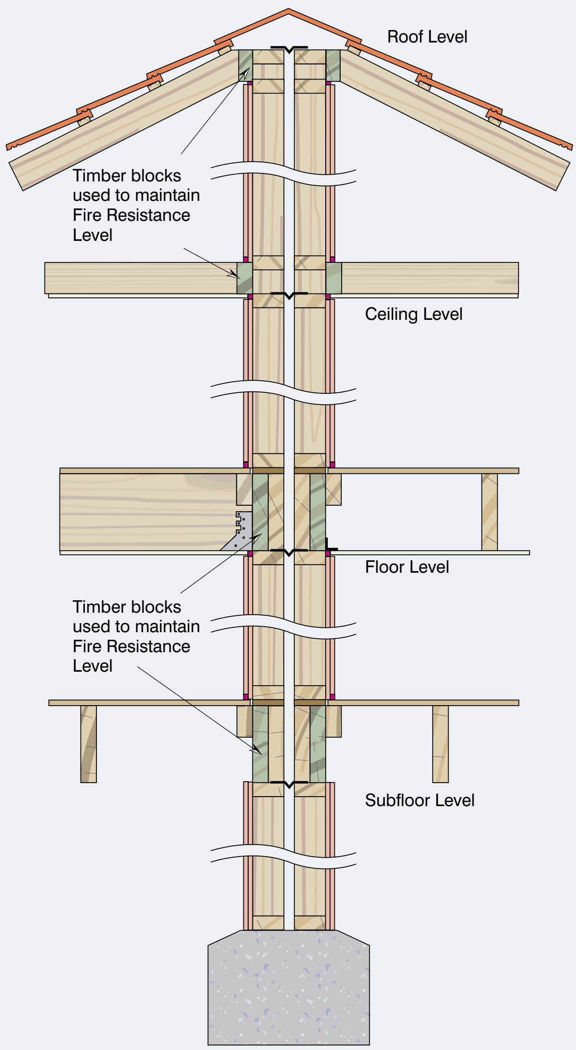

Figure 13: Common location of timber blocks that act as construction joints – elevation view.

For treating weak spots, suitable sealants have fire and sound ratings.

5.2 Principles for Achieving Sound Insulation in Timber-Framed Construction

Increasing mass of wall and floor elements can be particularly useful in reducing airborne sound transmission. A simple and effective means of doing this is to increase the thickness of wall linings and this is often achieved with the above mentioned fire-grade linings.

Isolating one side of a wall element from the other. This is also known as decoupling and can be useful in reducing both airborne and impact sound. Of note, it serves to limit the noise vibration from one side of the wall to the other and is an inherent feature of double stud cavity wall construction.

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 of the wall to the other. If required for structural stability, sound-resilient structural connectors should be used and should generally only be used at each floor or ceiling level.

Using absorptive materials to fill wall cavities can reduce airborne sound transmission. Cellulose fibre, glass fibre, polyester or mineral wool is generally used for this purpose.

Sealing sound leaks at the periphery of wall and floor elements or where penetrations are made for electrical and plumbing services. This is particularly important because penetrations create a weak spot in the system. Flexible sealants are often used in such situations and often have both a fire and a sound rating which enables requirements to be met.

5.3 Sound- and Fire-Rated Wall Construction Systems

Timber framed construction systems that have been developed to meet these fire and sound principles are shown in Figure 14 to Figure 16 and include:

- sound- and fire-resistant double stud walls, i.e. for separating walls (Figure 14);
- fire-resistant single stud, external clad walls (Figure 15); and
- fire-resistant brick veneer external walls (Figure 16).

These and similar systems are commonly provided using proprietary lining and insulation products. Each product must be assessed in order to prove compliance with the BCA. As a result, only the main design themes are shown in the drawings below.

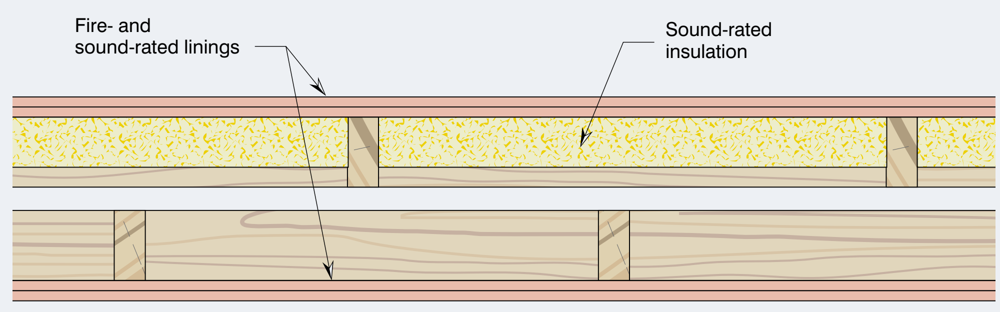

Figure 14: Fire- and sound-rated double stud separating wall systems – plan view.

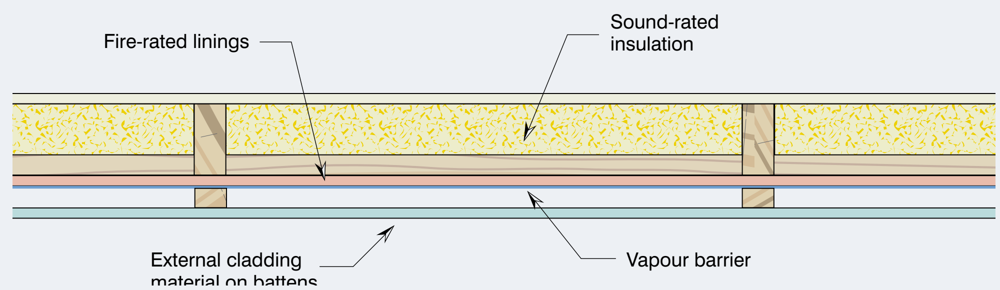

Figure 15: Fire-rated external stud wall systems (outside only) – plan view.

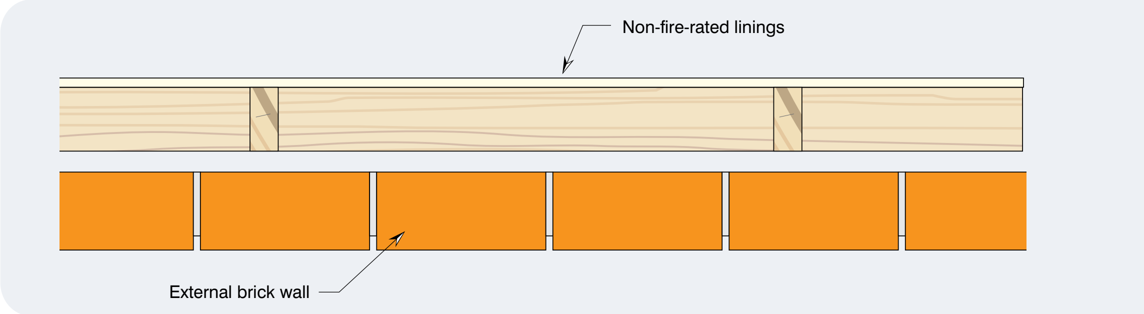

Figure 16: Fire-rated external brick veneer wall systems (outside only) – plan view.

5.4 Solid-Timber Construction Joints

As explained in Section 5.1, solid timber is used as an equivalent to fire-grade linings, the more blocks used the greater the Fire Resistance Level achieved. This is an important means of making fire-resisting joints between wall, floor and ceiling elements in timber-framed construction. A variety of common situations are shown in Figures 17, 18, 19 and 20; each system shows different ways to maintain the walls' integrity and are dependent on the installers preference and available support to the linings.

More solid timber blocks = greater fire resistance.

5.4.1 Non-Rated Walls Abutting Fire- and Sound-Rated Walls

Timber blocks can be used to close off walls where internal non-rated walls abut fire- and sound-rated walls. The blocking can be in the form of studs. Where the non-rated internal wall is loadbearing, the timber blocks used to maintain fire resistance generally cannot be used to support load.

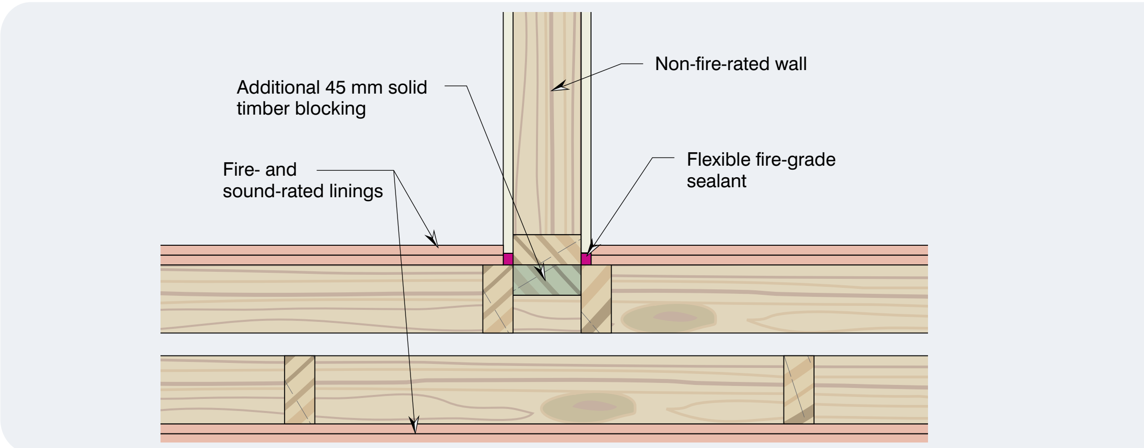

Figure 17: Junction between fire-rated and non-fire-rated and/or lower fire-rated wall – plan view.

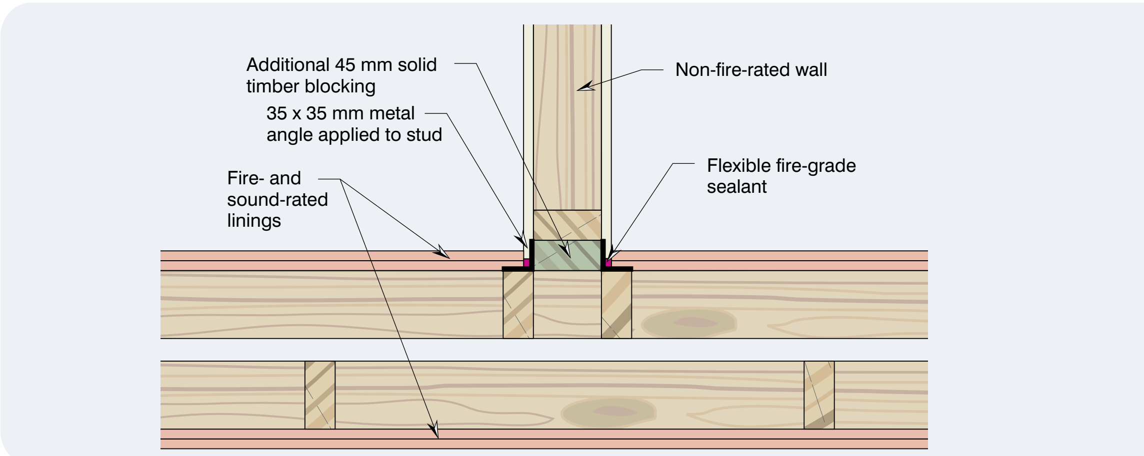

Figure 18: Junction between fire-rated and non-fire-rated wall – alternative method using metal angles – plan view.

If fire strikes, floors must be able to collapse while leaving separating walls intact.

5.4.2 Non-Rated Floor Abutting Rated Wall

Non-rated floors interfere with the wall lining to the separating wall. In this case timber blocks can again be employed. The following details a number of options that can be utilised and are generally dependant on individual choice or the framing situation. No one option is preferred.

In all cases it is also important to note that in the event of a fire, the flooring and floor joists must be free to rotate away from the separating wall. This requires that the floor sheet or boards not to be continuous under the separating wall framing. It is recommended that separate packers be used, or the flooring is sawn in this region.

Solid-Timber Blocking

Blocking is to be solid timber and measure at least the joist depth. For a Fire Resistance Level of 60/60/60, the timber blocking thickness is to be minimum of 45 mm.

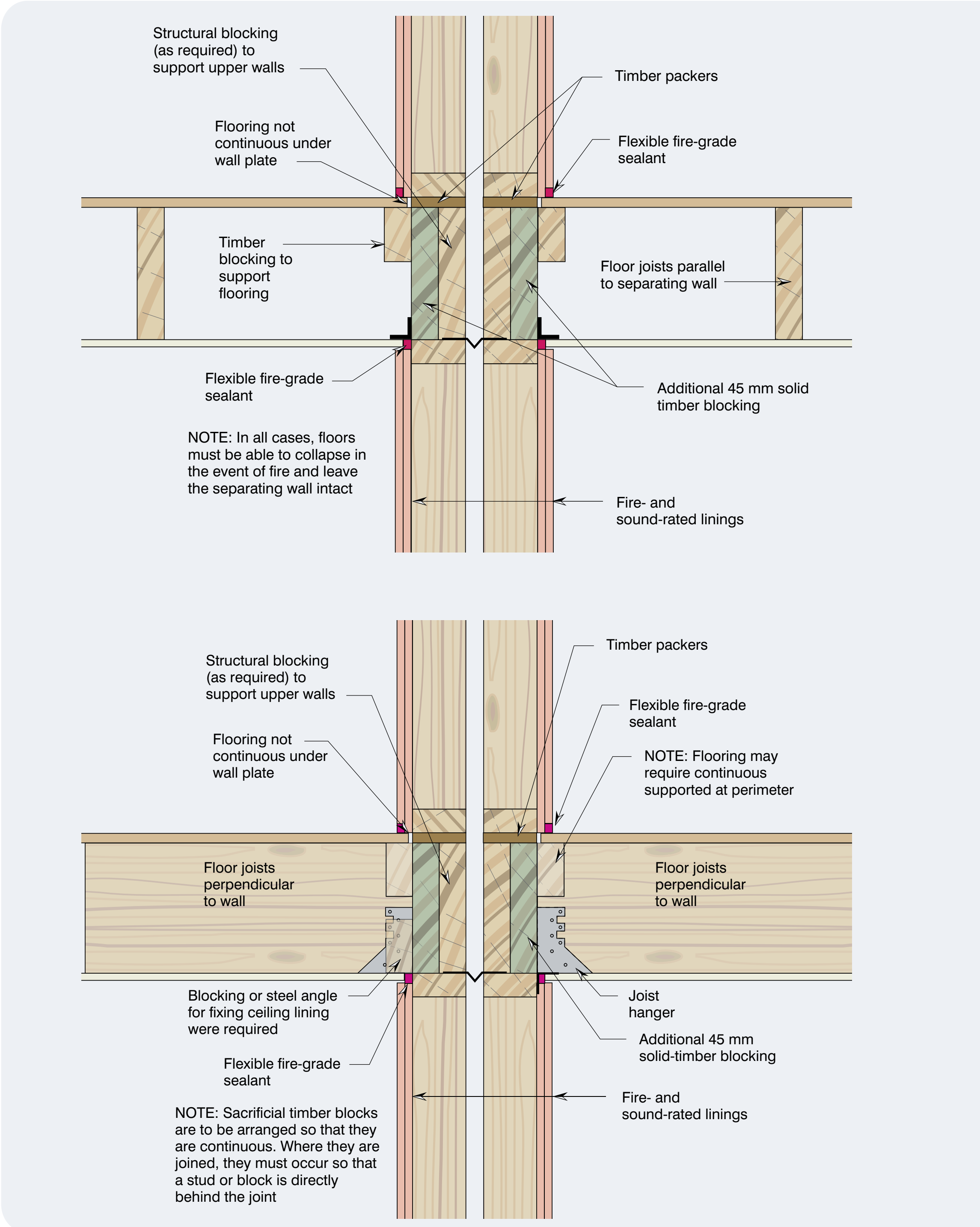

Figure 19: Joist parallel and perpendicular to wall, wall stud not continuous through junction – elevation view.

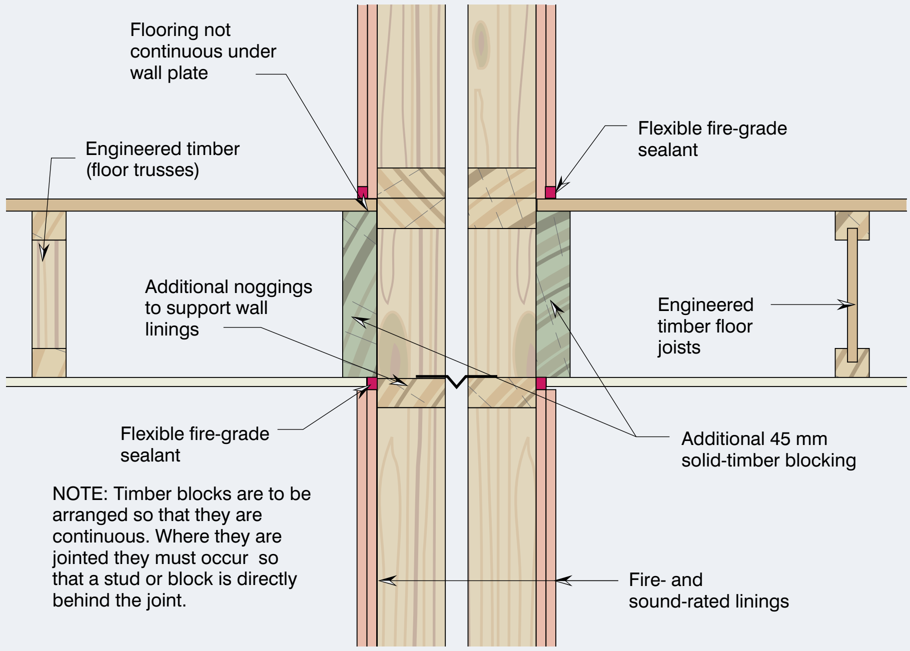

Figure 20: Wall stud continuous through junction with timber blocks – elevation view.

Burning joists that are free to rotate don't snag the wall above.

Fire Pockets in Separating Wall

Another method is to create pockets within the separating wall that allow the joists to bear on the wall. This detail can be achieved by utilising a similar technique discussed for double joists (refer to section 5.4.2.1) where one continuous solid timber joist the same depth of the joist system provides the fire protection. Where it is required to be joined, it must be butted closely, and the joint must be at least 100 mm away from any fire pocket formed.

The floor joists, being solid timber, I-beams or floor trusses, can now bear onto the top of the wall. Between the joists, additional solid-timber blocks the same depth and thickness as the inner blocking are to be tightly cut-in. The main floor joists are not to be nailed to blocking, any nailing is to occur at the base of the joist into the wall plate only. The timber packer directly above the joist that sits in the pocket is to be removed for the pocket portion width. This is to allow the joist to rotate in a fire event and not catch the bottom of the wall above (Figures 21 and 22).

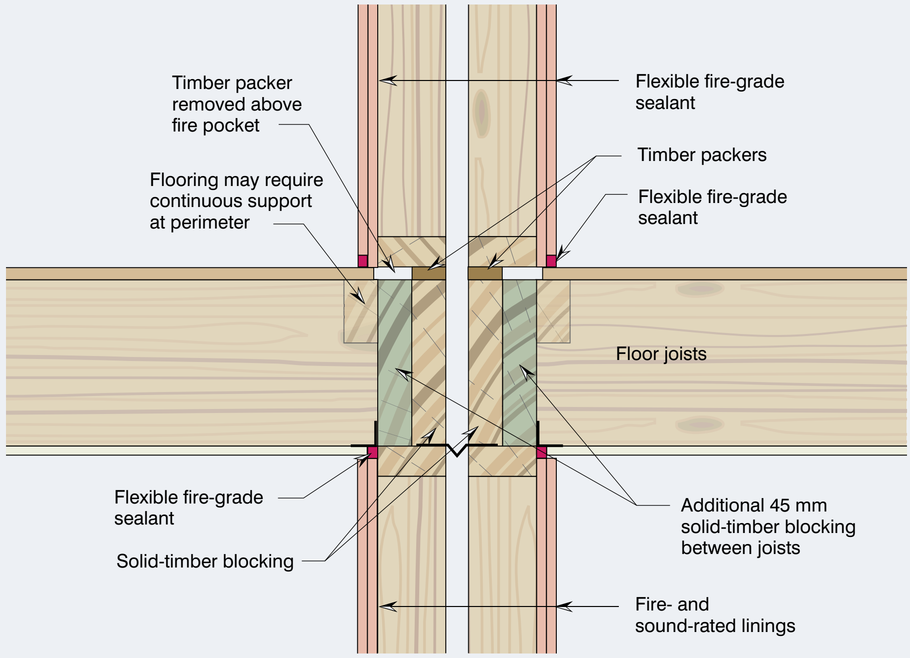

Figure 21: Fire pockets in separating wall – elevation view.

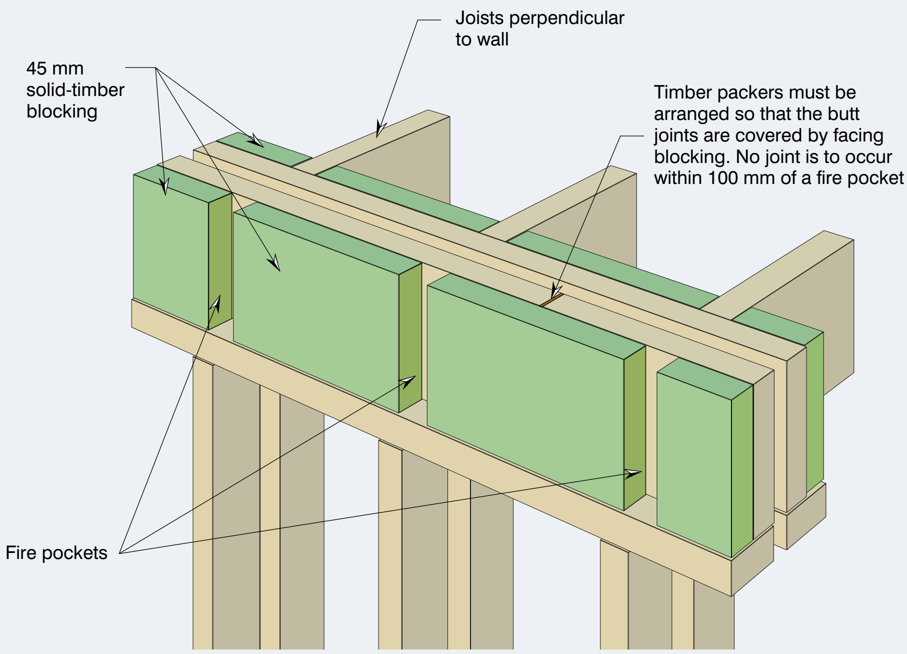

Figure 22: Pockets created in separating wall to accommodate floor joists – perspective view from above.

Top Chord Support Detail for Floor Truss

Floor trusses are commonly used as floor joists. This form of floor joist has the unique ability to be top chord supported. A similar support mechanism as the pocket described above can be used. Here only the top chord needs to be pocketed (Figure 23). An alternative method is to form a ledger to support the floor truss top chord (Figure 24).

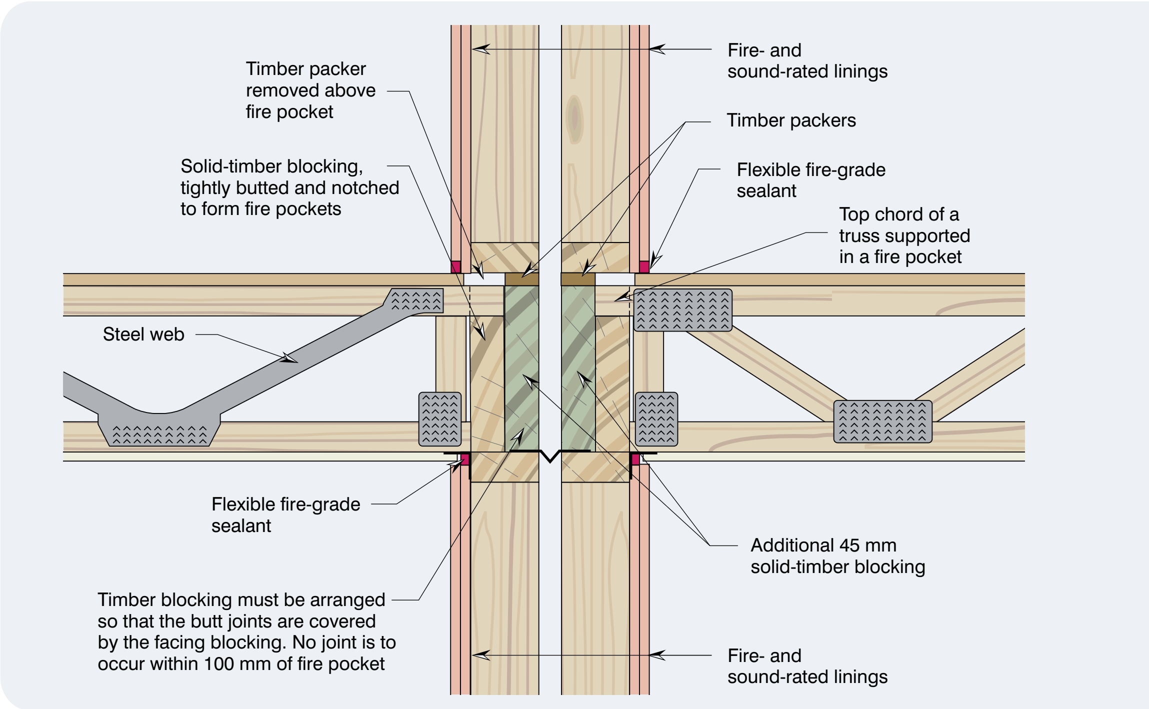

Figure 23: Floor truss top chord support in pockets – elevation view.

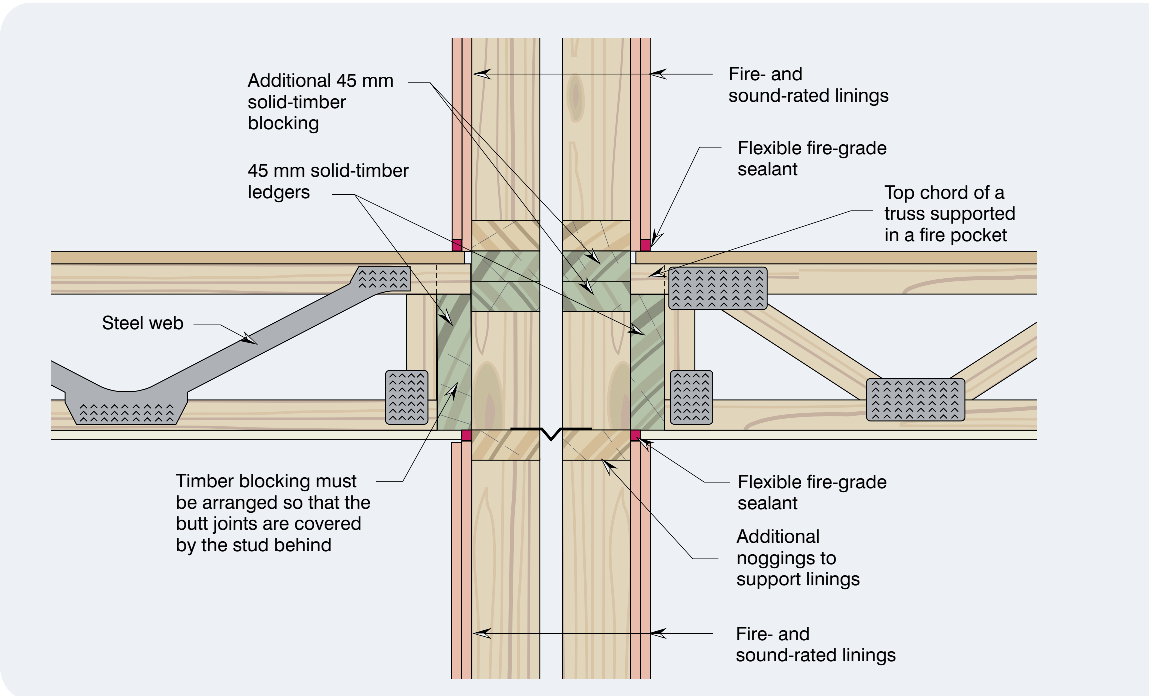

Figure 24: Floor truss top chord support on timber block – elevation view.

Separating walls must be fully grounded.

5.4.3 Lowest Floor and Subfloor

Where the lowest floor is elevated off the ground there is a requirement to continue the separating wall to the ground. Typically, a concrete or masonry plinth that is at least 75 mm higher than the finished ground level can be utilised.

Where the floor intersects with the separating wall, the construction details to maintain fire and sound resistance are similar to the junction of floors at the first floor level. Care is required to ensure construction in the subfloor region is durable for the location (Figure 25).

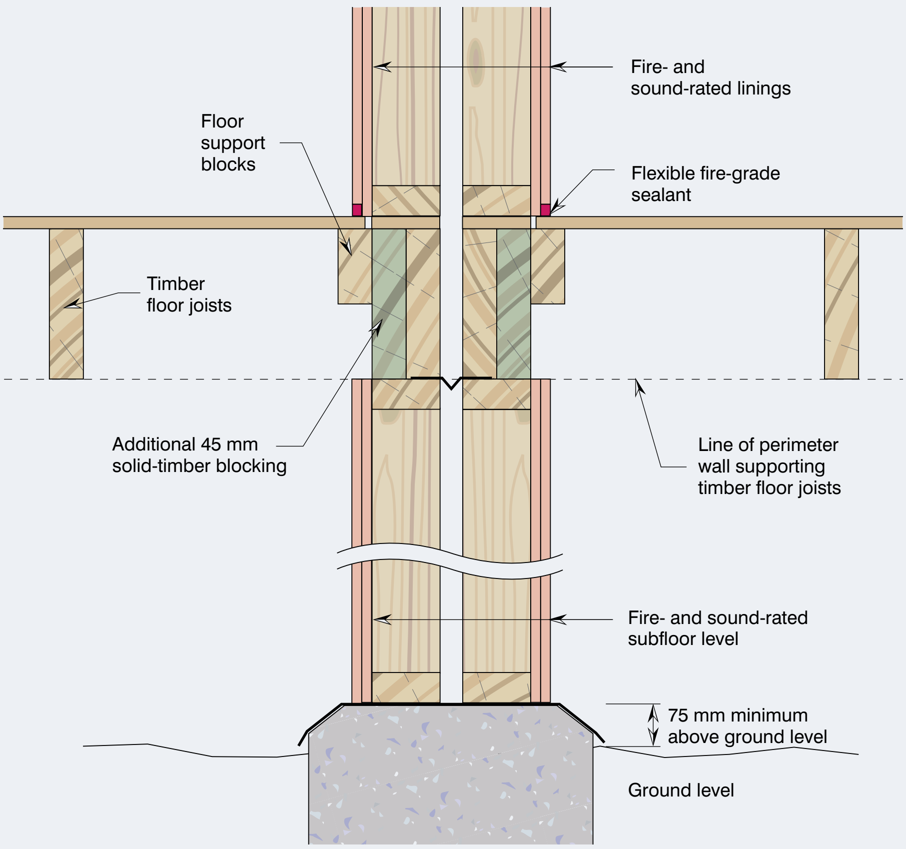

Figure 25: Subfloor details – elevation view.

5.5 Treatment of Roof Voids

As mentioned in Section 3.2, there is the possibility of fire and sound jumping from one dwelling to another through the roof void. To prevent this occurring in timber-framed construction, the fire/sound wall is continued through the roof void to the roof covering.

5.5.1 Roof Framing or Trusses Parallel to Separating Wall

Where the roof framing is parallel with the separating wall there are no special details other than to allow enough room to install the fire-grade linings (Figures 26 and 27).

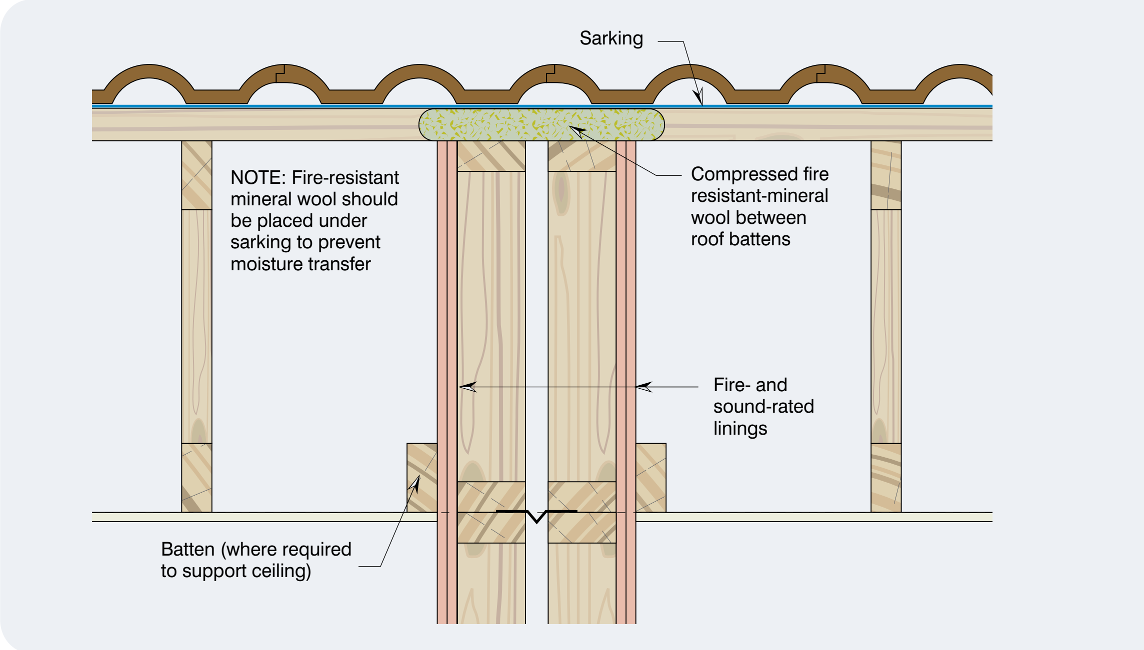

Figure 26: Double stud fire/sound rated wall in roof cavity – elevation view.

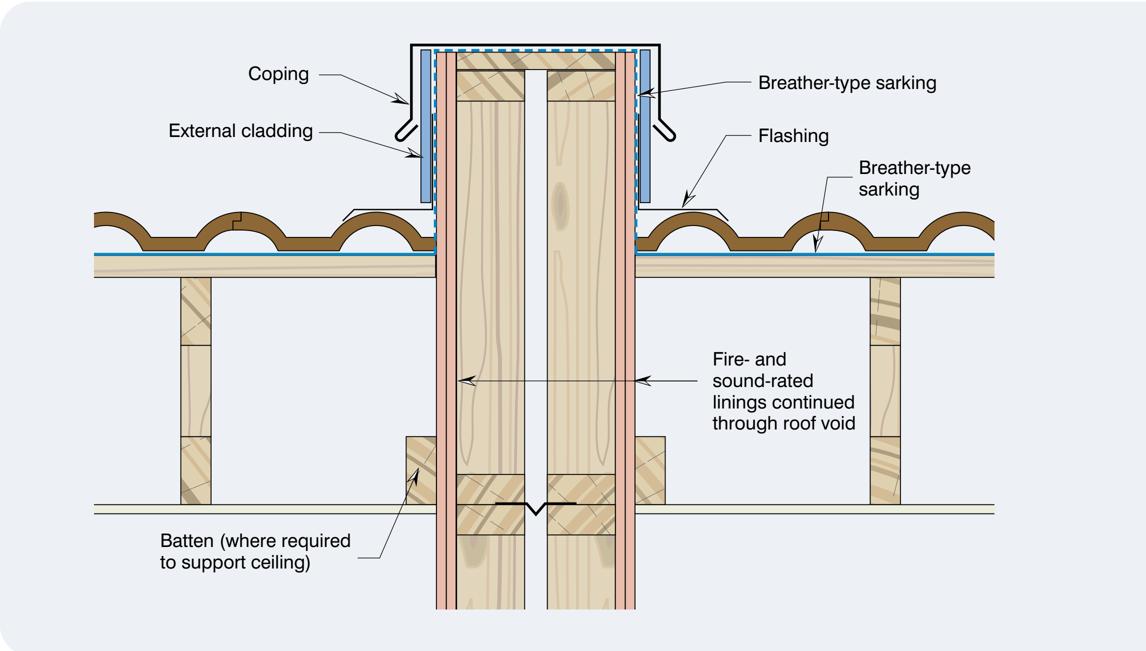

Figure 27: Separation wall above the roof line – elevation view.

5.5.2 Roof Framing or Trusses Perpendicular to Separating Wall

Where roof framing or trusses are perpendicular to the separating wall they need to be supported off the wall by the use of timber blocks as discussed for floor joists. The same technique can be utilised here (Figures 28 and 29).

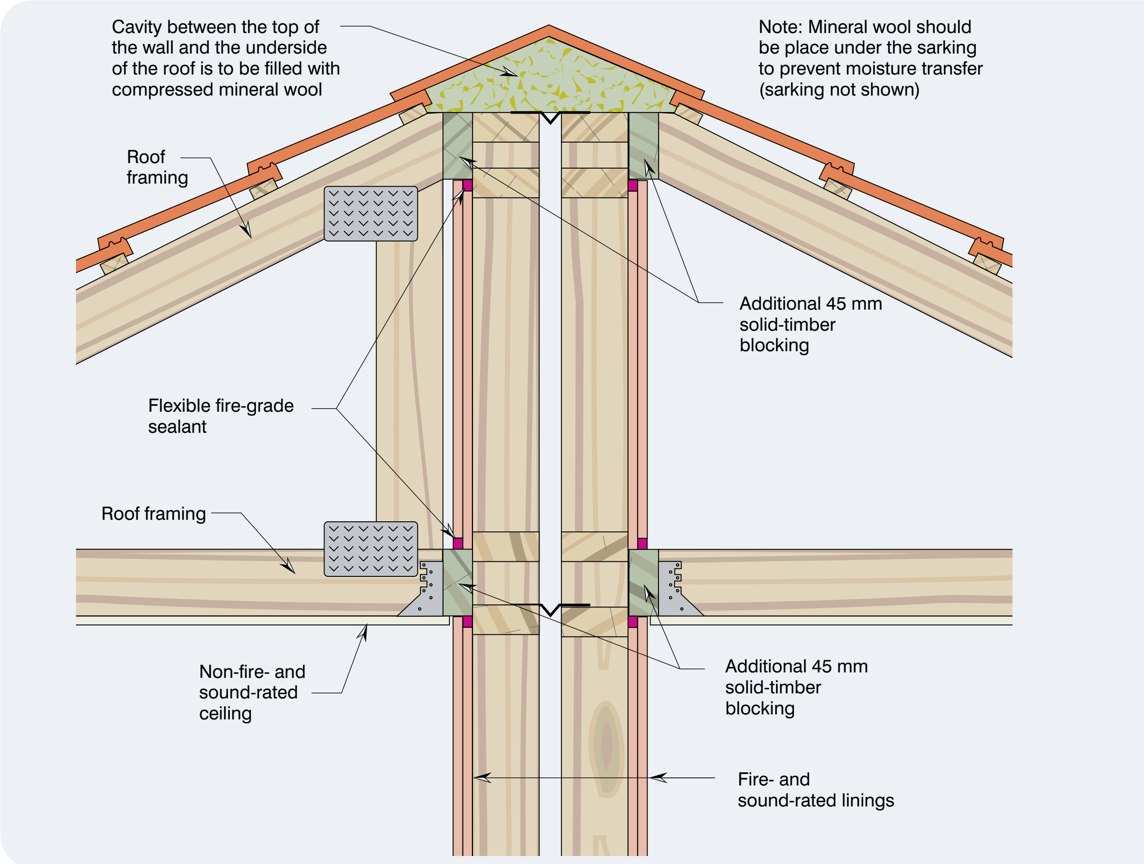

Figure 28: Trusses or roof framing support off separating wall – elevation view.

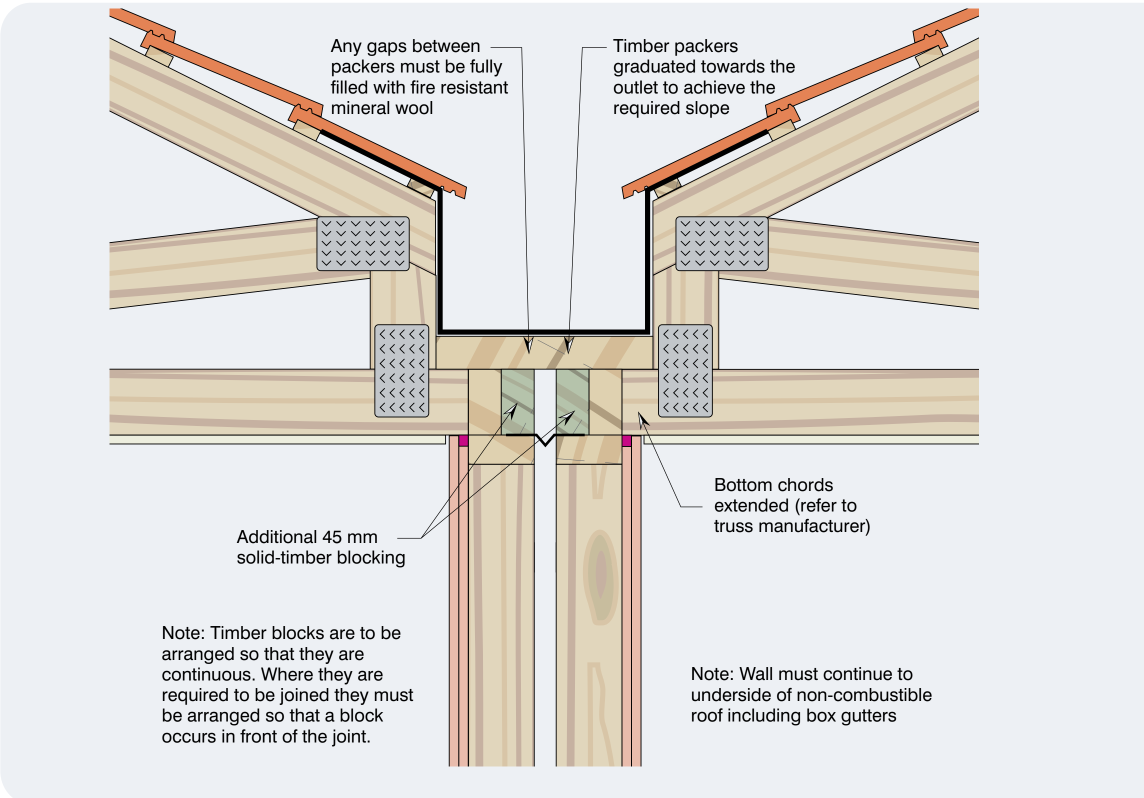

Figure 29: Typical box gutter detail at top of separating wall – elevation view.

Alternatively, a girder truss can be utilised to support the roof framing or trusses off the separating wall to allow access to uninstall the fire-resistant linings (Figure 30).

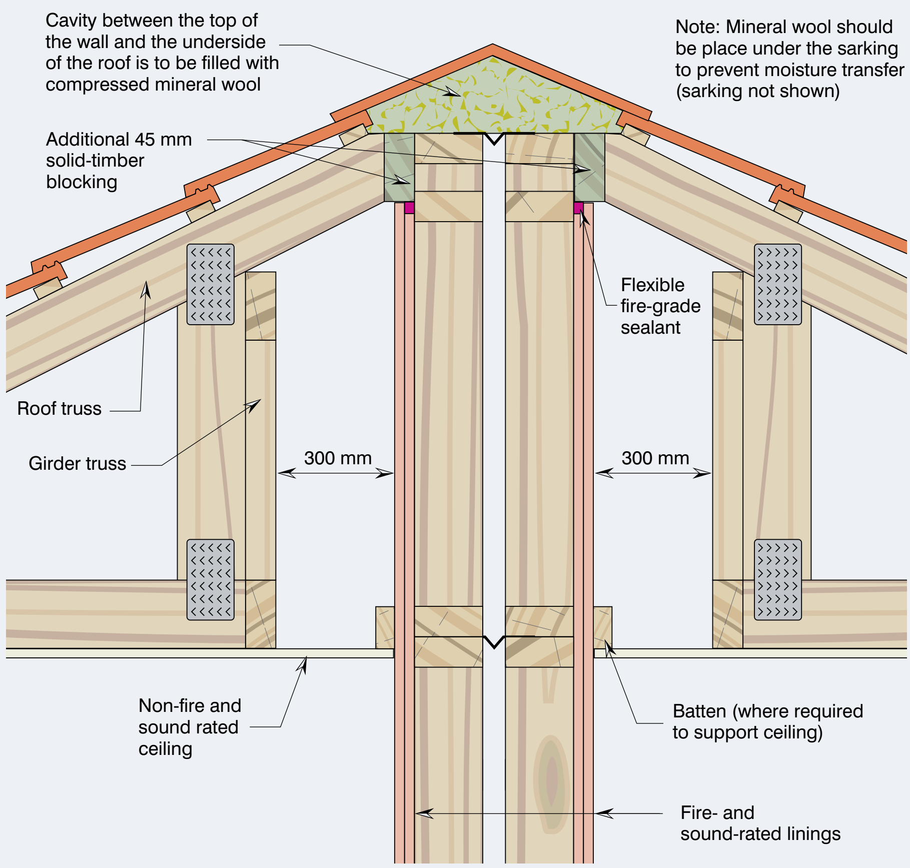

Figure 30: Alternative support detailing girder truss running parallel to wall, allowing access for wall lining installation – elevation view.

These days, roof 'voids' are anything but!

5.5.3 Eaves and Verandah Roof Voids

Where eaves and verandah roofs are open to the roof space and are common to more than one dwelling, the roof void is required to be separated by non-combustible linings.

This can be achieved by the inclusion of fibre-cement or plasterboard lining to one side of the framing as shown in Figure 31 or closing of the space back to one of the dwellings as shown in Figure 32.

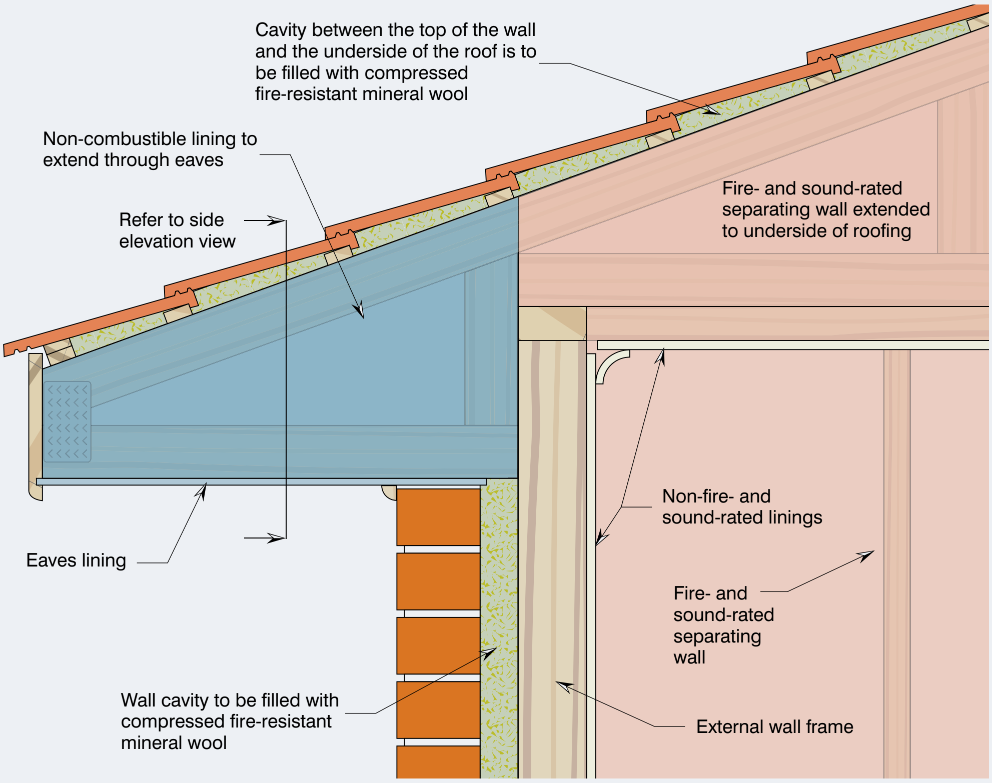

Figure 31: Eaves blocking – front elevation view.

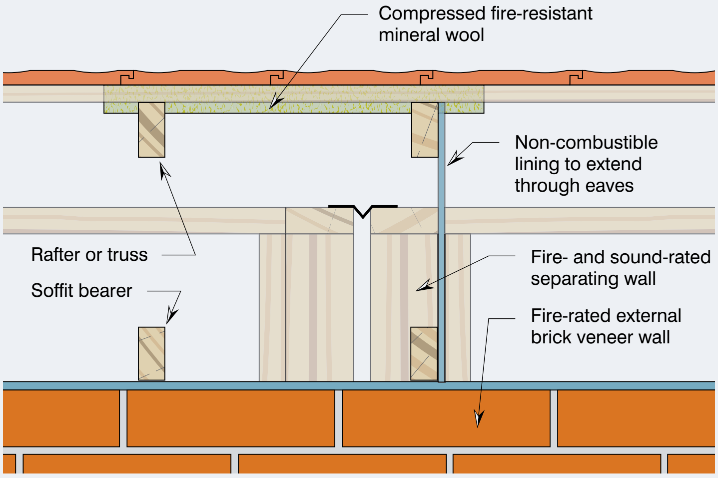

Figure 31a: Eaves blocking – side elevation view.

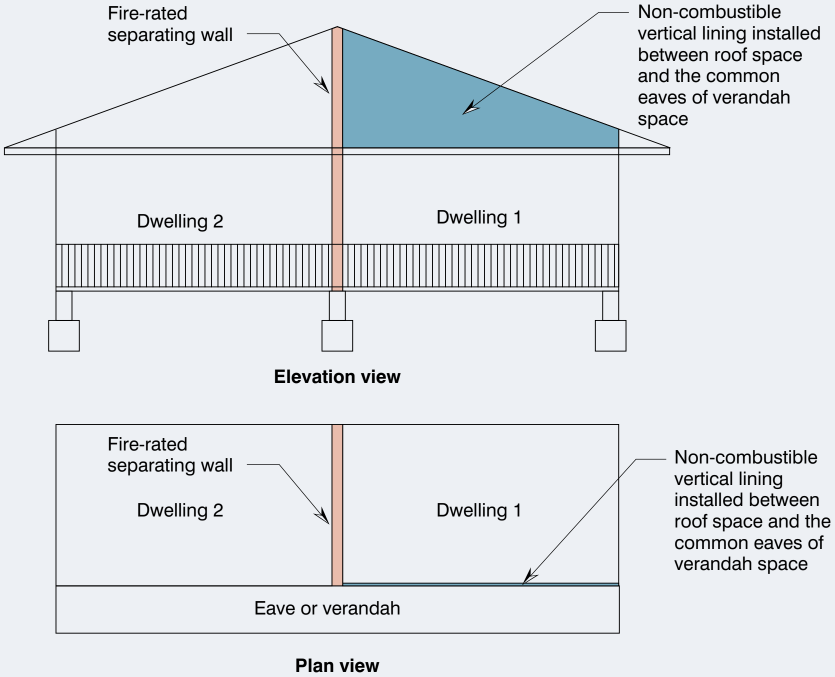

Figure 32: Sealing of eaves or verandah voids.

5.6 Separation Wall Abutting External Walls

5.6.1 Brick Veneer Cavity

Cavity materials must be fire resistant and durable.

The gap formed at the end of the separating wall and the external brick skin of the brick veneer wall requires fire-resistant construction. Timber blocks are used to extend the separating wall to the cavity. Within the cavity the materials used must be fire-resistant and durable. Figure 33 details fire-resistant mineral wool and a moisture break between the brick skin and the fire-resistant material is required.

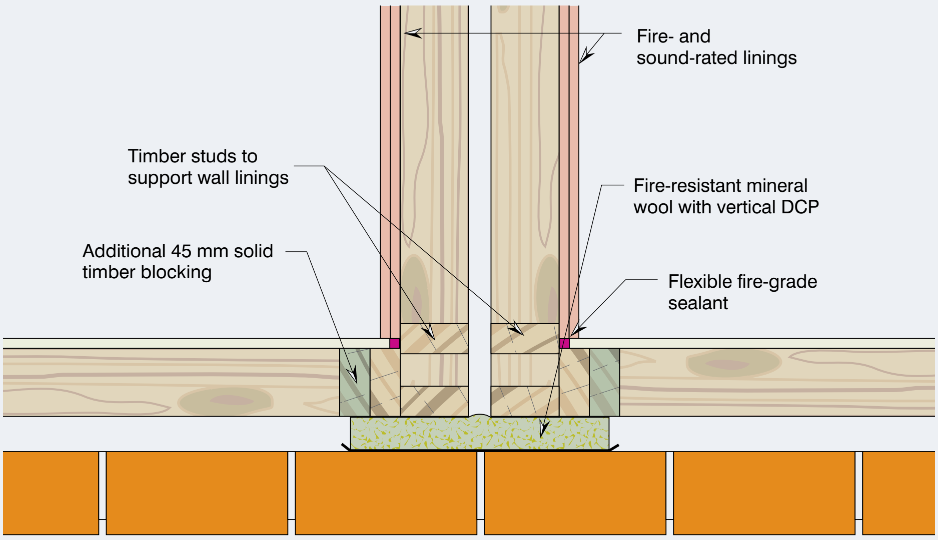

Figure 33: Fire-resistant mineral wool in brick veneer cavity – plan view.

5.6.2 Separating Walls at Staggered External Wall Alignments

Where dwellings are offset to each other continuation of the separation wall is recommended. Figure 34 details typical additional fire-resistant construction.

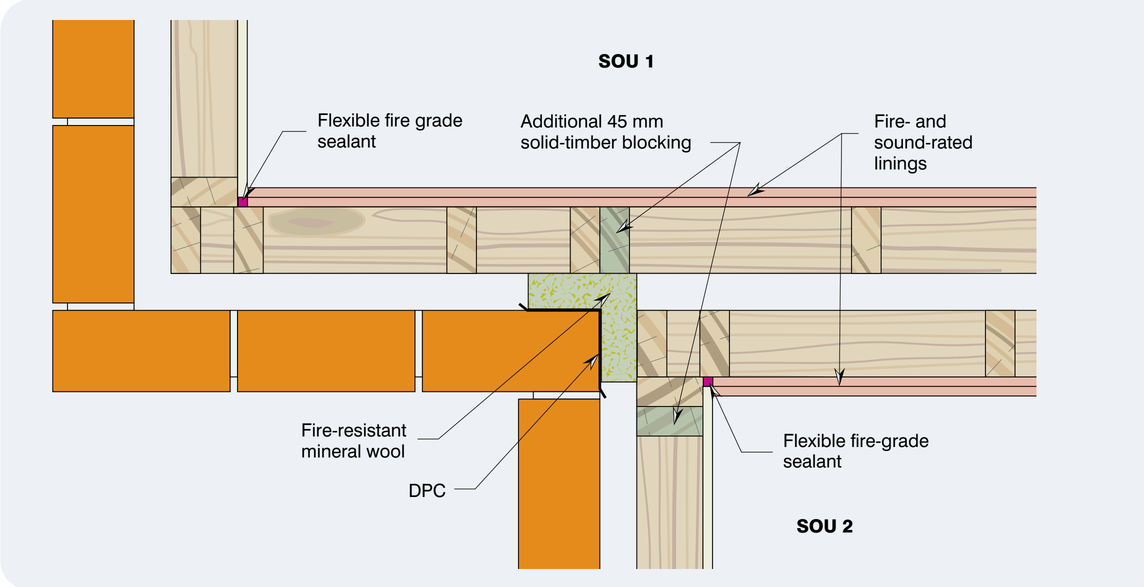

Figure 34: Additional blocking in offset dwellings – plan view.

5.6.3 Lightweight Wall

For lightweight walls, timber blocking is only required to extend the separating wall to the exterior lining (Figure 35).

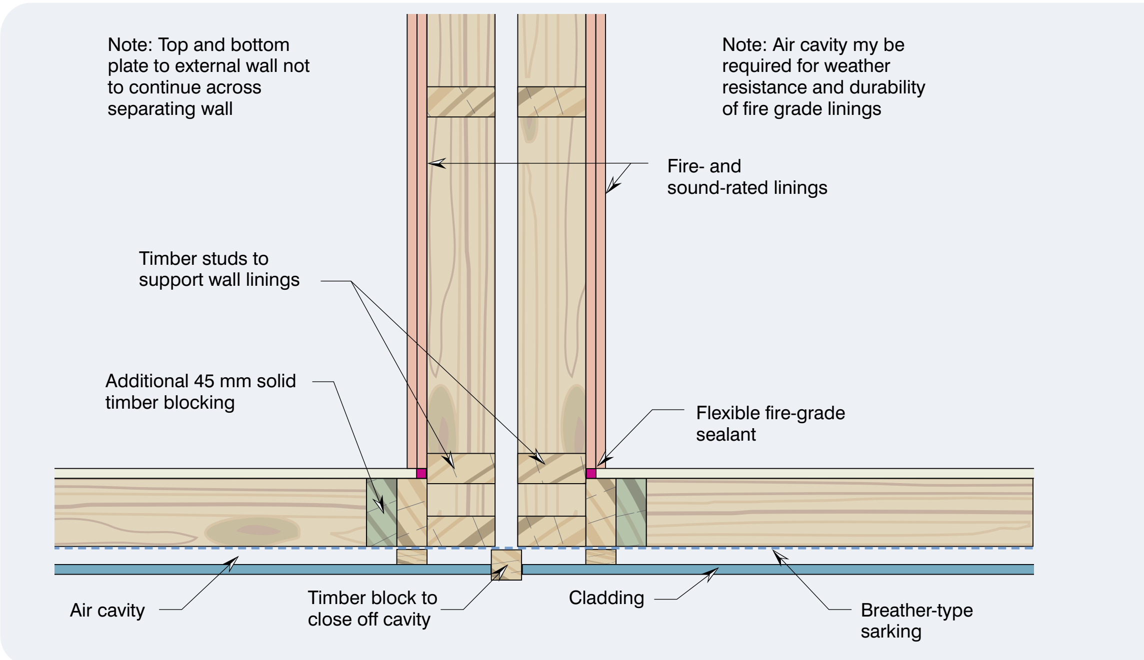

Figure 35a: Lightweight walls – plan view.

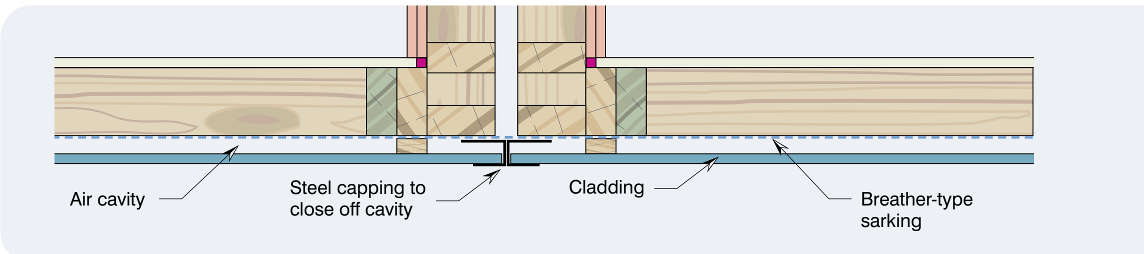

Figure 35b: Lightweight walls – alternative detail – plan view.

5.6.4 Staggered Roof Linings at Separating Walls

Although no guidance is given in the BCA, it is recommended that where separation walls in staggered roof linings are made, that the higher leave of the separating wall is continued up to the highest roof line. Fire resistance is to be maintained as for Figure 36.

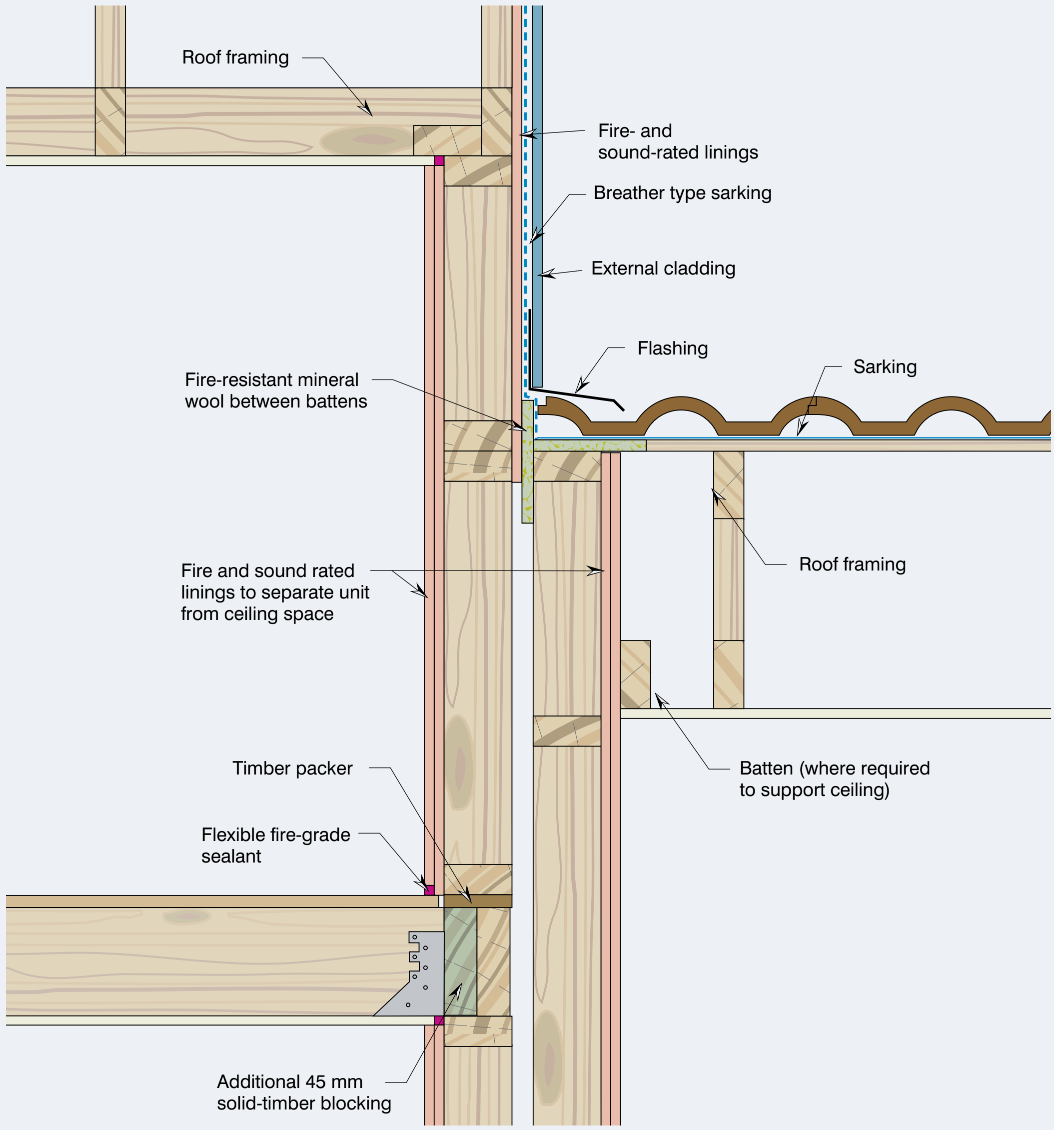

Figure 36: Staggered roof lines meeting at a separating wall – elevation view.

5.7 Steel Columns in Separating Walls

Steel beams can create complications, but solutions are at hand.

In modern living there is often a need to provide large openings. In typical timber-framed townhouse construction there may be a large opening at the end of the building spanning between separating walls, supporting brickwork above.

Often it is desirable to enclose the beam and its support within the timber framing, meaning that the steel beam column supports are often housed in the separating wall. This creates a complication in maintaining fire resistance as the steel beam is normally not fire protected, and during a fire, the steel beam may collapse and impair the separating wall.

To account for this, testing has been carried out to design a steel beam and its column enclosed within the wall. To achieve this outcome it is necessary to create a pocket for the steel beam to sit within the wall. Then, during a fire, the beam may rotate out of the pocket, leaving the separating wall intact.

This pocket is achieved by sitting the steel beam on top of the column with no physical connection other than bearing. The column is located by the surrounding timber framing, and is fire protected as the fire-rated linings run pass the column face.

Mineral wool features heavily in fire-resistant designs.

The beam sits in its own created pocket with timber framing surrounding it. Fire safety is achieved by using fire-resistant mineral wool packed in and around the beam. A metal flashing is placed at the back of the pocket to seal the pocket from the separation wall cavity.

Directly above where the beam will sit in the pocket it is necessary to leave a minimum of 20 mm gap to allow this rotation of the beam. Normally this could simply be achieved by removing the floor sheet or packer at this location. Again fire-resistant mineral wool is placed in this void to maintain the fire rating. Figure 37 is a detailed cut away view of the framing and columns and Figure 38 contains more precise detail information.

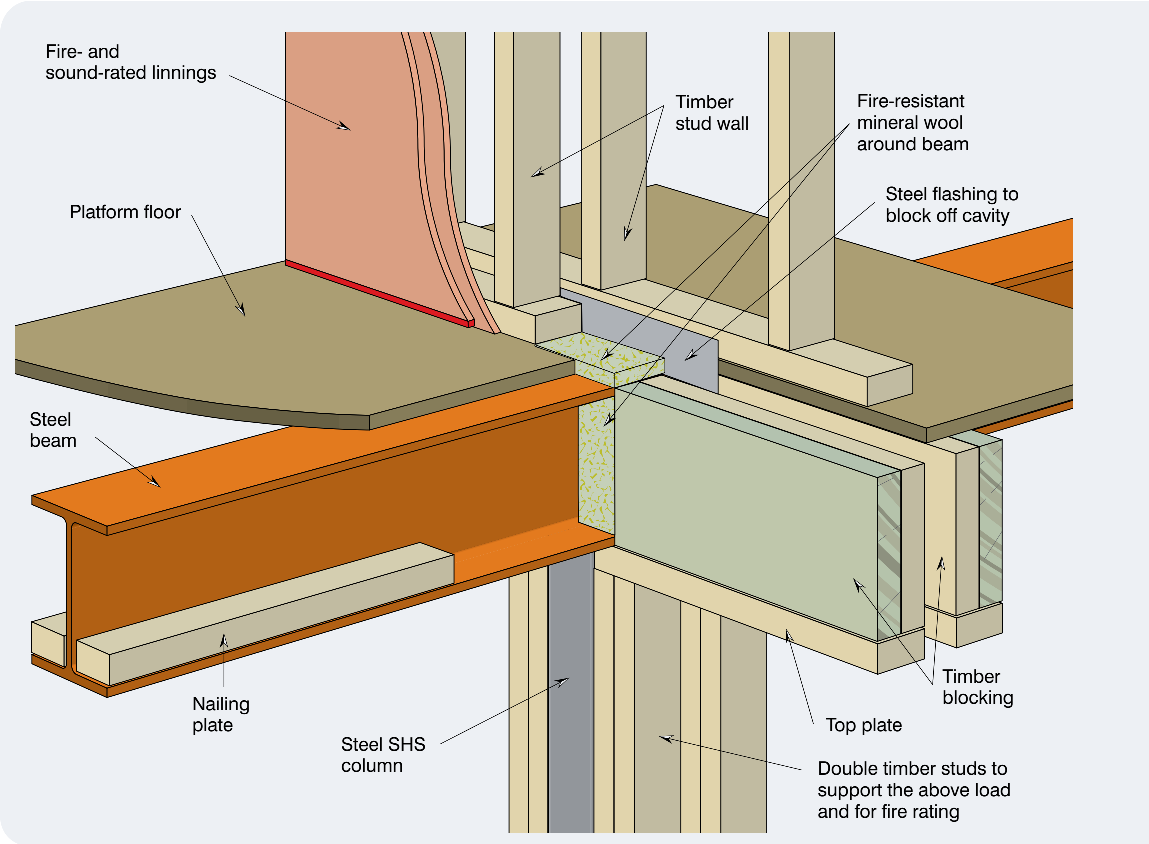

Figure 37: Cut away view of steel beam and column housed in a timber-framed separating wall – perspective view from above.

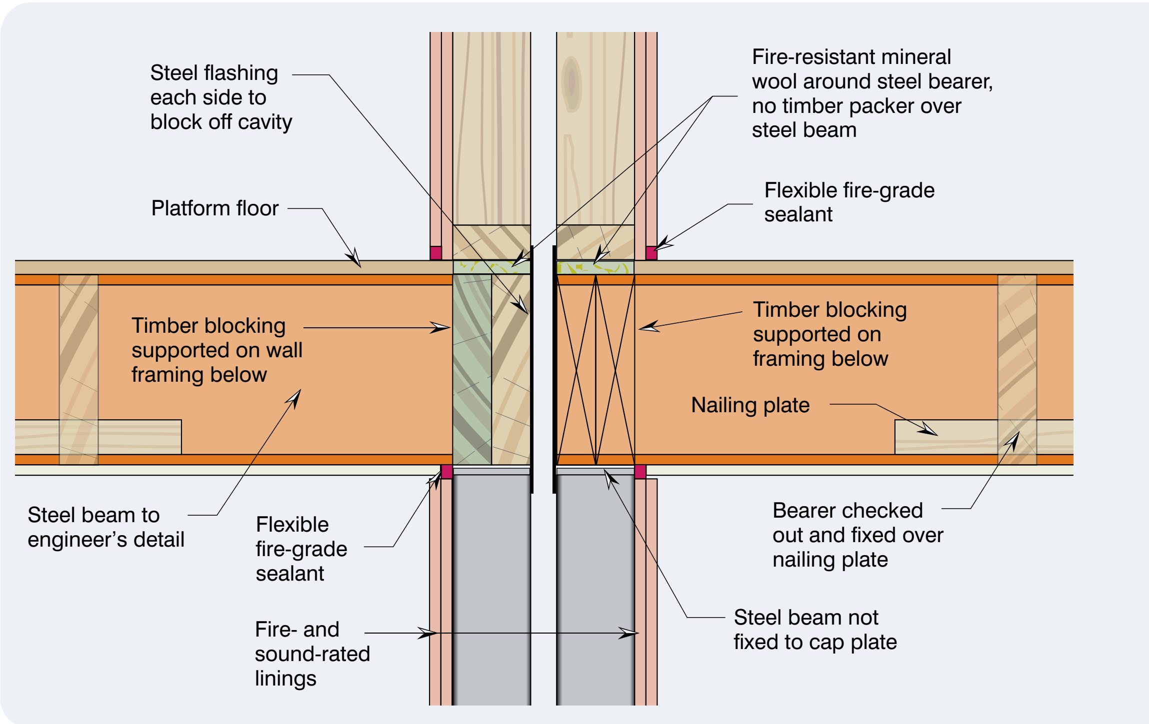

Figure 38a: Details of the steel beam pocket in timber-framed separation wall – elevation view.

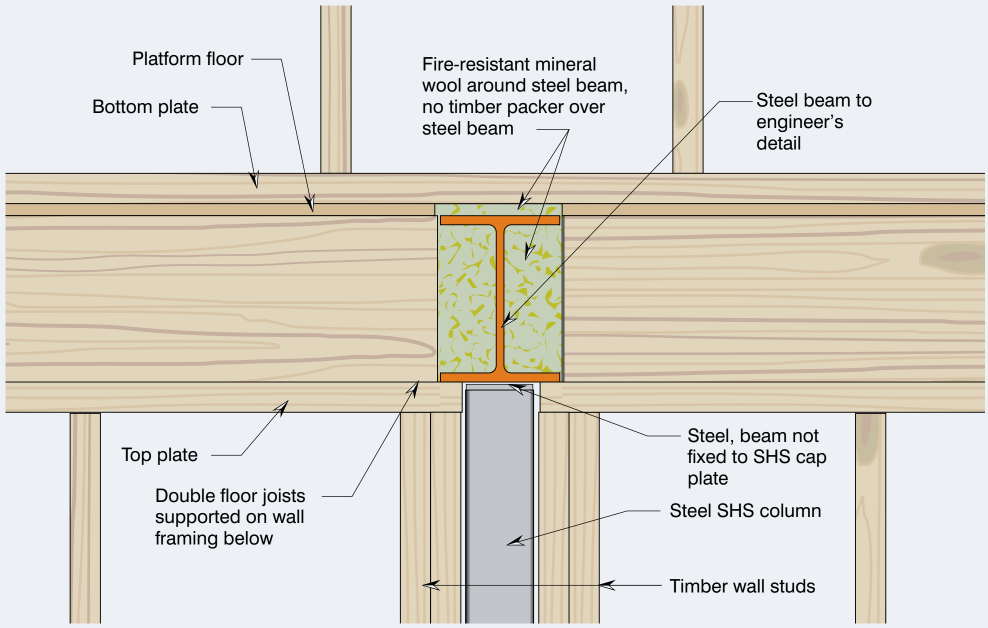

Figure 38b: Details of the steel beam pocket in timber-framed separation wall – elevation view.

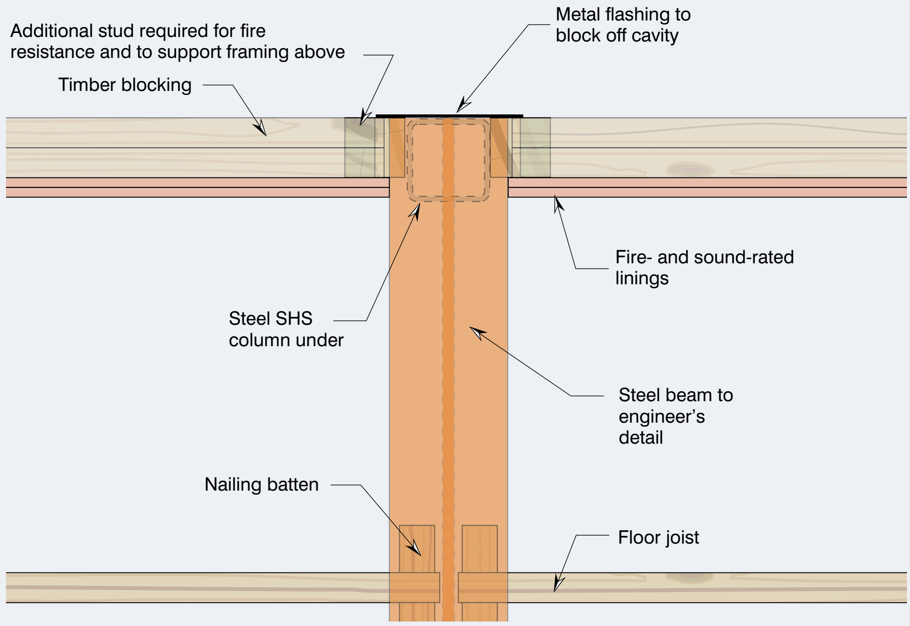

Figure 38c: Details of the steel beam pocket in timber-framed separation wall – plan view showing one wall leaf only.

5.8 Service Penetrations

Strive to minimise service penetrations of separating walls.

The installations of plumbing or electrical services in separating walls have the potential to reduce the fire and sound performance. Where possible, these services should not be located within separating walls, i.e. place them in neighbouring internal walls or false walls over the separating wall.

Where services within separating walls cannot be avoided, the integrity of the wall must be maintained for both sound and fire resistance.

Two options are available, either using the Deemed to Satisfy Provisions in the BCA Clause 3.7.1.8 and 3.8.6.4, or using a system that has been tested for the fire resistance and acoustic performance required.

6

Step 6 – Further Design Assistance (Appendices)

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

Appendix A – Resolving Structural Design Considerations and Construction Practices

It's ironic that the best structural designs pay heed to their possible destruction.

Loads, timber member sizes and construction practices not described in the Guide should be determined in accordance with AS 1684 – Residential Timber-Framed Construction Standard.

In designing stud sizes for fire-rated walls it is necessary to consider a special load condition for fire. This is another load condition required by the loading and timber engineering standards. In most cases today, the wall systems offered by lining manufacturers are not sensitive to the fire load condition as long as the walls are laterally supported at a maximum of 3.0 m intervals, discussed in more detail below. As this manual does not go into the particular design details of proprietary systems, reference to the provider of the fire-rated wall system is required to ensure this fire condition design is satisfied or is required.

A key consideration is the need for fire-load design as the lateral support from the floor and ceiling structure cannot be taken into account when it is from the potentially fire-affected side. As separating walls are normally double stud there will potentially be no lateral restraint to the entire wall height (i.e. on the fire side of the separating wall). This is because the floor or ceiling framing on one side of the wall is designed to rotate away during a fire without dragging the wall with it. This means that under fire, the separating wall can stay in place to carry structural loads and retain the fire-resistant linings.

The 3.0 m height reflects the maximum height fire testing of walls is typically undertaken. As a result, extra structural support is required in the wall system to deal with the gap between theoretical assumptions and what is achievable in practice. In a double stud wall this is commonly dealt with under the assumption that the non-fire affected side of the wall will remain laterally restrained by the first floor and ceiling, even though the floor on the (other) fire affected side has burnt and rotated away.

Resilient structural connectors are then used to hold the fire affected side of the wall, to the non-fire affected side. Such ties are typically placed at each floor and ceiling level (only) as the BCA requires discontinuity of light weight walls except at their periphery. It is important that these ties be 'acoustic ties' in order to prevent sound transmission across the wall structure. Such ties are typically placed at 1200 mm spacings (Figure A1).

Ties at the roof line are normally achieved by the tile or roof sheet battens. Where battens are not tying the top of the wall, additional ties will be require.

It is also important to note to allow this rotation of the flooring away from the separating wall requires that the floor sheet or boards not be continuous under the separating wall framing. It is recommended that separate packers be used under the bottom plate or the flooring is saw cut in this region.

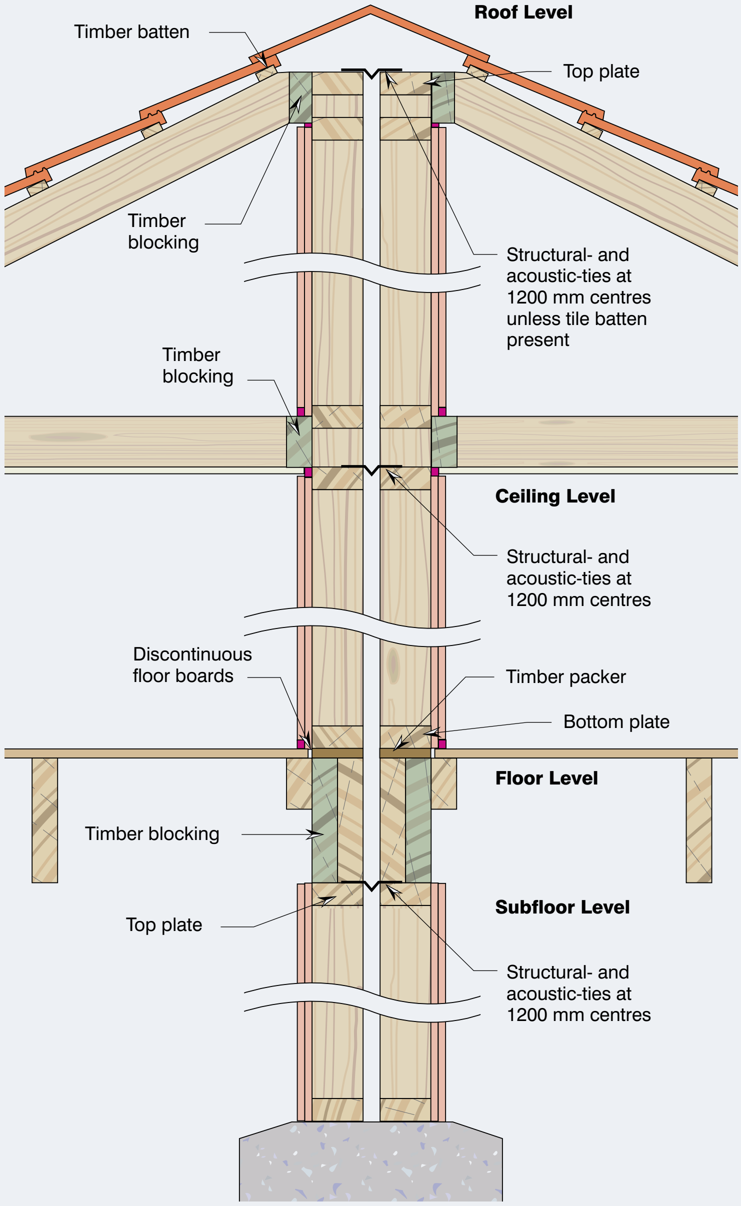

Figure A1: Structural and acoustic ties used to laterally support the separating wall – elevation view.

Appendix B – Design References

Design References

Australian Building Codes Board

- Building Code of Australia (BCA) 2009 – Volume 1 & 2.

Australian Standards

- AS1530.4 – Methods for fire tests on building materials, components and structures – Fire-resistance tests on elements of construction.
- AS1684 – Residential Timber Framed Construction Standard.
- AS/NZS 1267.1 Acoustics – Rating of sound insulation in buildings and building elements.
- AS/NZS 2908.2 – Cellulose cement products – Flat sheets.
- AS4072.1 – Components for the protection of openings in fire-resistant separating elements – Service penetration and control joints.

WoodSolutions

Free resources available at woodsolutions.com.au

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

- #02 Timber-Framed Construction for Multi-Residential Buildings Class 2, 3 and 9c – Design and construction guide for BCA compliant sound- and fire-rated construction
- #03 Timber-Framed Construction for Commmercial Buildings Class 5, 6, 9a and 9b – Design and construction guide for BCA compliant fire-rated construction

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 2005, September 2008.
- 22567B Assessment Report: The likely fire resistance performance of MRTFC wall floor junctions if tested in accordance with AS 1530.4 2005, September 2008.
- RIR 22567B Regulatory Information Report: The likely fire resistance performance of MRTFC wall floor junctions if tested in accordance with AS 1530.4 2005, September 2008.
- 2256701 Test Report: Fire resistance test of a timber wall floor junction in general accordance with AS 1530.4 2005, September 2008.
- 2256702 Test Report: Fire resistance test of a wall beam junction when tested in general accordance with AS 1530.4 2005, September 2008.

Exova Warringtonfire Australia

- 2365300 Test Report: Fire resistance test of floor junctions incorporating timber and plasterboard in general accordance with AS 1530.4 2005, November 2009.
- 2365400 Test Report: Fire resistance test of floor junctions incorporating timber and plasterboard in general accordance with AS 1530.4 2005, November 2009.
- 2365500 Test Report: Fire resistance test of floor junctions incorporating timber and plasterboard in general accordance with AS 1530.4 2005, November 2009.

Appendix C – Glossary

BCA

Building Code of Australia (BCA) 2009 – Volume 1 – Class 2 to 9 Buildings.

Cavity barrier

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 BCA to maintain fire resistance. Refer to Deemed-to-Satisfy Provision C3.16, Volume 1, BCA.

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 BCA
- a doorway opening to a road or open space.

Fire-grade lining

Either fire-grade 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 and within a fire-resisting shaft or enclosure.

Fire-isolated passageway

A corridor or hallway of fire-resisting construction which provides egress to a fire-isolated stairway or ramp.

Fire-protective covering

- 13 mm fire-grade plasterboard; or
- 12 mm cellulose fibre-reinforced cement sheeting complying with AS 2908.2; or
- 12 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-grade 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 BCA) for the following:

- Structural adequacy
- Integrity
- Insulation.

Mineral wools are not all the same. Check product sheets to ensure correct fusion temperature.

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 manual, must be fire-resisting and therefore must have a fusion temperature in excess of 1160^{o} 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 BCA for that element.

Fire-resisting construction

Construction which satisfies Volume 2 of the BCA.

Fire-resisting junction

The intersection between a fire-rated wall or floor/ceiling system and or another rated or non-rated system, which maintain the fire resistance at the intersection.

Fire-resisting sealant

Fire-grade material used to fill gaps at joints and intersections in fire-grade 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: Fire walls 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.

Unit

Sole-Occupancy unit.

Weighted sound reduction index (R_w)

The rating of sound insulation in a building or building element as described in AS/NZS 1267.11999.


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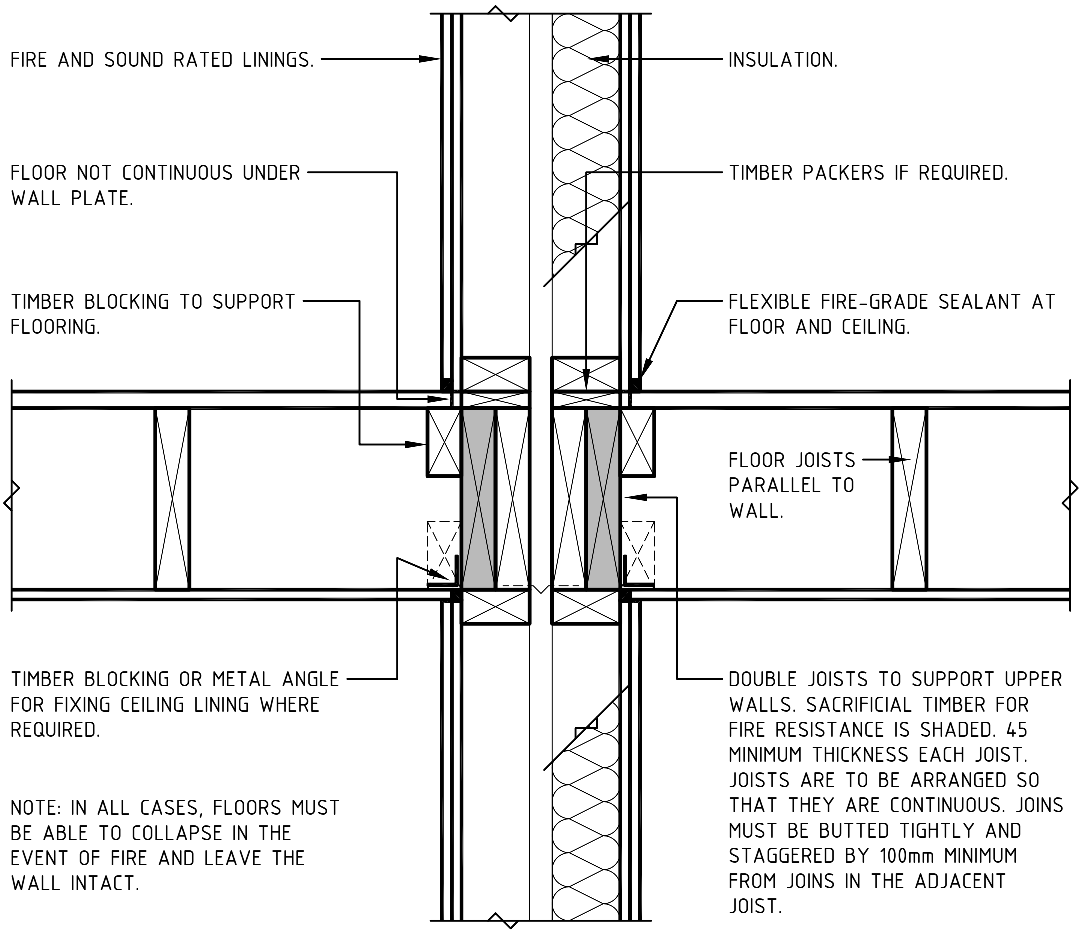
THE TABLE BELOW REFERENCES THE WOODSOLUTIONS TECHNICAL DESIGN GUIDE FIGURES TO WOODSOLUTIONS pdf FILES.
(File name: WS_TDG1_Design_Files_pdf_1)

TDG #	FIGURE #	CAD DETAIL #	REMARKS
1	02 -	-	Not provided. TDG detail is diagrammatic.
1	03 -	-	Not provided. TDG detail is diagrammatic.
1	04 -	-	Not provided. TDG detail is diagrammatic.
1	05 -	-	Not provided. TDG detail is diagrammatic.
1	06 -	FD0001	-
1	07 -	FD0003	Variation of figure FD0004 with joists perpendicular on
1	07 -	FD0004	-
1	08 -	WD0001	-
1	09 -	WD0002	-
1	10 -	-	Not provided. TDG detail is diagrammatic.
1	11 -	WD0020	-
1	12 -	WD0003	-
1	13 -	-	Not provided to avoid duplication (this detail is an assembly
1	14 -	-	Not provided. A plan detail of a short section of straight wall is not as useful as a vertical section to depict wall construction systems.
1	15 -	-	Not provided. A plan detail of a short section of straight wall is not as useful as a vertical section to depict wall construction systems.
1	16 -	-	Not provided. A plan detail of a short section of straight wall is not as useful as a vertical section to depict wall construction systems.
1	17 -	WD0023	-
1	18 -	WD0024	-
1	19 bottom	FD0002	-
1	19 top	FD0001	-
1	20 -	FD0005	CAD detail varied to be more generic by showing solid section joists instead of floor truss and timber I-beam sections.
1	21 -	FD0007	Refer FD0008 for plan detail.
1	22 -	FD0008	CAD detail drawn as an orthogonal plan view to simplify project customisation if necessary.
1	23 -	FD0009	CAD detail varied to be more realistic by showing same style of floor truss both sides of separating wall. Refer FD0008 for plan detail.
1	24 -	FD0011	CAD detail varied to be more realistic by showing same style of floor truss both sides of separating wall.
1	25 -	FD0013	-
1	26 -	RD0006	-
1	27 -	RD0007	-

TDG #	FIGURE #	CAD DETAIL #	REMARK
1	28 -	RD0001	CAD detail varied to be more realistic by showing trusses both sides instead of trusses on one side, and rafters and ceiling joists on the other.
1	29 -	RD0004	CAD detail amended to show sarking and anti-ponding board to comply with BCA.
1	30 -	RD0003	-
1	31 -	RD0020	CAD detail amended to show sarking and anti-ponding board where required by the BCA. Refer RD0021 for elevation detail.
1	31 a	RD0021	CAD detail amended to show sarking.
1	32 -	-	Not drawn. TDG detail is diagrammatic.
1	33 -	WD0020	-
1	34 -	WD0025	CAD detail varied to be more generic by showing a break line to the staggered length of masonry wall.
1	35 a	WD0026	CAD detail has been varied to change the small timber block to a larger one to permit better fixing to the separating wall framing.
1	35 b	WD0026	CAD detail has been varied to change U shaped steel cappings to a double angle for simplicity and the notation is more generic.
1	36 -	RD0023	CAD detail varied to be more generic by omitting the floor to the upper level, and adding breaklines in 2 places. CAD detail shows the wall framing above the upper ceiling to be a stud wall rather than a gable truss (the web configuration of a truss is typically not suitable to receive external linings without additional battens).
1	37 -	-	Not drawn. Considered that an isometric detail is harder to customise for a project compared to orthogonal view. The subsequent details from the TDG's cover this detail.
1	38 a	FD0014	Refer FD0015 for elevation detail.
1	38 b	FD0015	Refer FD0016 for plan detail.
1	38 c	FD0016	CAD detail varied to show both leaves of the separating wall. Timber packers and mineral wool shown on one side, and solid blocking, double studs and column shown on the other.
1	A1 -	-	Not drawn to avoid duplication (this detail is an assembly of other details).



SECTION DETAIL - FLOOR TO DOUBLE STUD WALL, JOISTS PARALLEL, FRL 60/60/60 OR -/60/60 FD0001A

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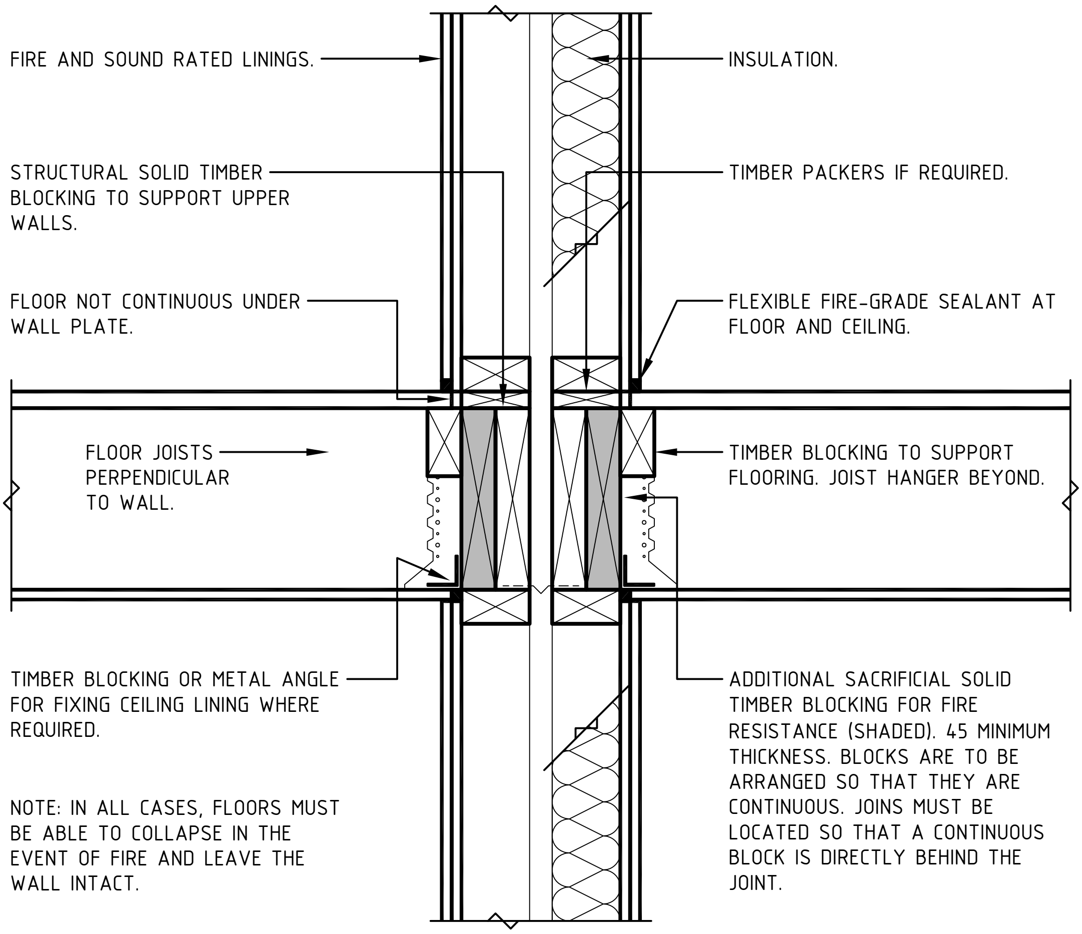

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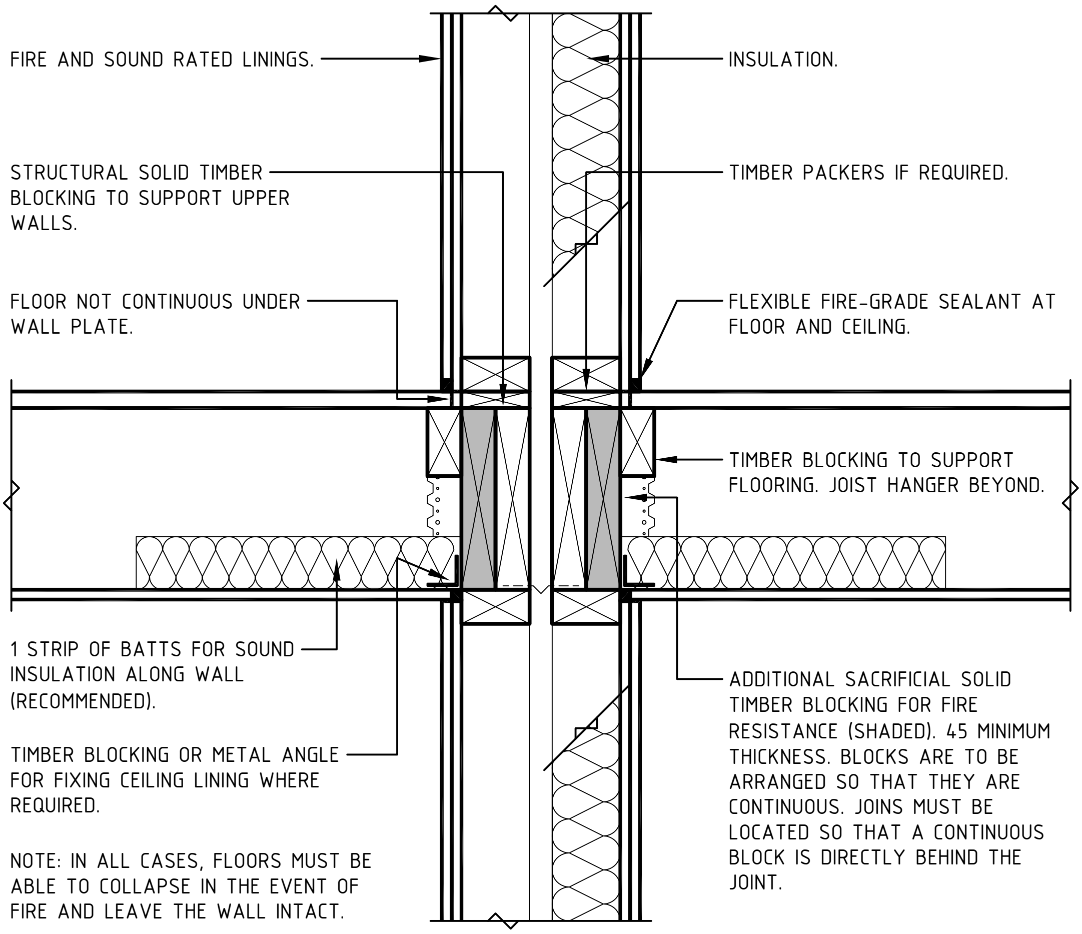

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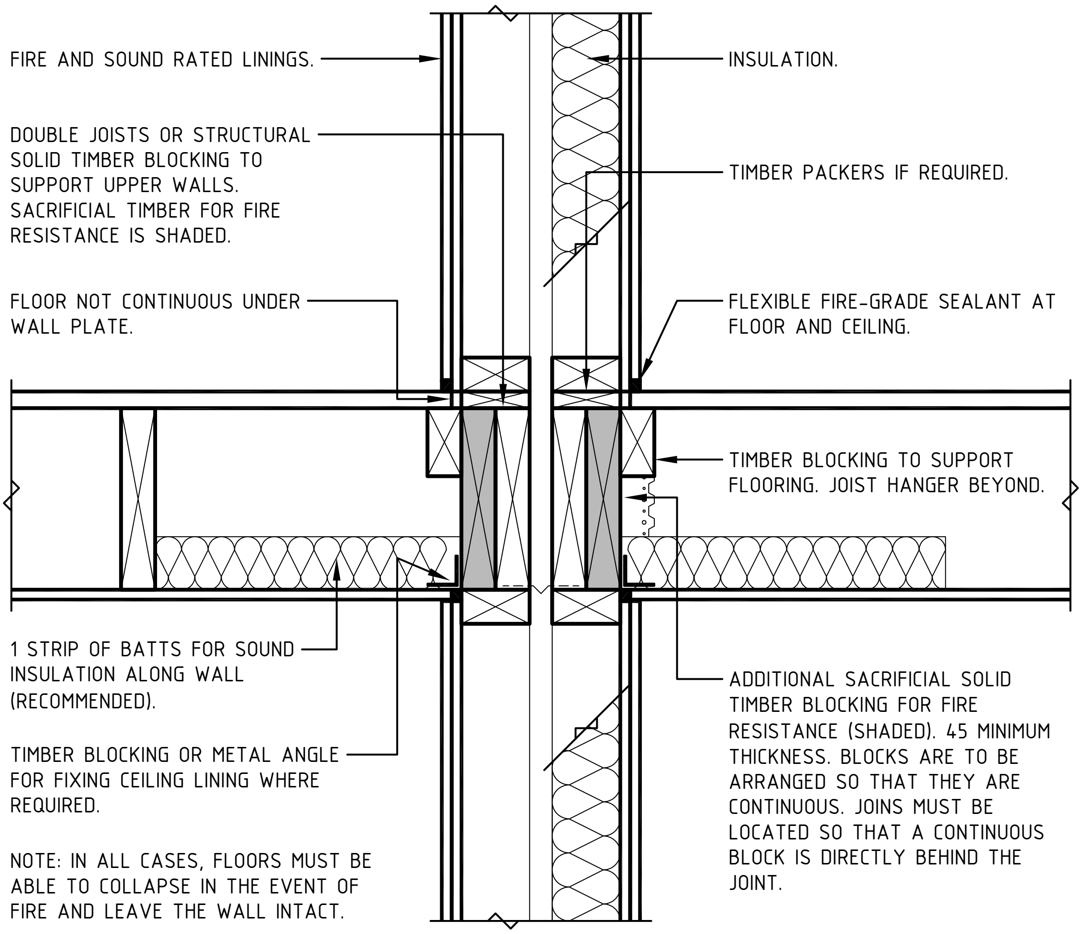

SECTION DETAIL - FLOOR TO DOUBLE STUD WALL, JOISTS PERPENDICULAR & PARALLEL WITH SOUND INSULATION, FRL 60/60/60 OR -/60/60 FD0004A

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Researcher:
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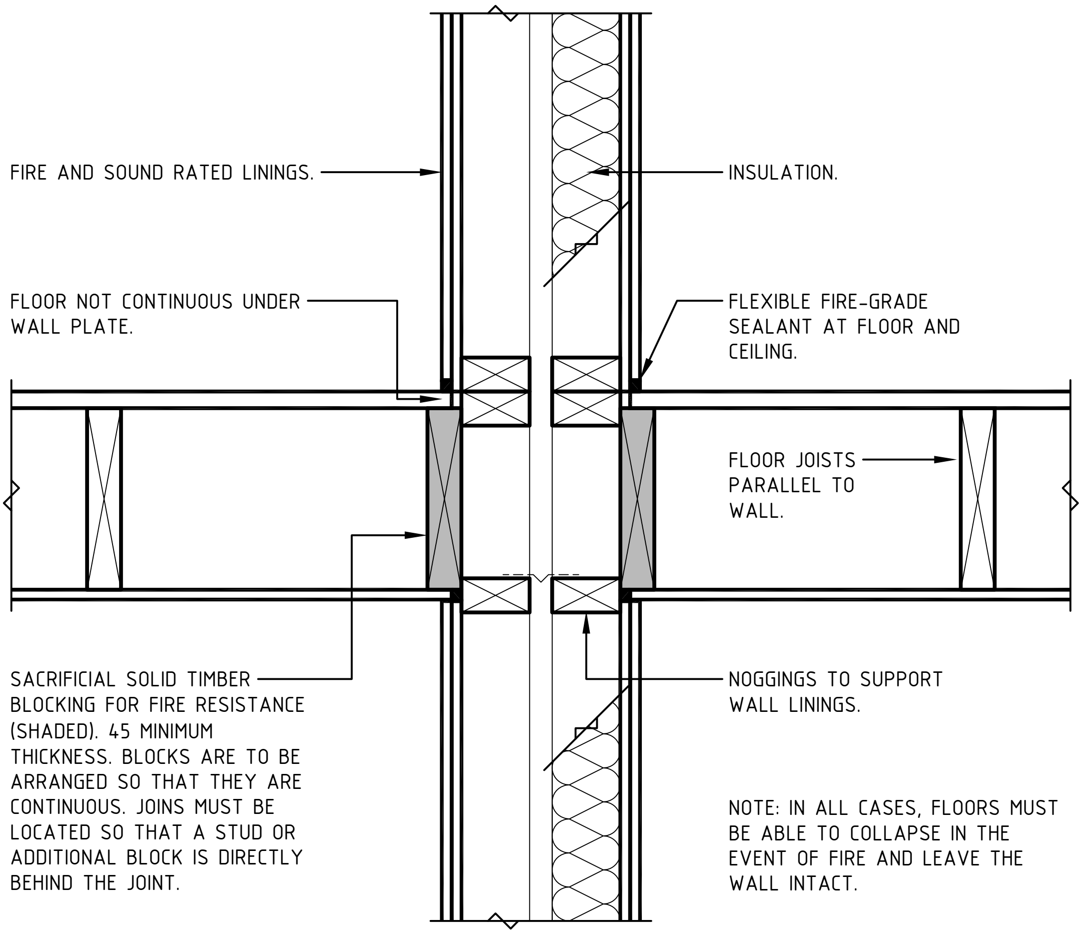

SECTION DETAIL - FLOOR TO CONTINUOUS DOUBLE STUD WALL, JOISTS PARALLEL, FRL 60/60/60 OR -/60/60 FD0005A

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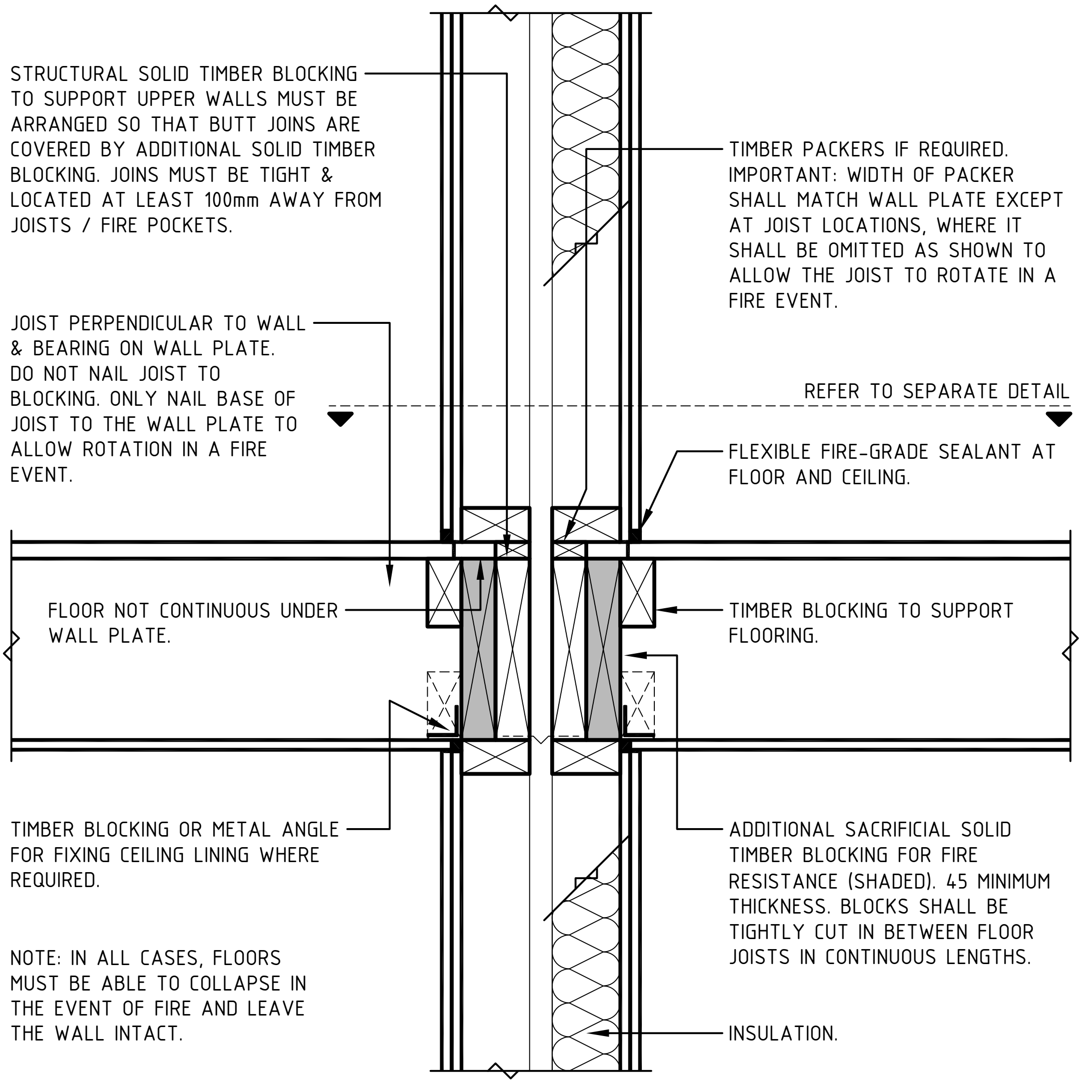

SECTION DETAIL – FLOOR TO DOUBLE STUD WALL, PERPENDICULAR JOISTS BEARING ON WALL PLATE, FRL 60/60/60 OR –/60/60

FD0007A

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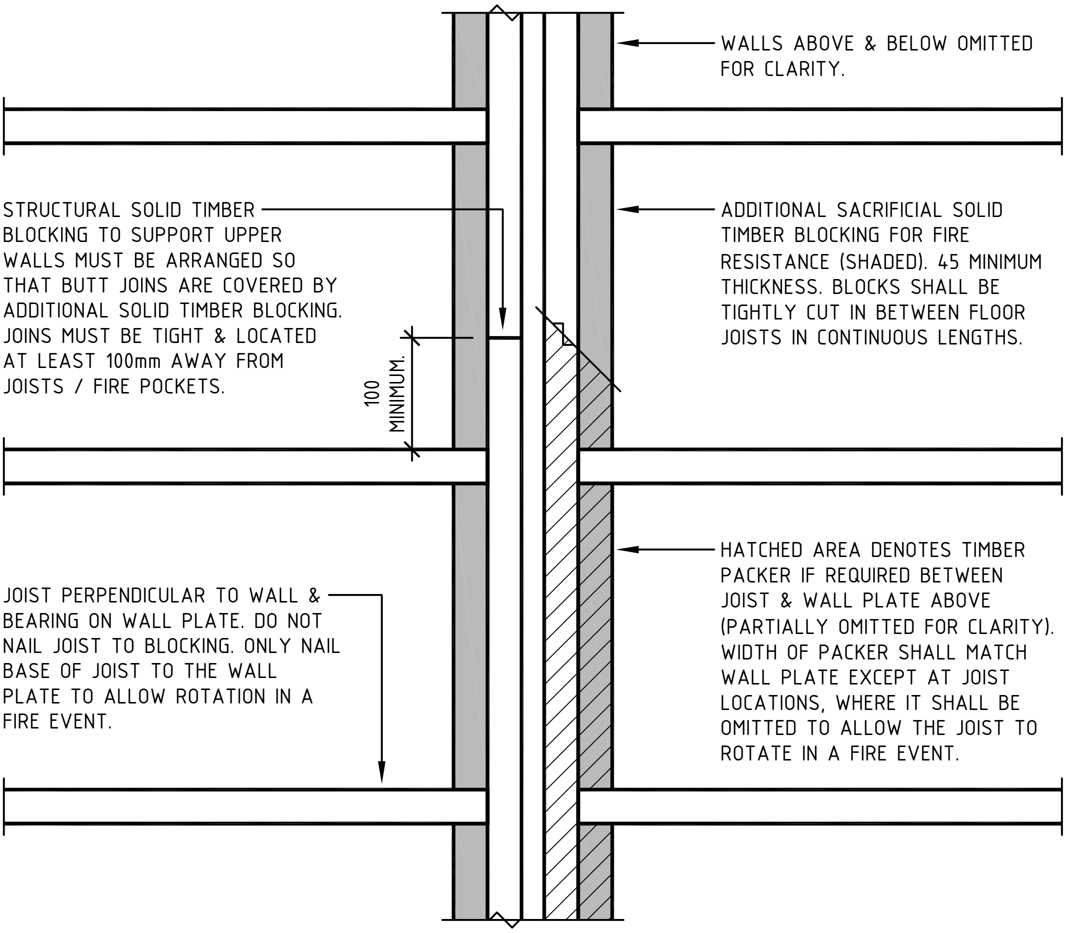

PLAN DETAIL – FLOOR TO DOUBLE STUD WALL, PERPENDICULAR JOISTS BEARING ON WALL PLATE, FRL 60/60/60 OR FRL –/60/60 FD0008A

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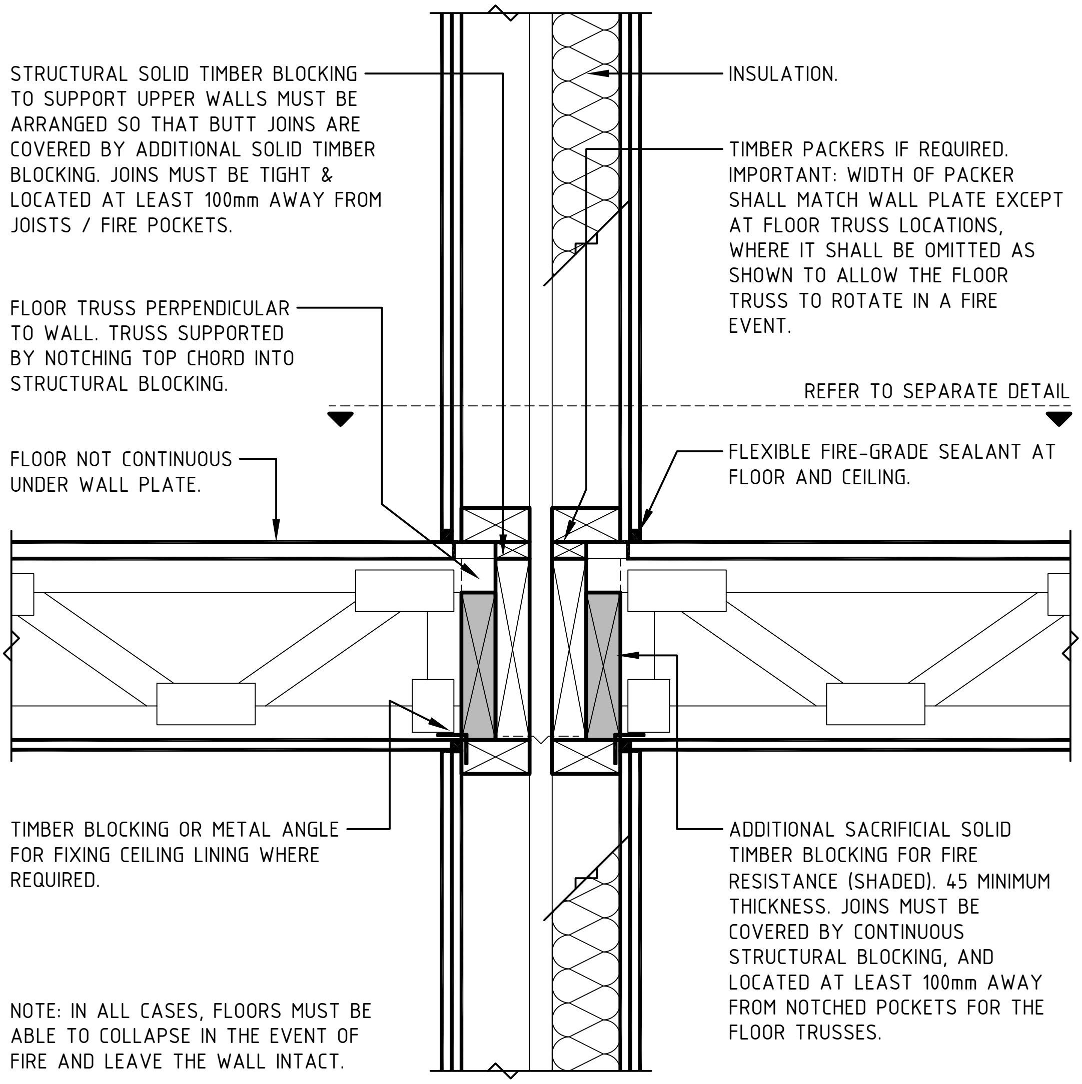

SECTION DETAIL – FLOOR TO DOUBLE STUD WALL, PERPENDICULAR FLOOR TRUSSES, FRL 60/60/60 OR –/60/60 FD0009A

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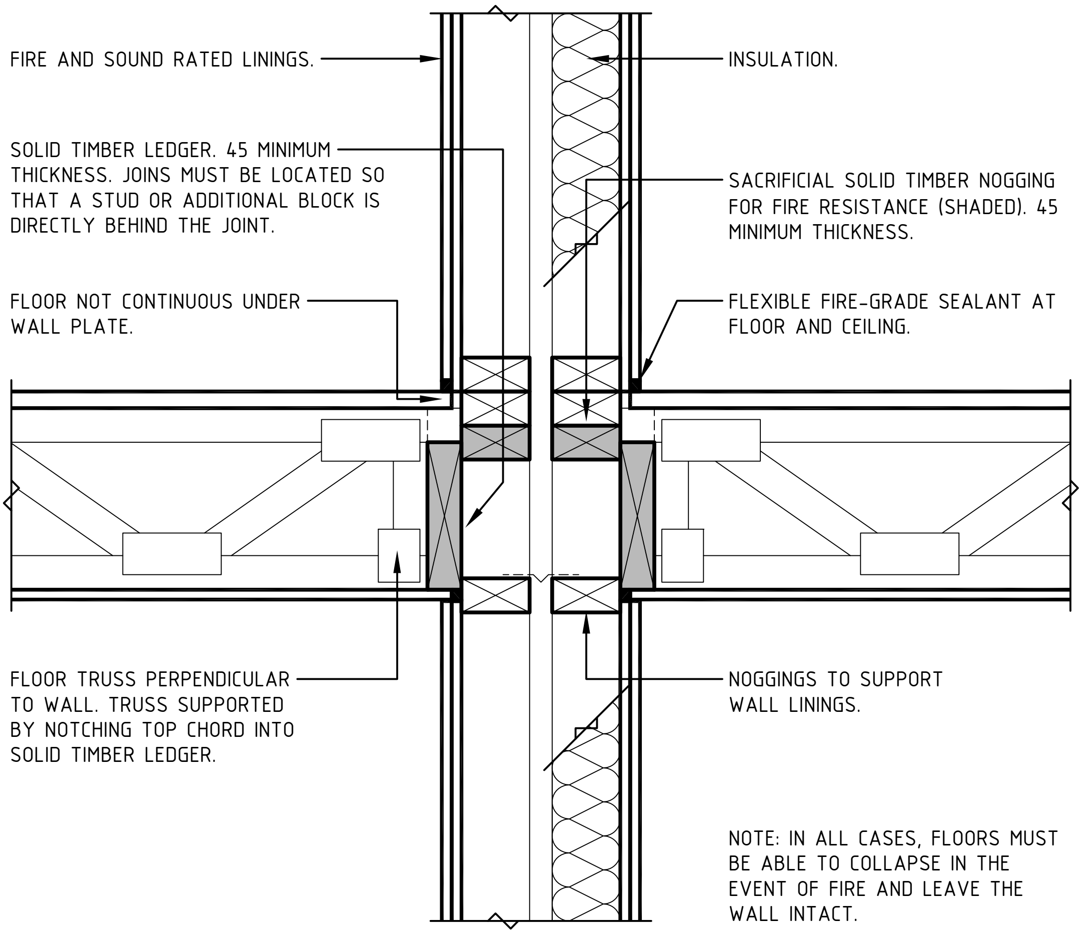

SECTION DETAIL - FLOOR TO CONTINUOUS DOUBLE STUD WALL, PERPENDICULAR FLOOR TRUSSES, FRL 60/60/60 OR -/60/60

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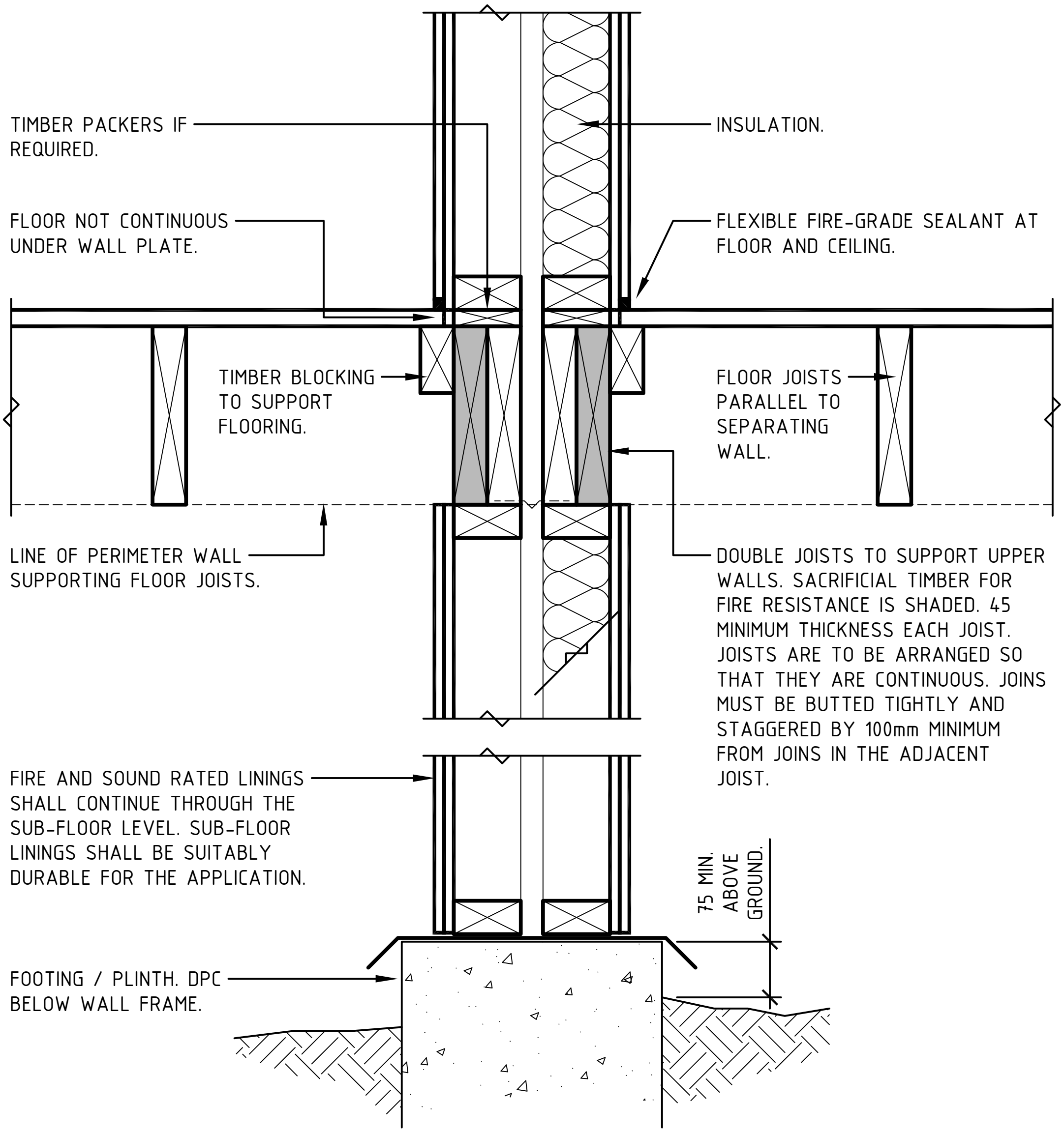

SECTION DETAIL - DOUBLE STUD WALL AT SUB-FLOOR LEVEL, FRL 60/60/60 OR -/60/60

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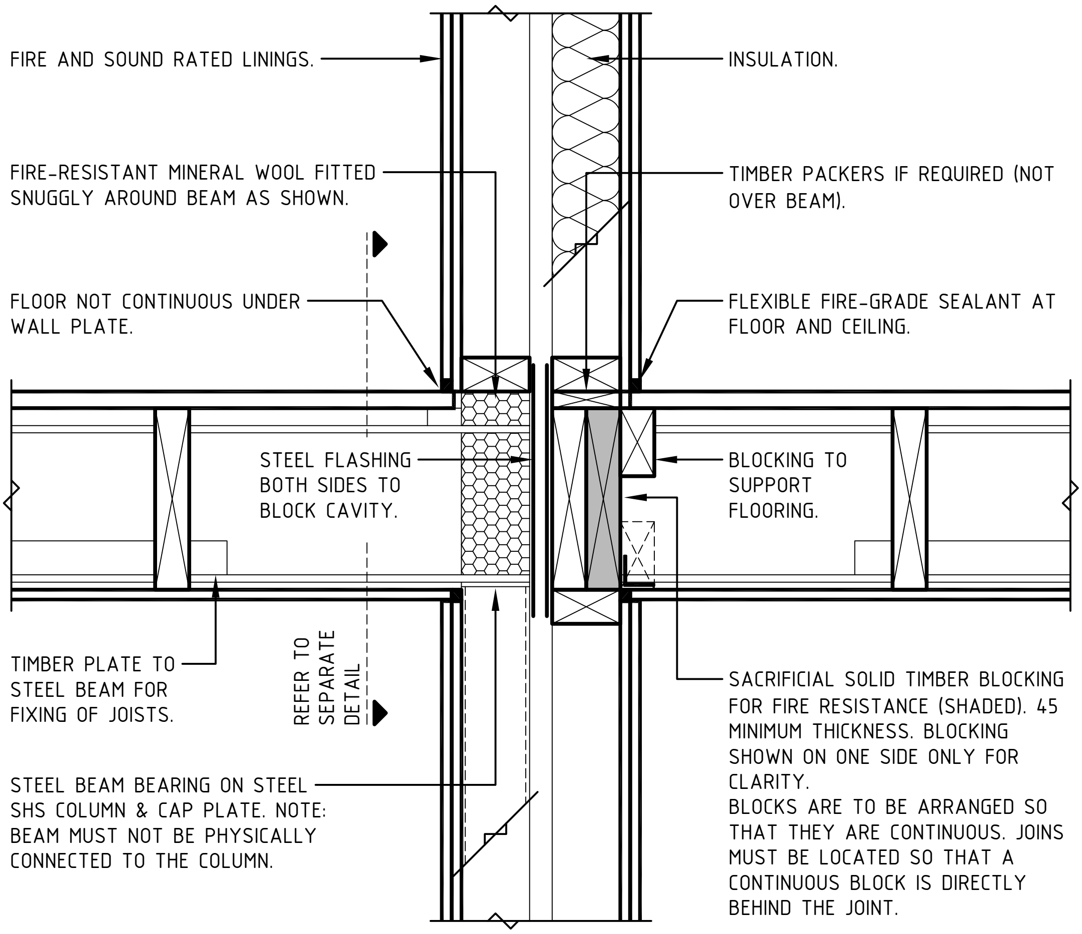

SECTION DETAIL – STEEL FLOOR BEAM TO DOUBLE STUD WALL, JOISTS PARALLEL

FD0014A

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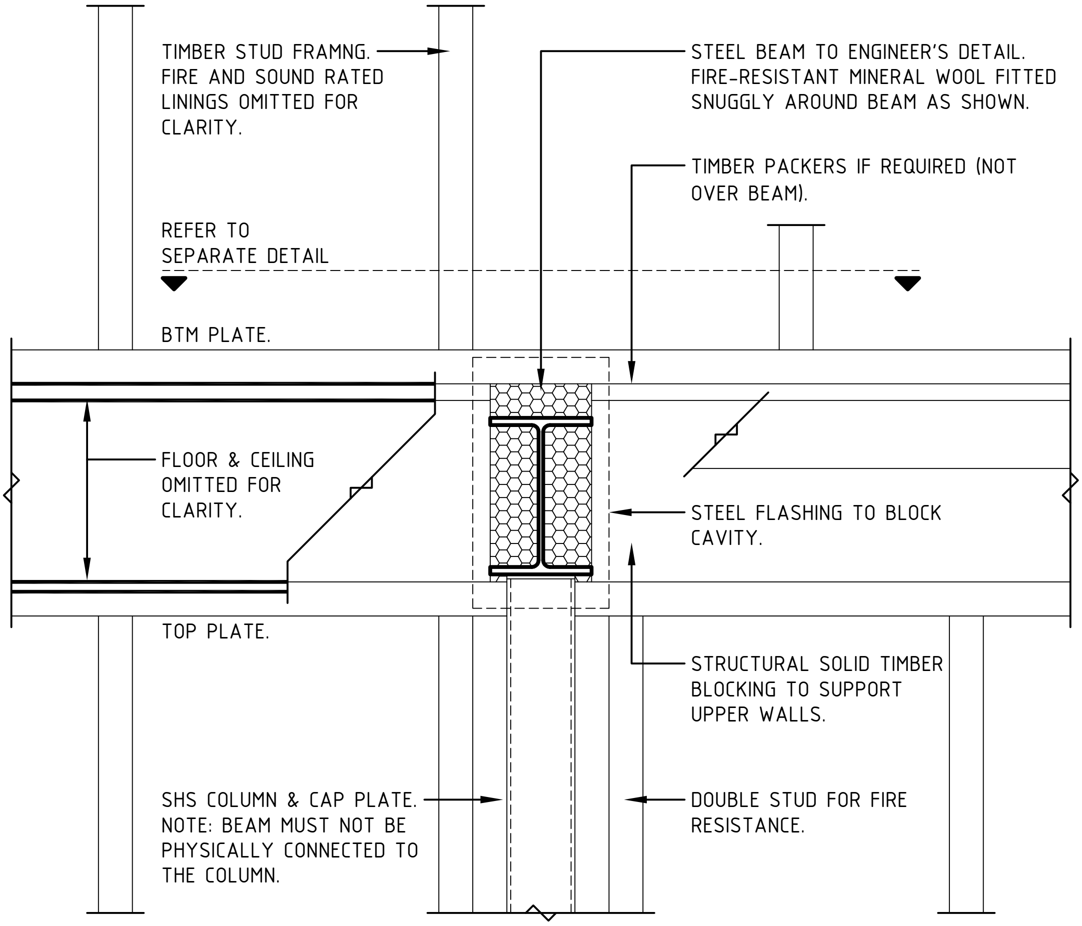

ELEVATION DETAIL - STEEL FLOOR BEAM TO WALL, JOISTS PARALLEL

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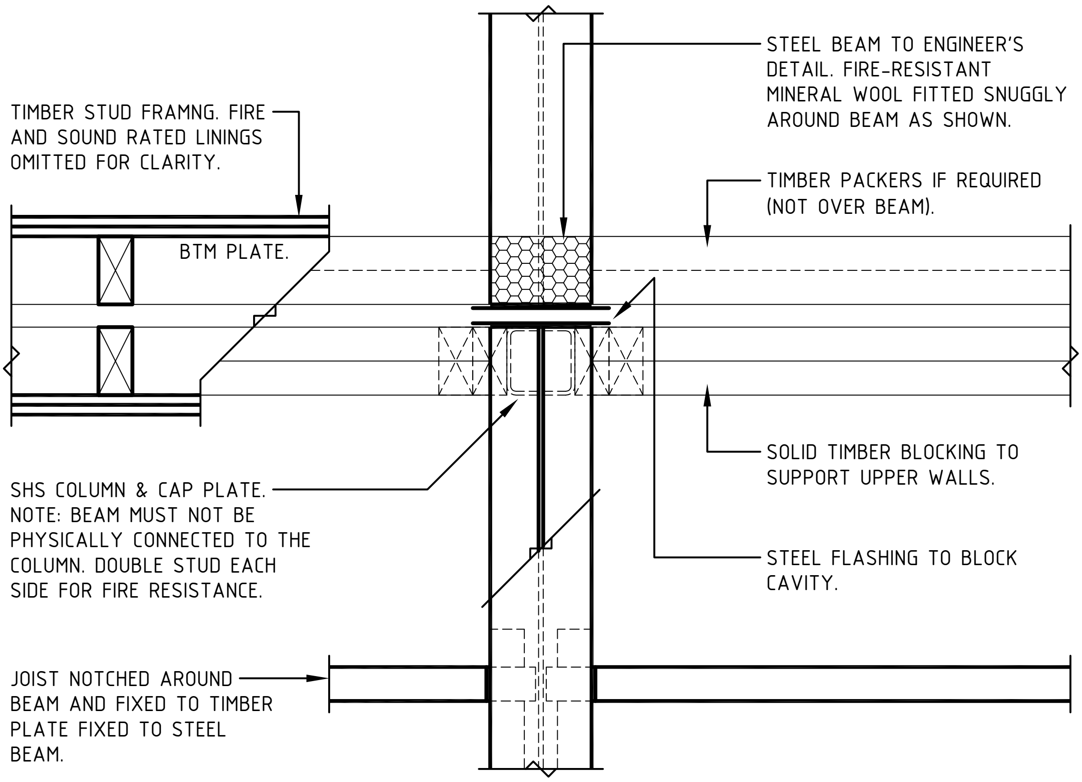

PLAN DETAIL – STEEL FLOOR BEAM TO DOUBLE STUD WALL, JOISTS PARALLEL

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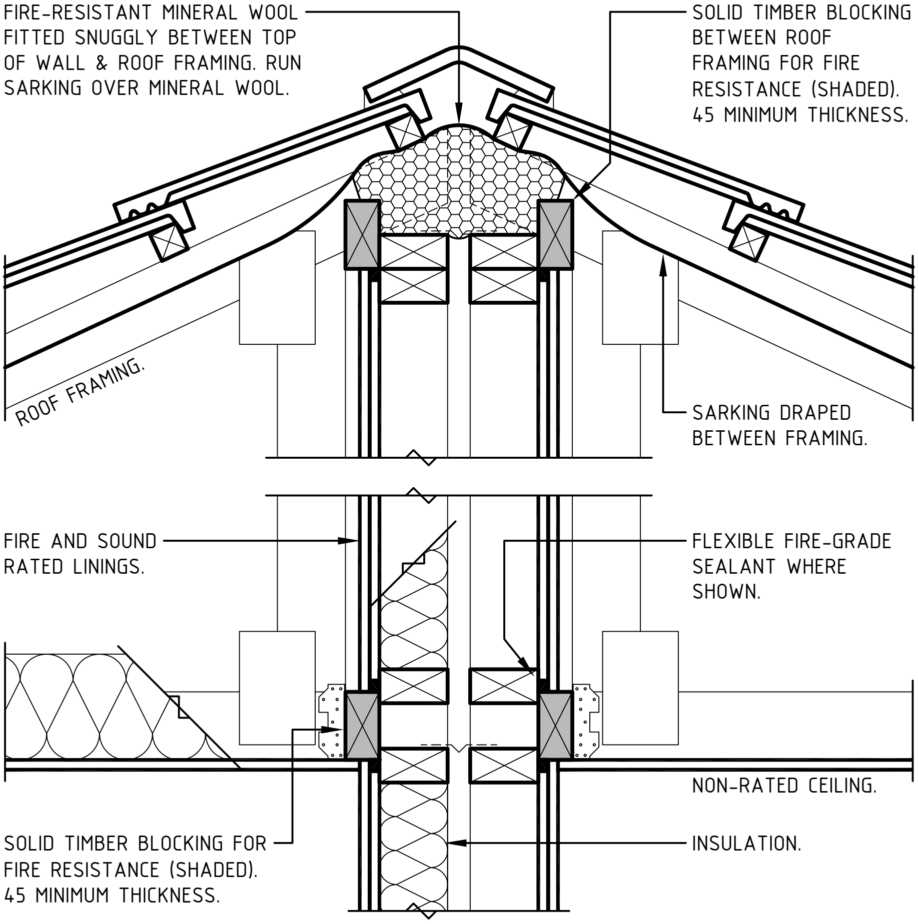

SECTION DETAIL - ROOF FRAMING TO DOUBLE STUD WALL, TRUSSES PERPENDICULAR, FRL 60/60/60 OR -/60/60 RD0001A

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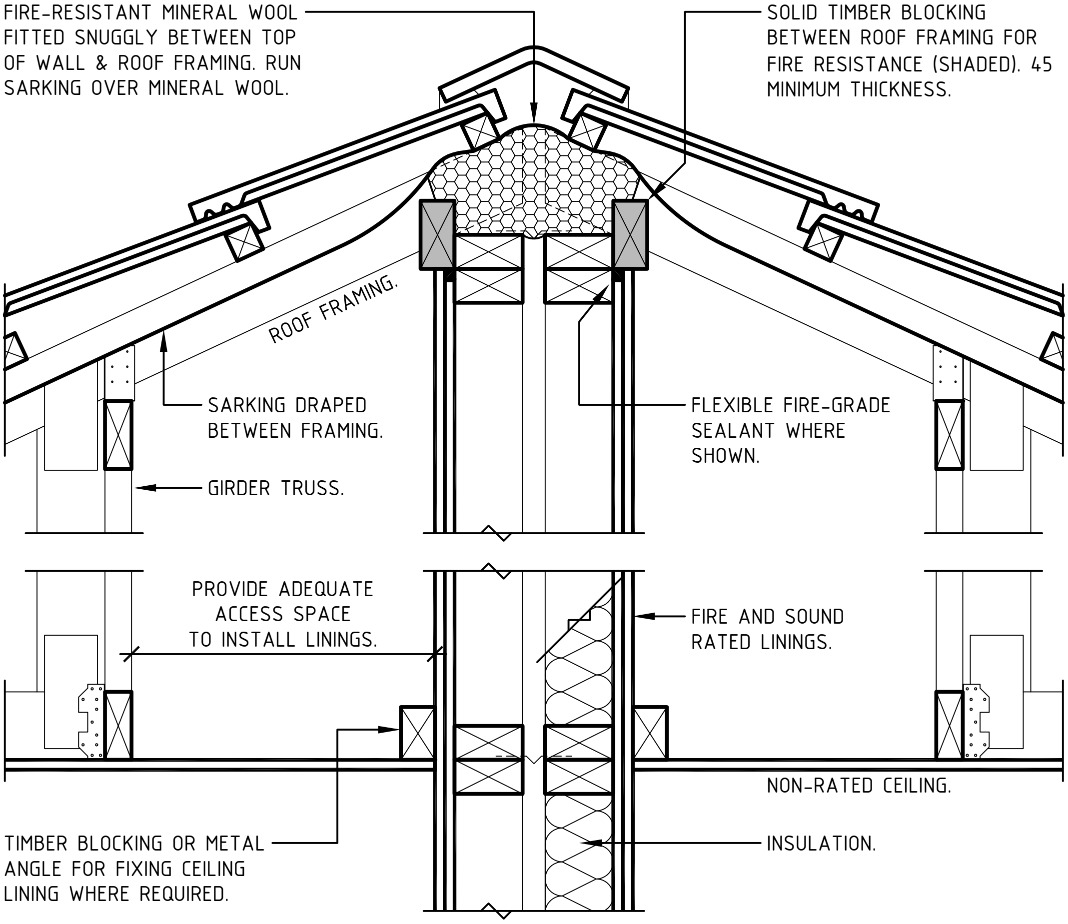

SECTION DETAIL - ROOF FRAMING TO DOUBLE STUD WALL, TRUSSES PERPENDICULAR & PARALLEL GIRDER TRUSS RD0003A

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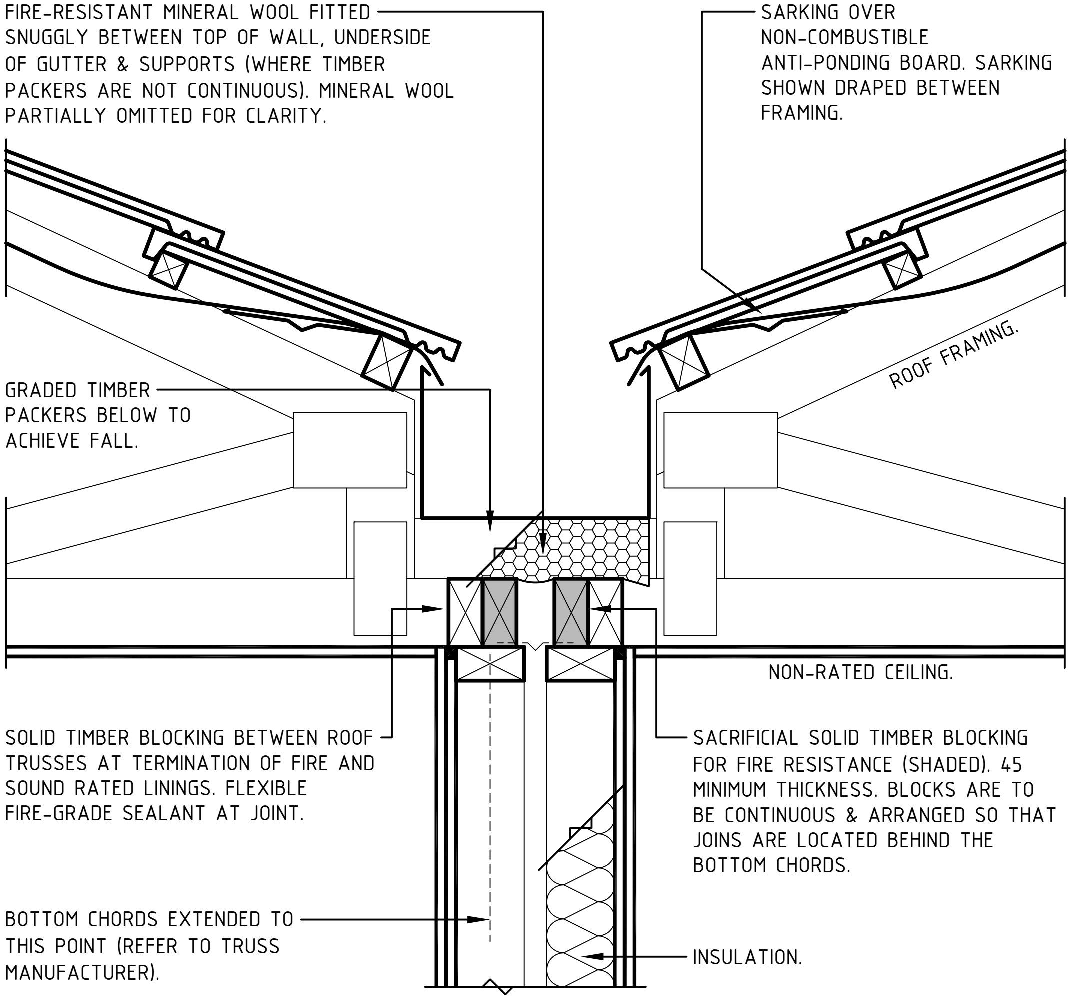

SECTION DETAIL - ROOF FRAMING TO DOUBLE STUD WALL, BOX GUTTER & TRUSSES PERPENDICULAR, FRL 60/60/60 OR -/60/60 RD0004A

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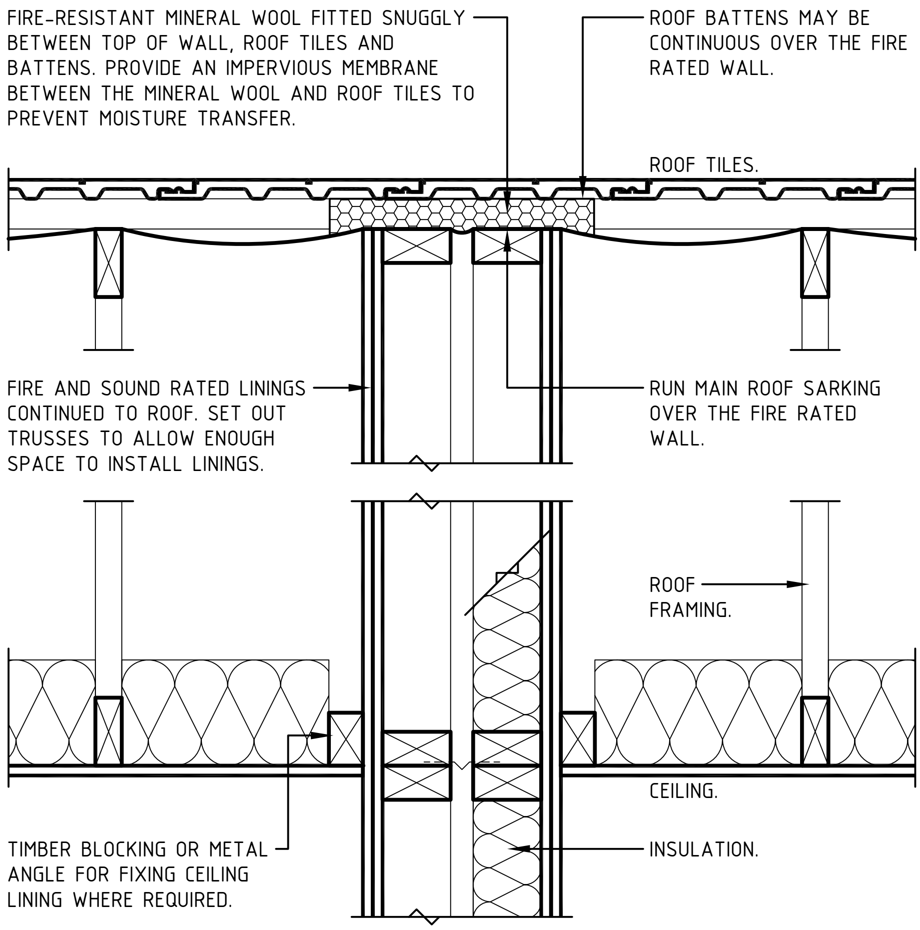

SECTION DETAIL – ROOF FRAMING TO DOUBLE STUD WALL, TRUSSES PARALLEL RD0006A

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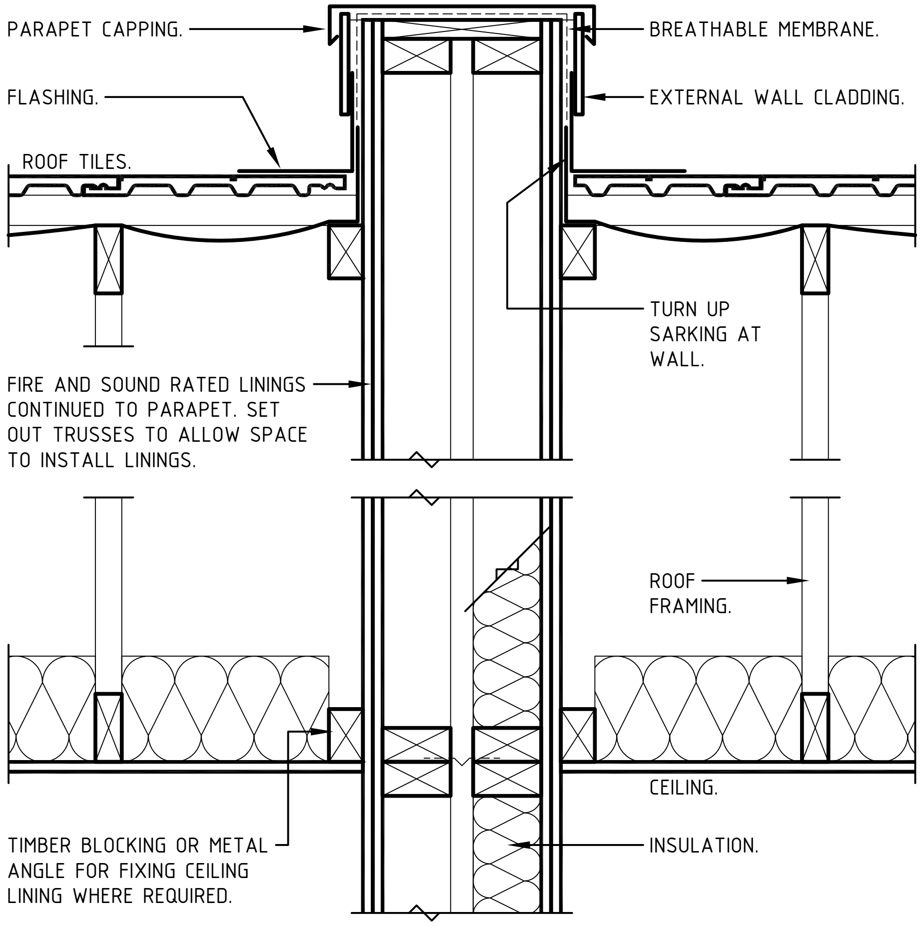

SECTION DETAIL - ROOF FRAMING TO DOUBLE STUD WALL WITH PARAPET, TRUSSES PARALLEL, FRL 60/60/60 OR -/60/60 RD0007A

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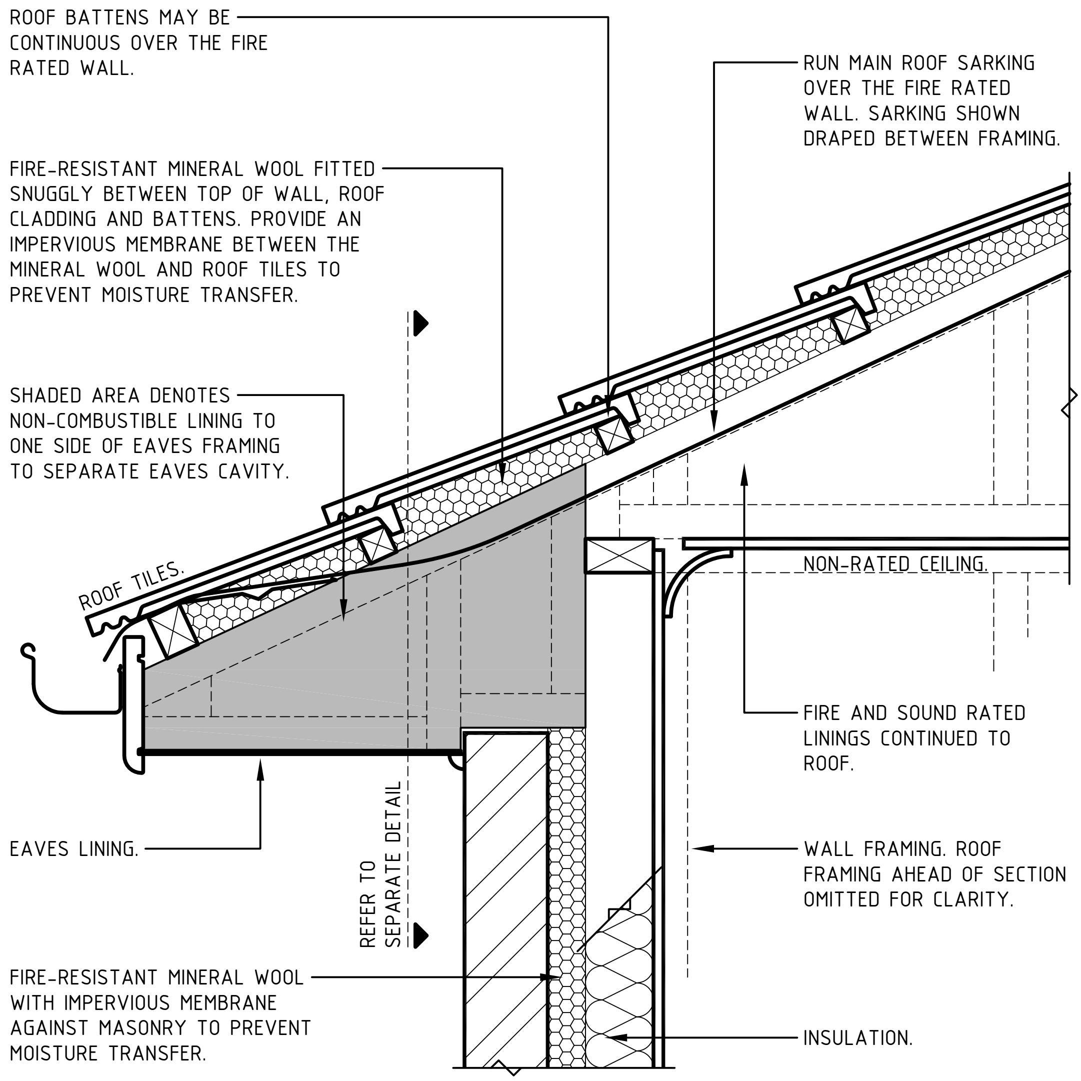

SECTION DETAIL – EAVES BLOCKING, MASONRY VENEER EXTERNAL WALL RD0020A

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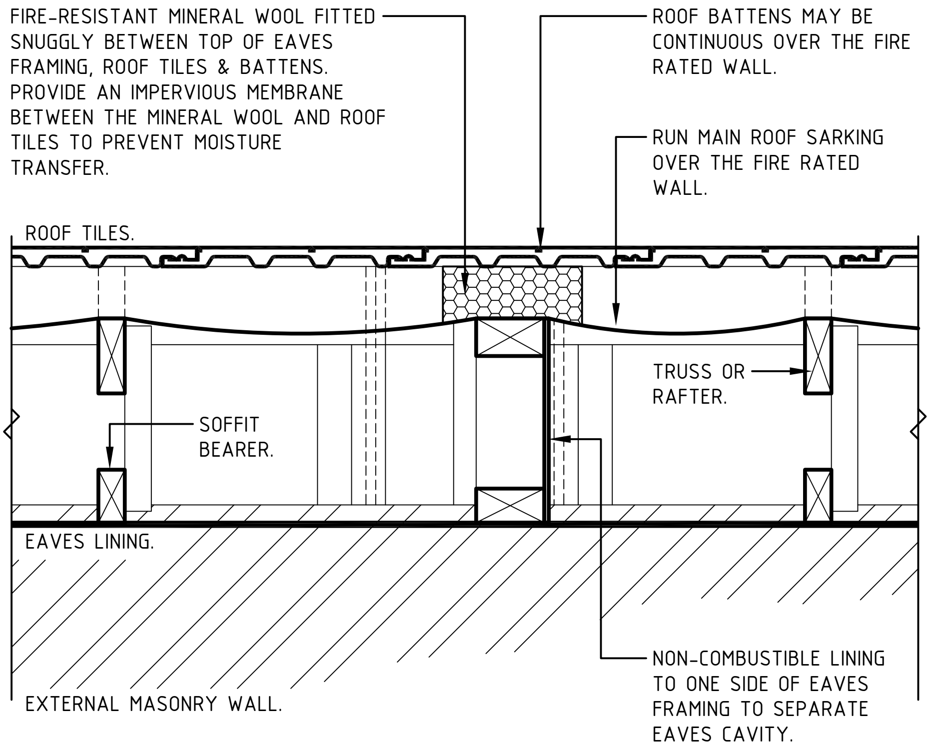

ELEVATION DETAIL - EAVES BLOCKING AT DOUBLE STUD WALL, MASONRY VENEER EXTERNAL WALL

RD0021A

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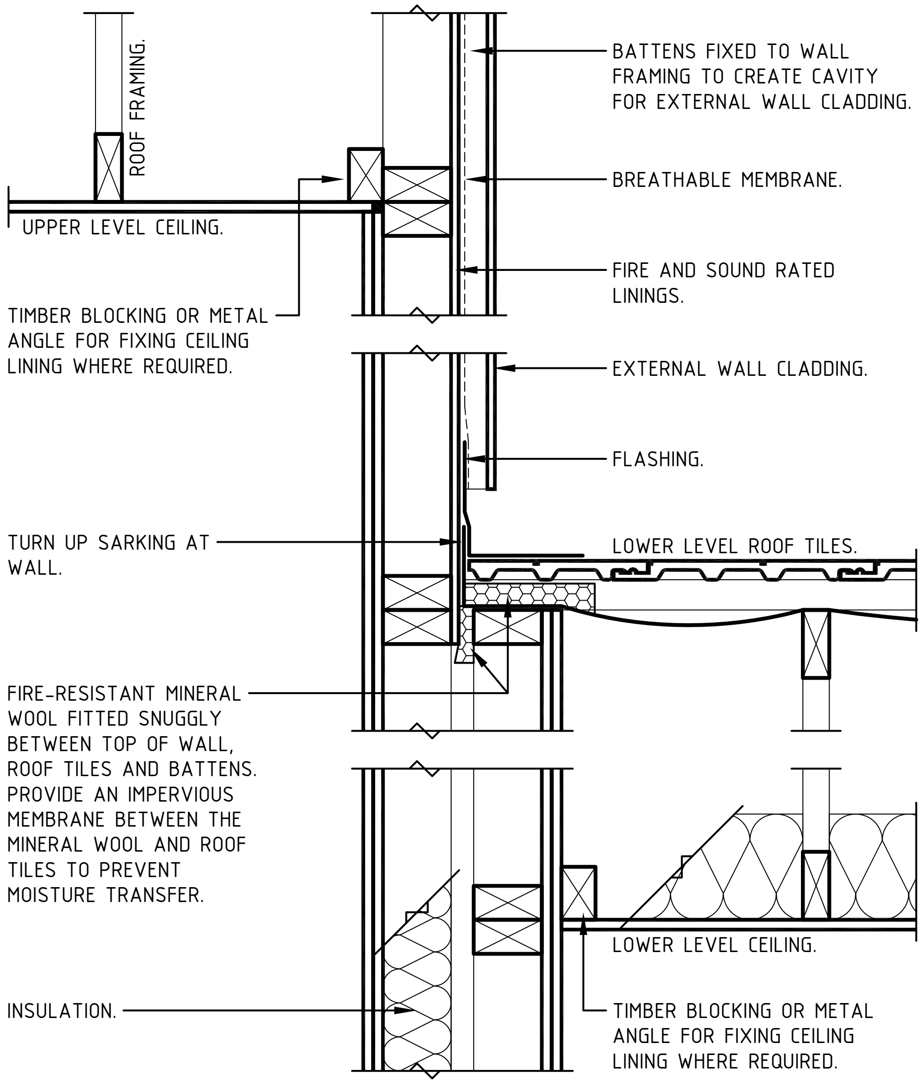

SECTION DETAIL - ROOF FRAMING TO DOUBLE STUD WALL WITH STEPPED ROOF LINE, TRUSSES PARALLEL RD0023A

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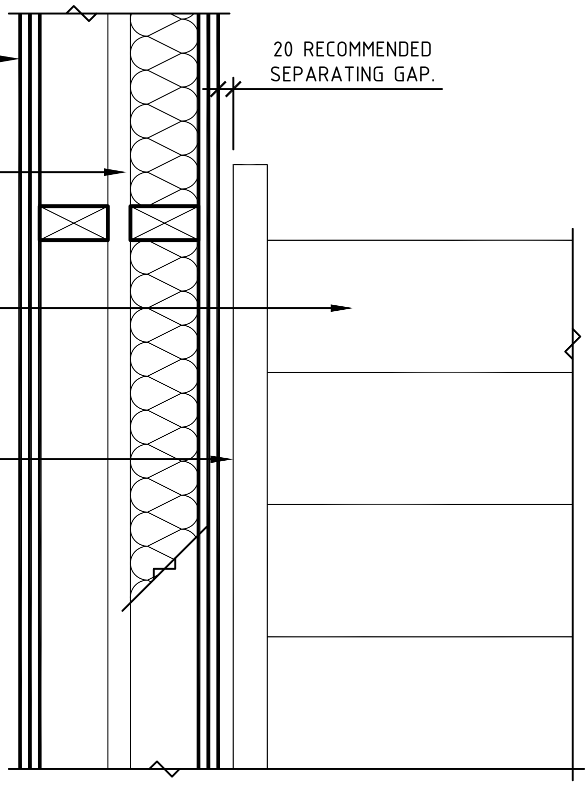

SECTION DETAIL - STAIR ISOLATED FROM WALL WD0001A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

WD0001A

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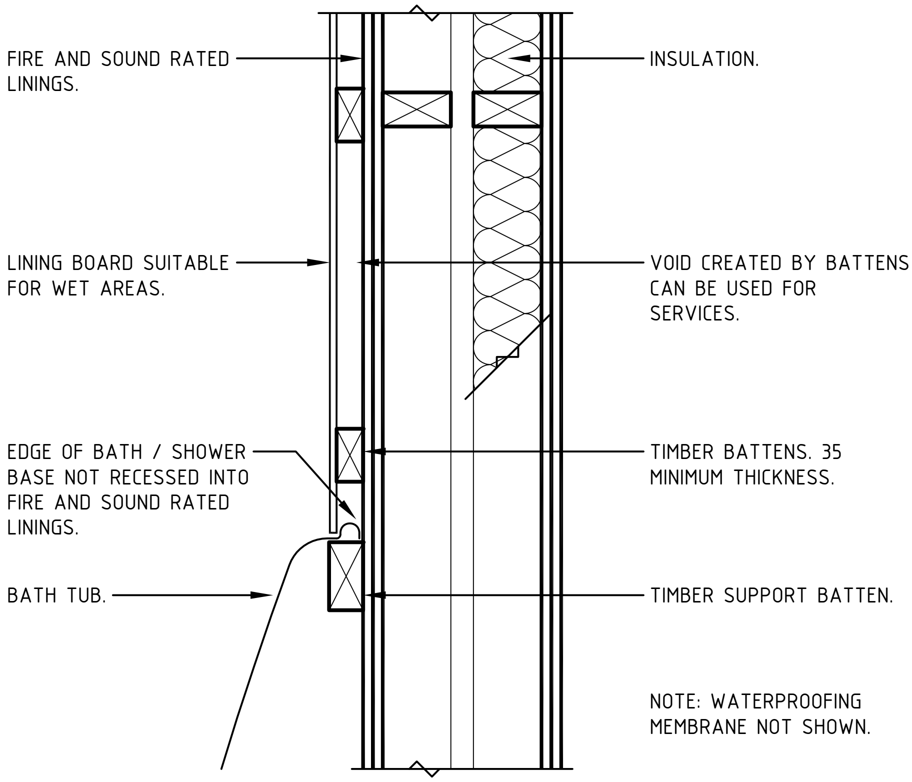

SECTION DETAIL - DOUBLE STUD WALL BATTENED TO RECEIVE SERVICES & BATH / SHOWER

WD0002A

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WD0002A

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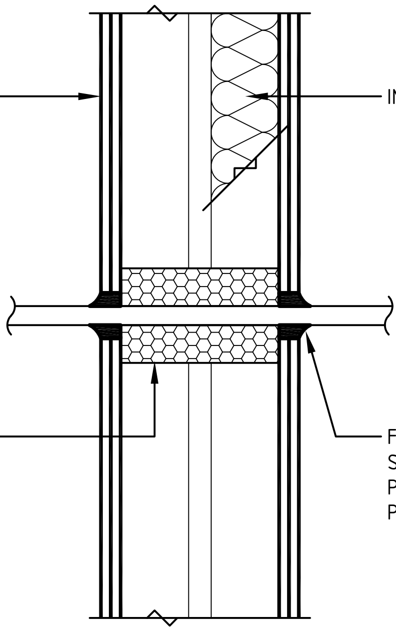

SECTION DETAIL - PIPE PENETRATION THROUGH DOUBLE STUD WALL

WD0003A

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WD0003A

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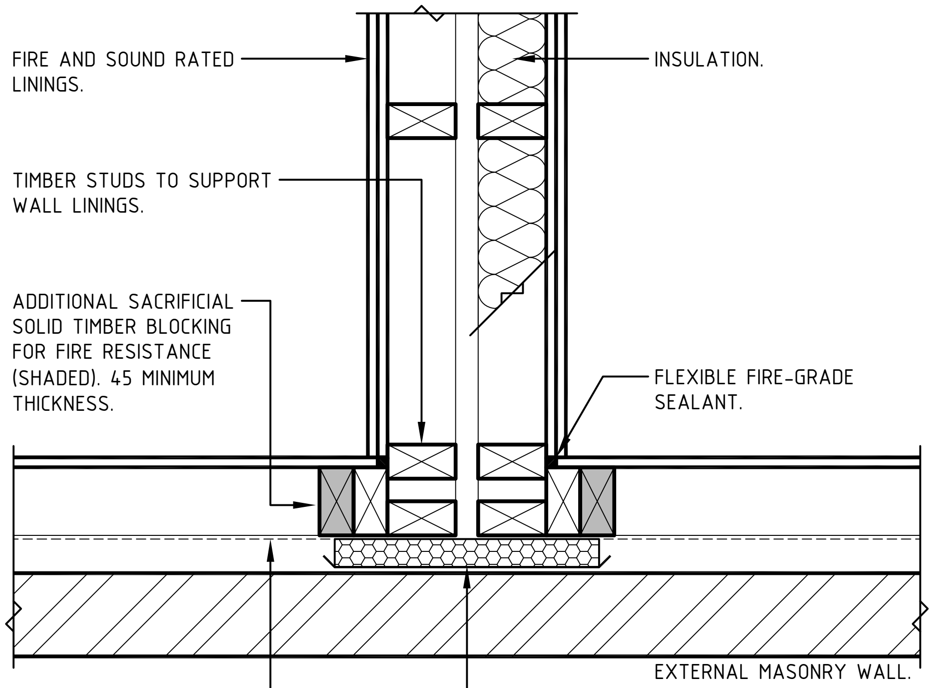

PLAN DETAIL - JUNCTION OF MASONRY VENEER WALL TO DOUBLE STUD WALL, FRL 60/60/60 OR -/60/60

WD0020A

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WD0020A

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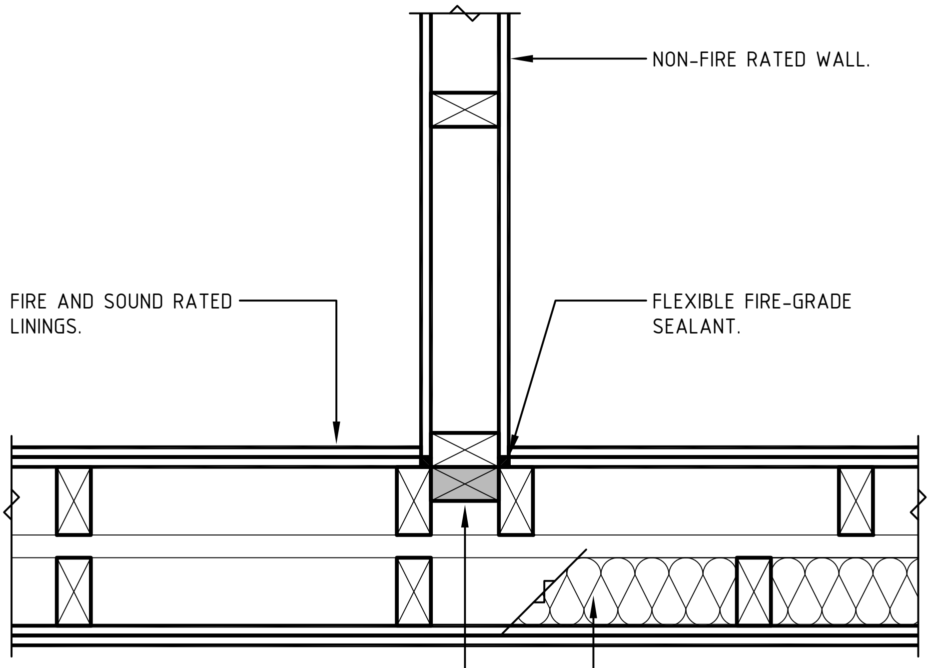

PLAN DETAIL - JUNCTION OF FIRE RATED DOUBLE STUD WALL TO NON-FIRE RATED WALL, FRL 60/60/60 OR -/60/60 WD0023A

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DETAIL REFERENCE NO.

WD0023A

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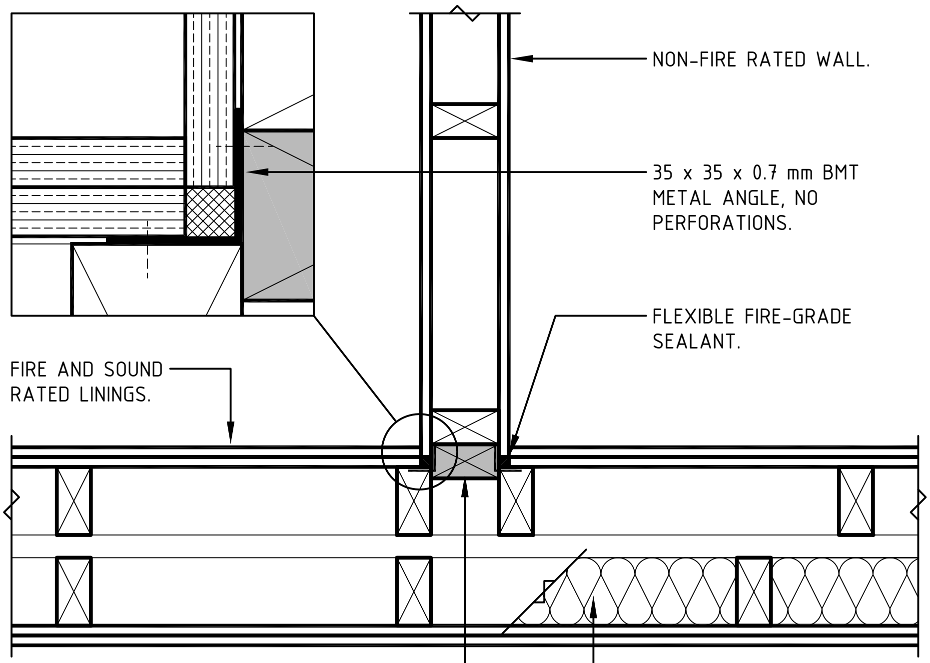

PLAN DETAIL - JUNCTION OF FIRE RATED DOUBLE STUD WALL TO NON-FIRE RATED WALL, FRL 90/90/90 OR -/90/90 WD0024A

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Researcher:
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WD0024A

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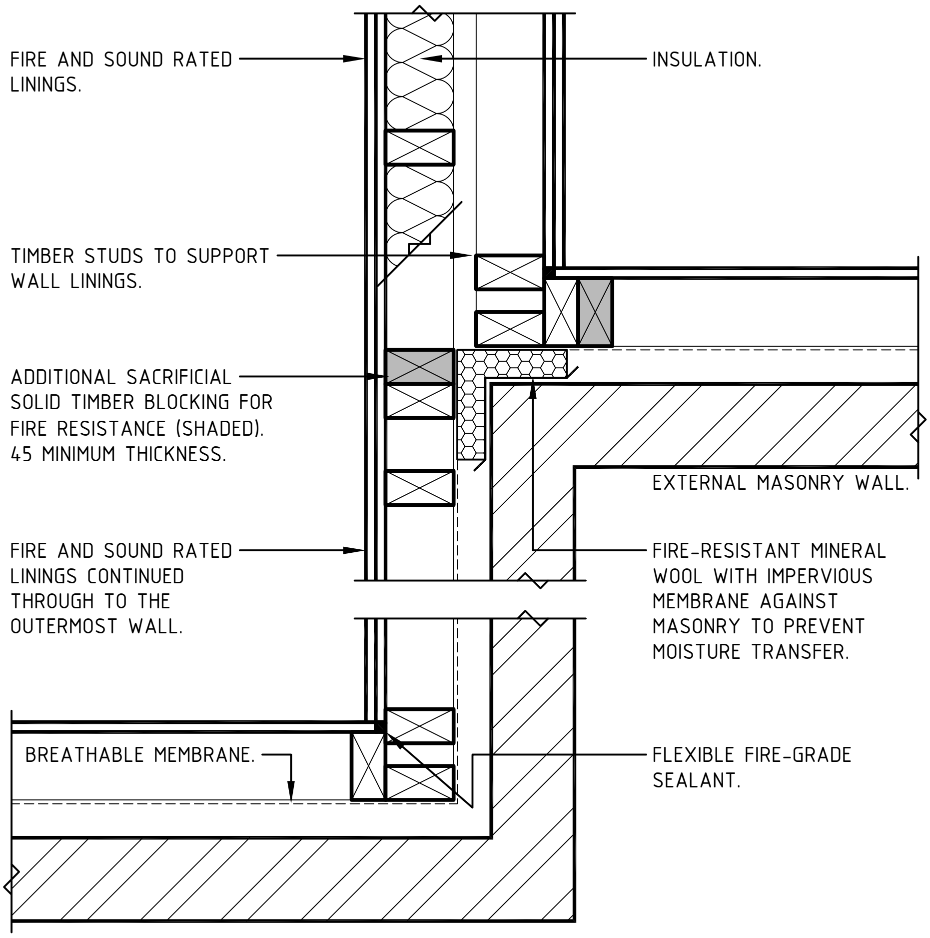

PLAN DETAIL - JUNCTION OF STAGGERED MASONRY VENEER WALL TO DOUBLE STUD WALL WD0025A

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WD0025A

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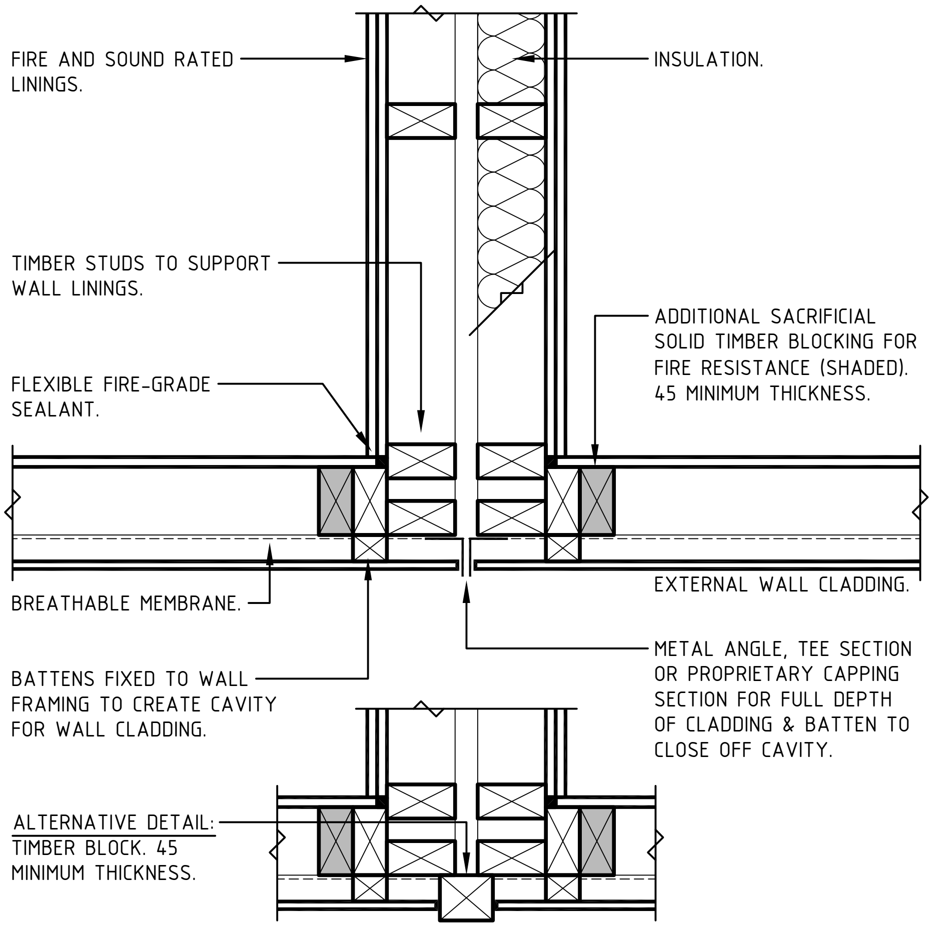

PLAN DETAIL - JUNCTION OF CLAD FRAME WALL TO DOUBLE STUD WALL WD0026A

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02

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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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WoodSolutions is an industry initiative designed to provide independent, non-proprietary information about timber and wood products to professionals and companies involved in building design and construction.

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Table of Contents

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.

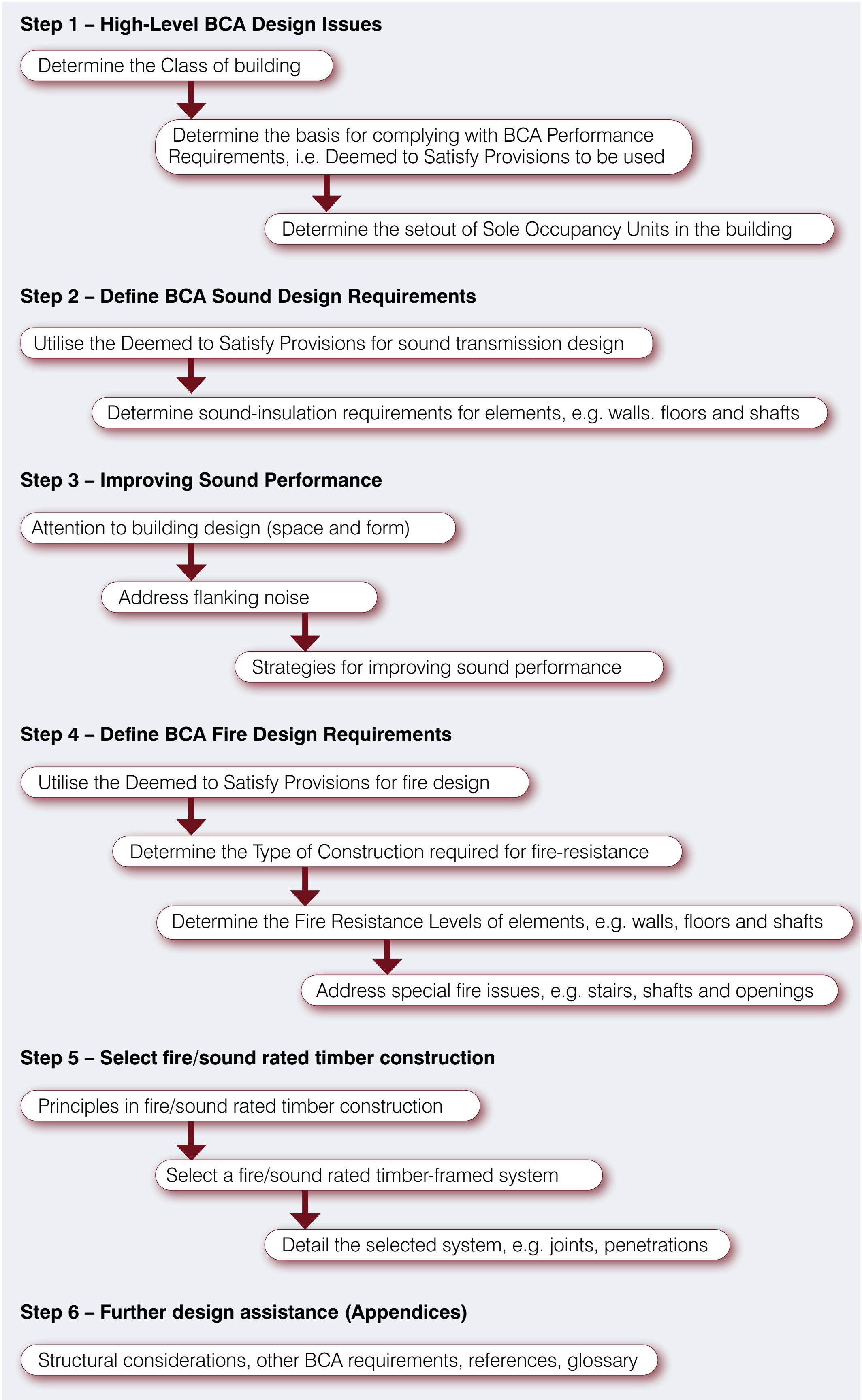


Figure 1: Design process for sound and fire-resistance of timber-framed construction.

1

Step 1 – High-Level NCC Design Issues

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.

This Guide covers NCC Class 2 and 3 buildings.

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.

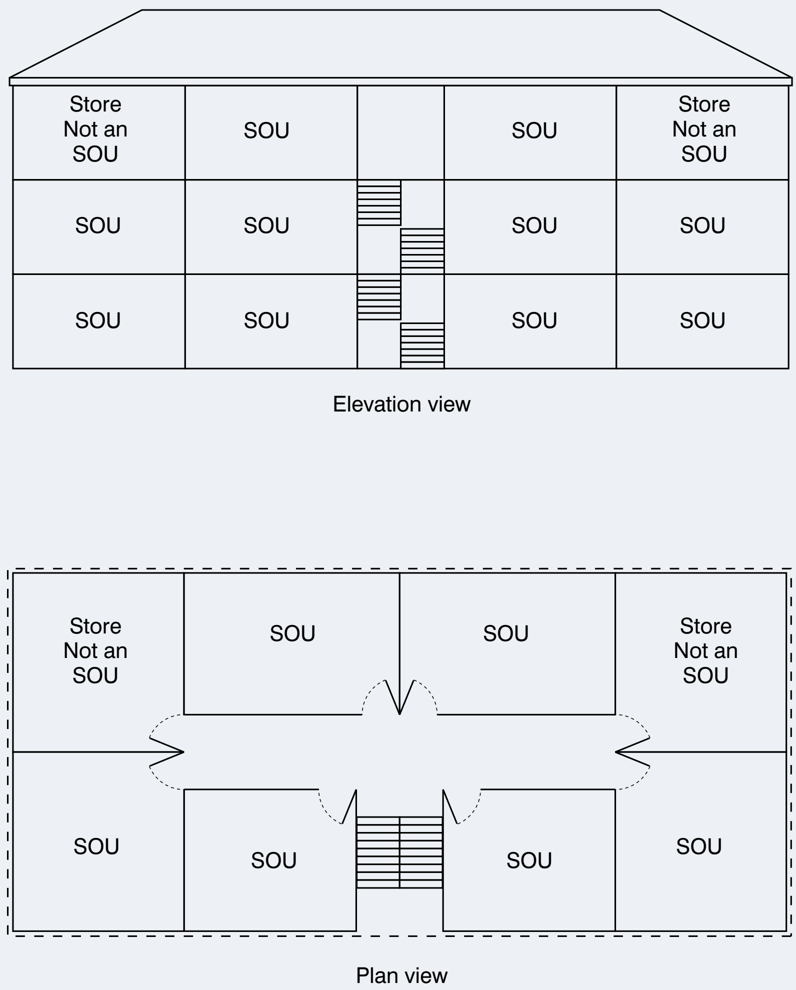


Figure 2: Examples of Sole Occupancy Units.

2

Step 2 – Define NCC Sound-Design Requirements

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.

2.1 Utilising the NCC's Provisions for Sound Insulation Design

Airborne and impact sound: different sources need different handling.

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).

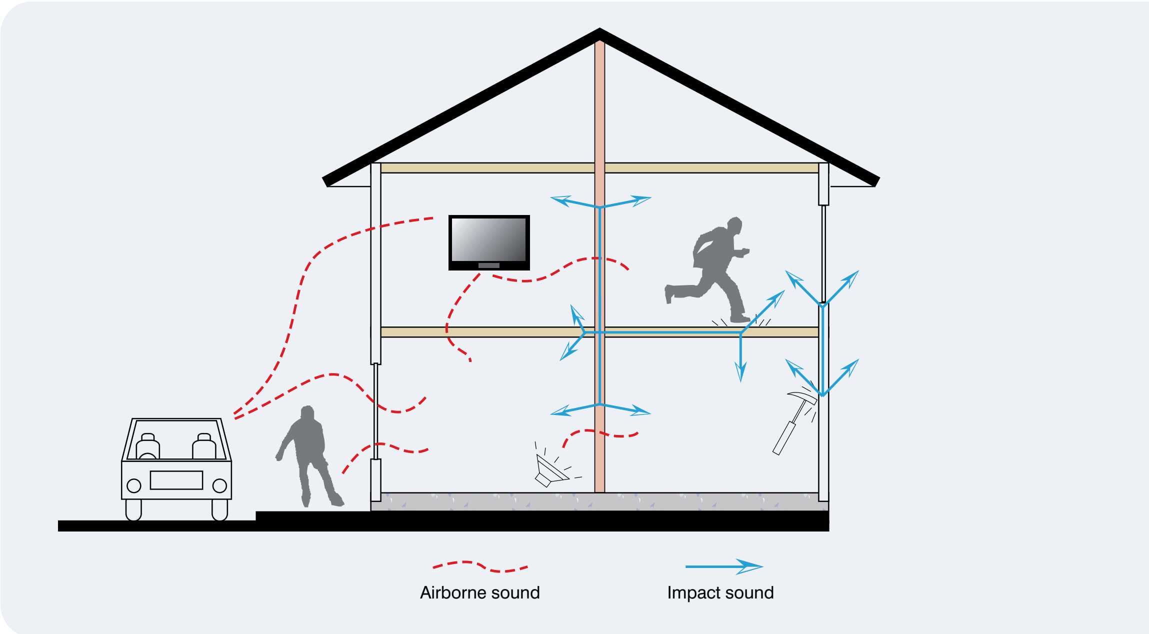


Figure 3: Examples of impact and airborne sound.

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.

Clear definitions +accurate measurements = optimal results.

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

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

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.

Step 3 – Improve and Upgrade Sound Performance

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.

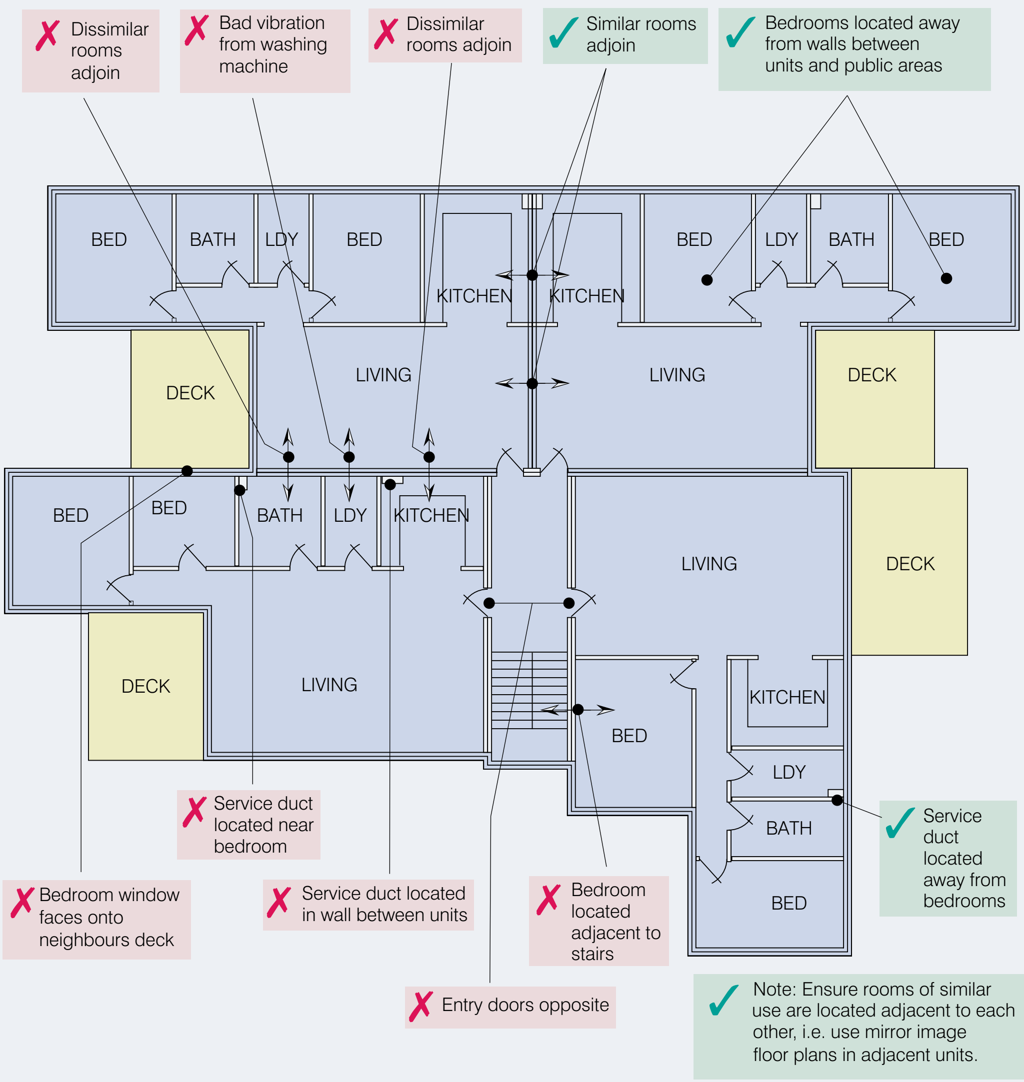


Figure 5: Good and poor sound design practices in building layout – plan view.

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).

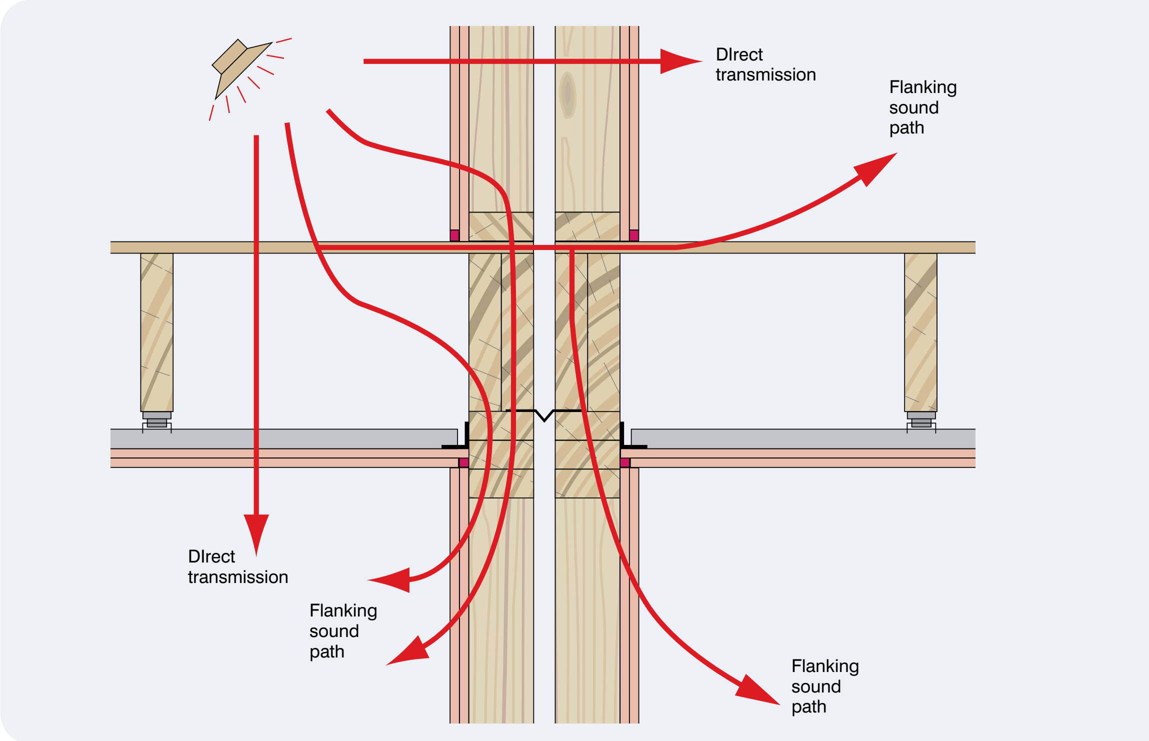


Figure 6: Flanking and direct noise pathways – elevation view.

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.

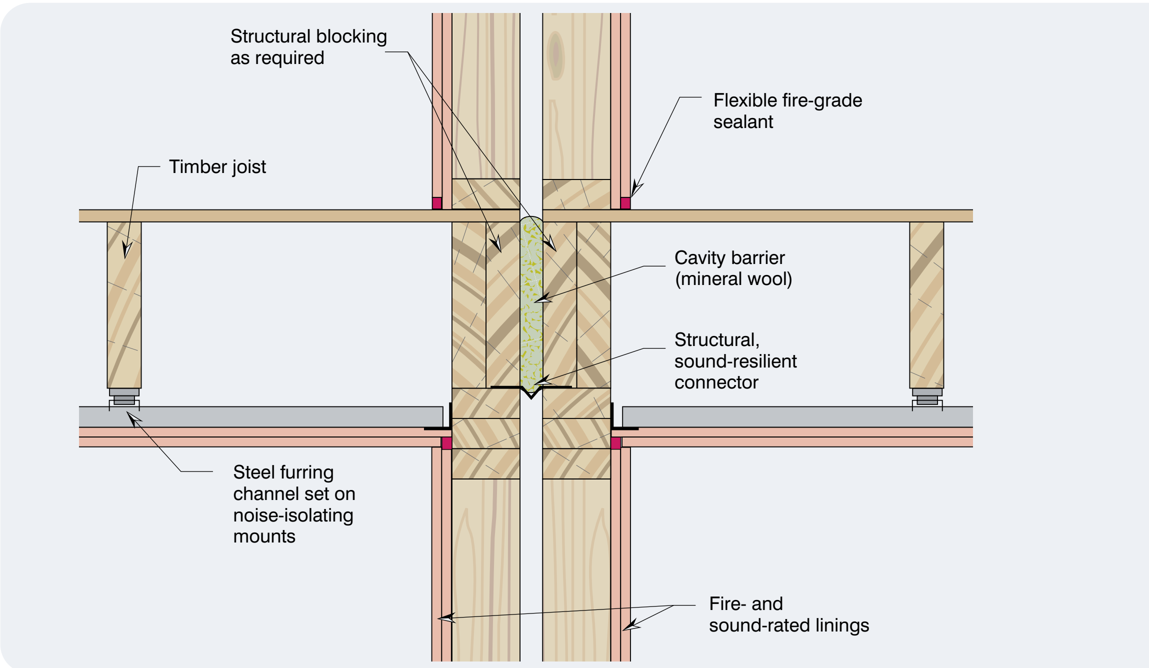


Figure 7: Discontinuous floor joist and floor sheeting – elevation view.

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.

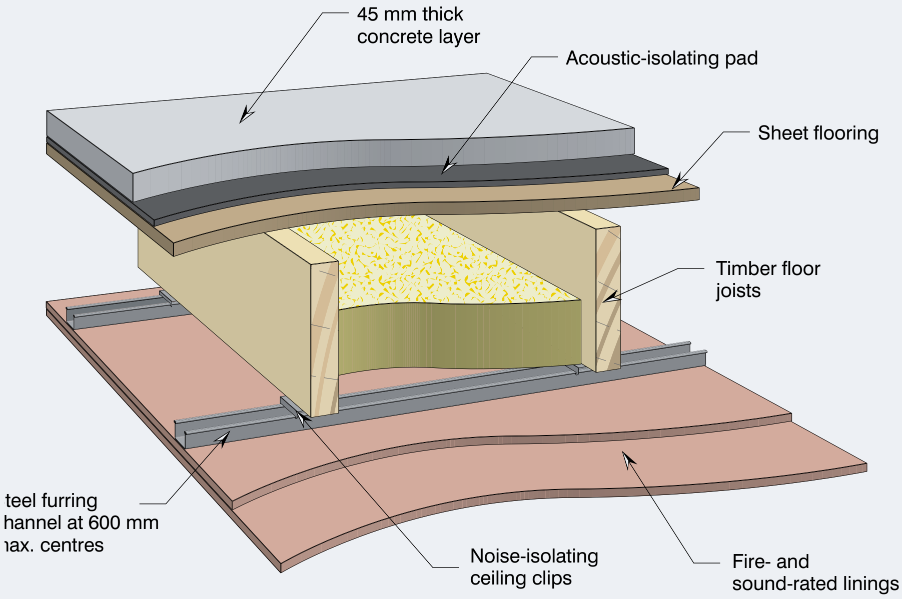


Figure 8: Concrete topping on the floor system with underlying resilient mat.

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.

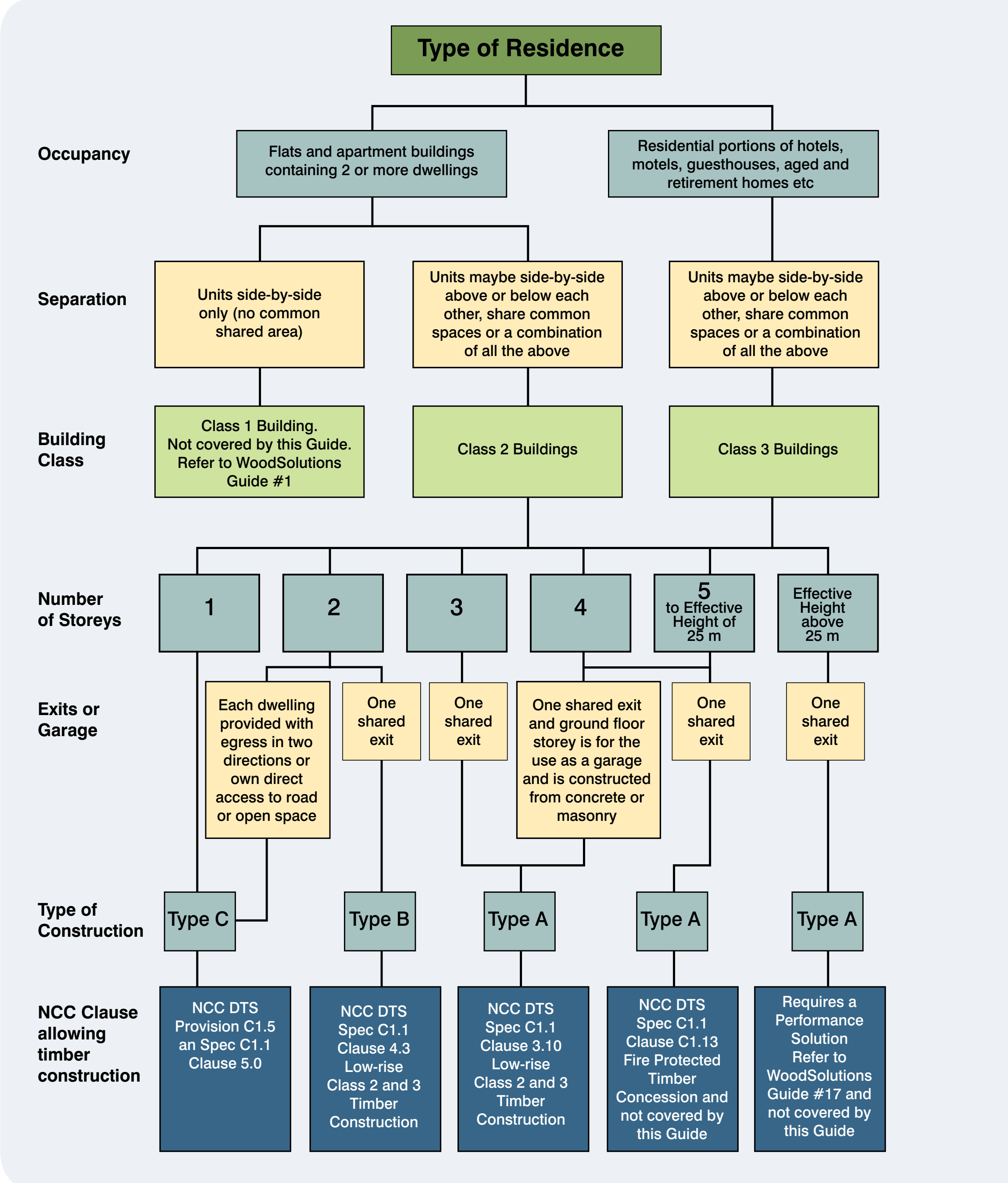


Figure 9: Determine the NCC's type of construction and applicable Deemed-to-Satisfy provision.

4.2.1 Two-Storey Class 2 and 3 Type C Concession

Refer to:
NCC Spec. C1.1.

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.

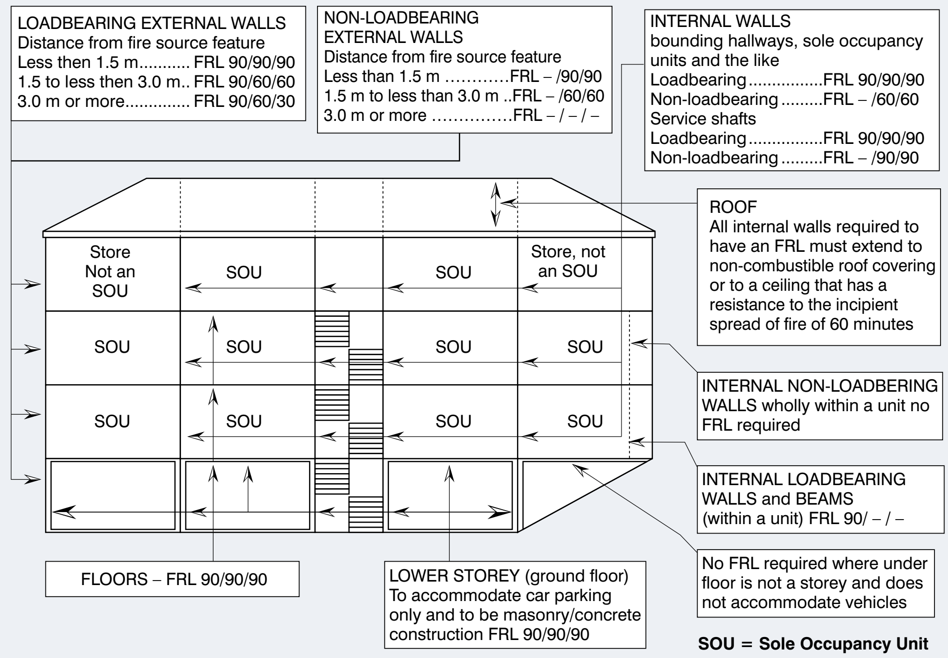


Figure 11a: Type A Construction Deemed-to-Satisfy Requirements – without sprinklers.

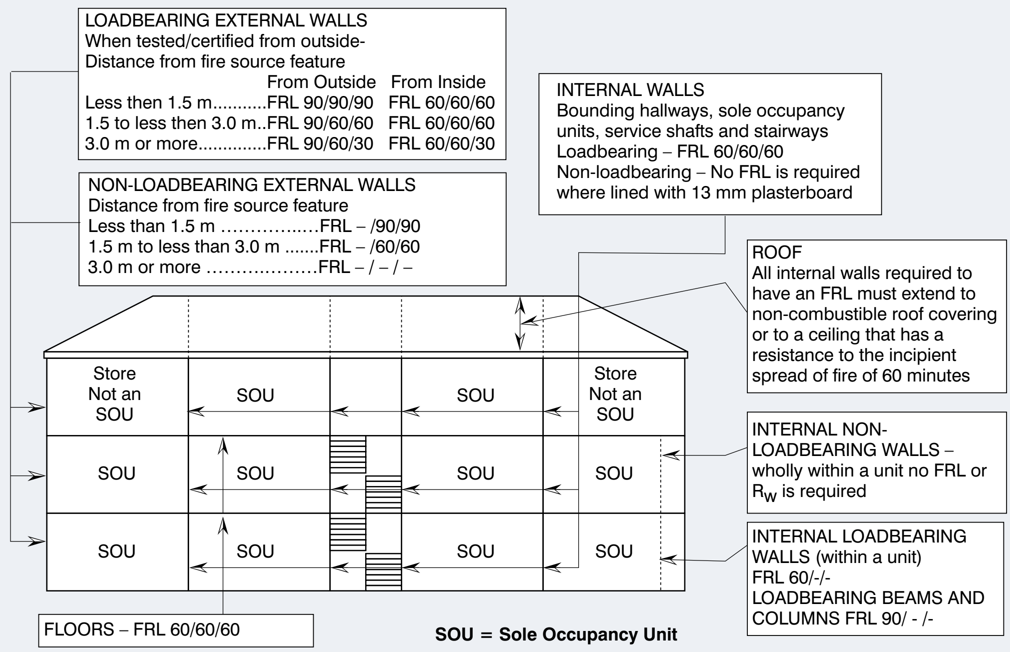


Figure 11b: Type A Construction Deemed-to-Satisfy Requirements – without sprinklers.

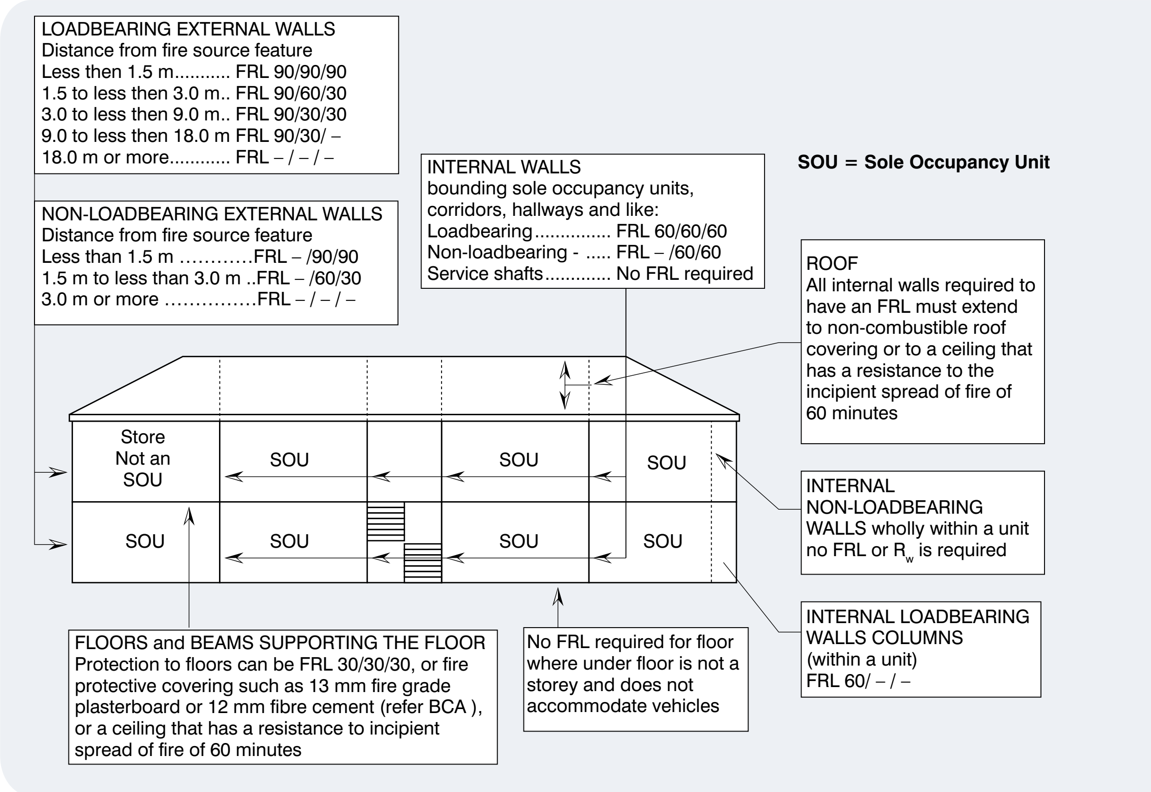


Figure 12a: Type B Construction Deemed-to-Satisfy Requirements – without sprinklers.

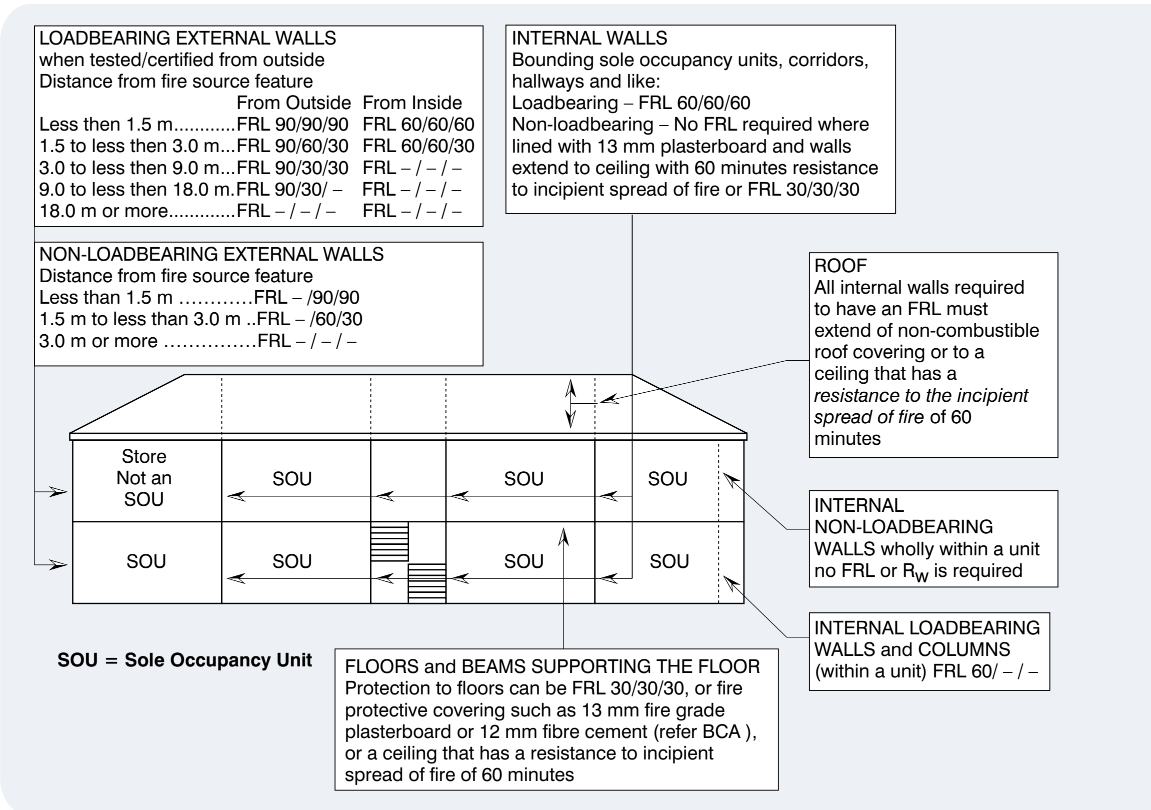


Figure 12b: Type B Construction Deemed-to-Satisfy Requirements – with sprinklers and smoke alarms.

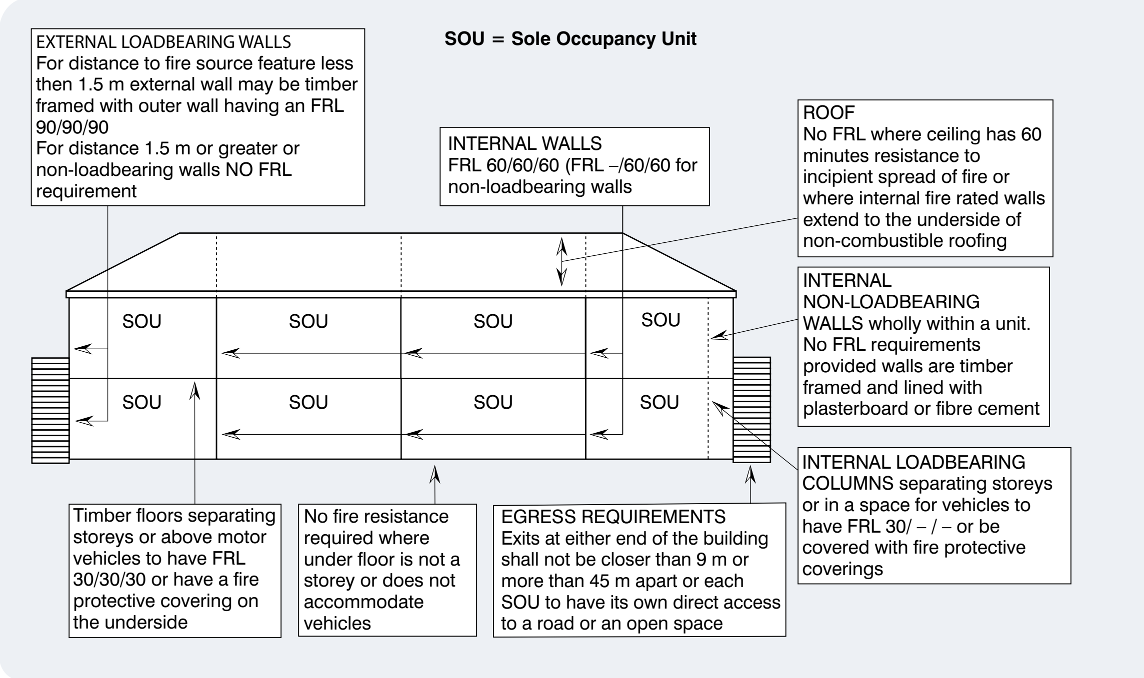


Figure 13: Type C Construction Deemed-to-Satisfy Requirements.

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.

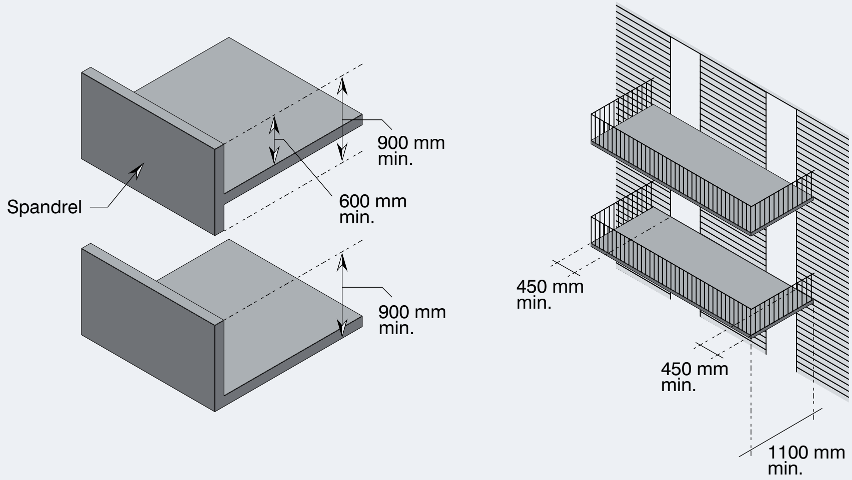


Figure 14: Required dimensions for spandrel panels.

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

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

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

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.

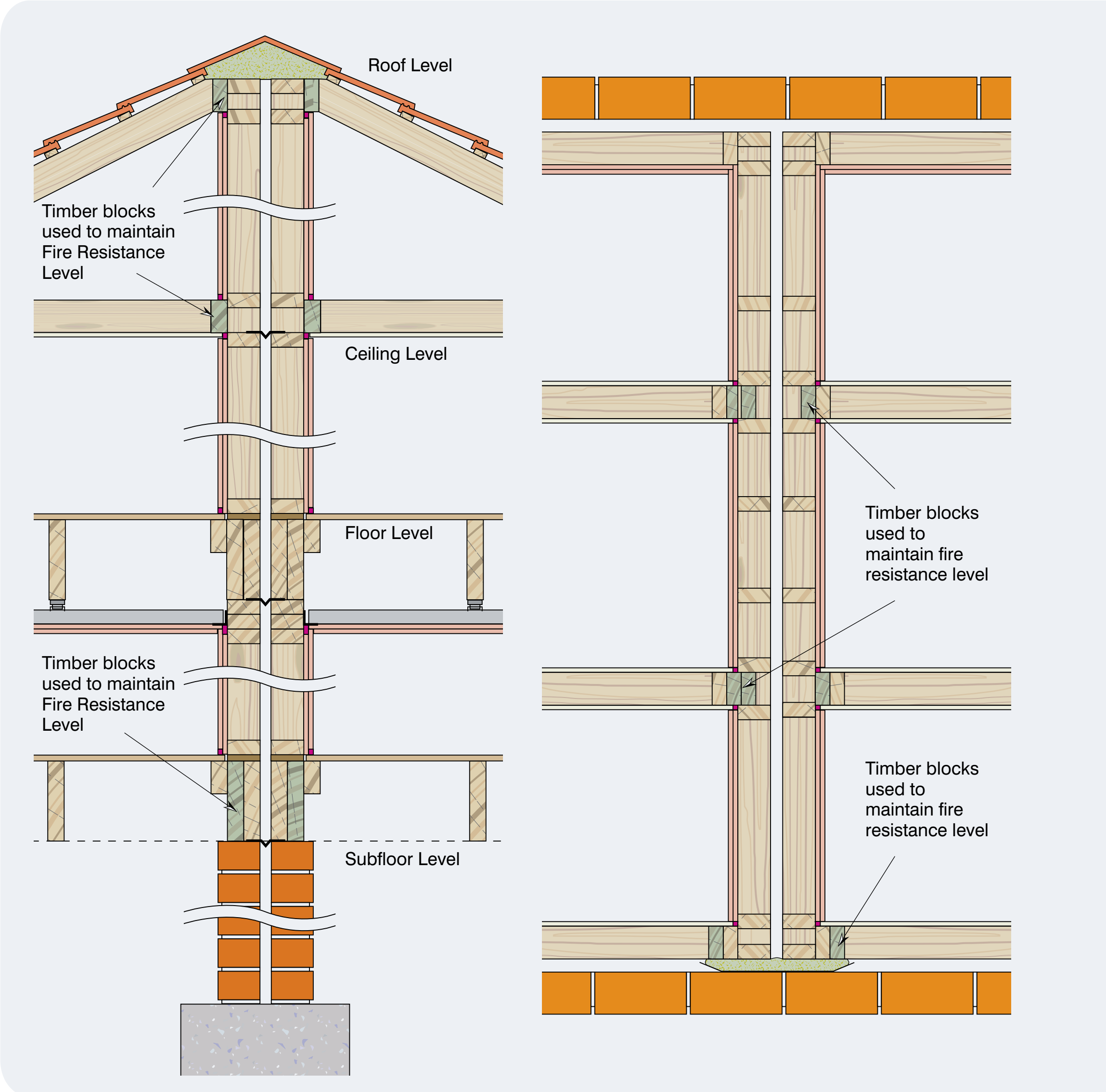


Figure 15: Common locations where solid-timber blocks are used to maintain fire-resistance.

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.

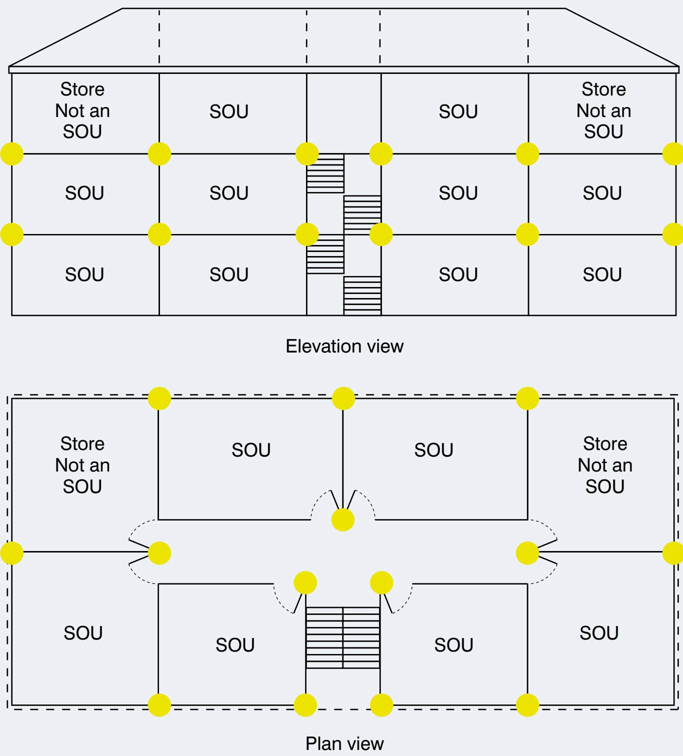


Figure 17: Key locations for cavity barriers.

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.

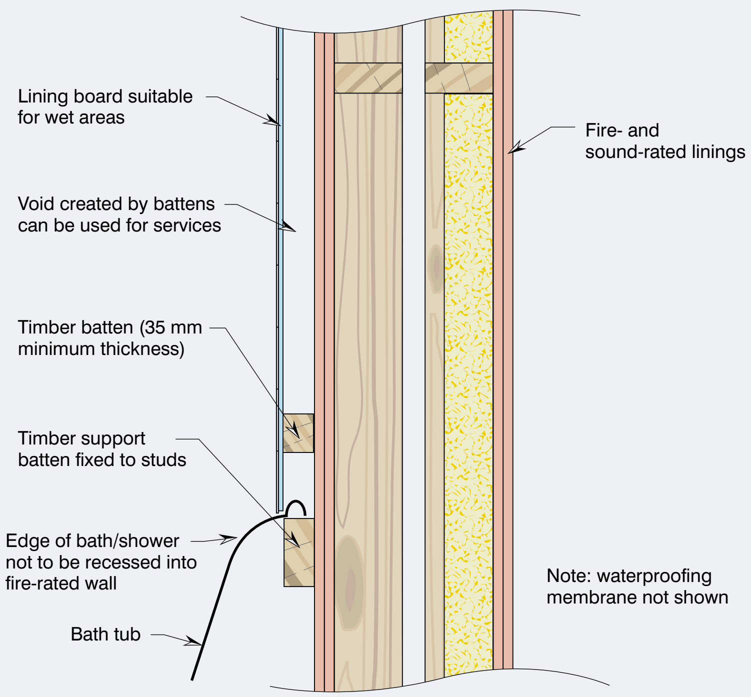


Figure 18: Batten detail for wet area walls – elevation view.

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.

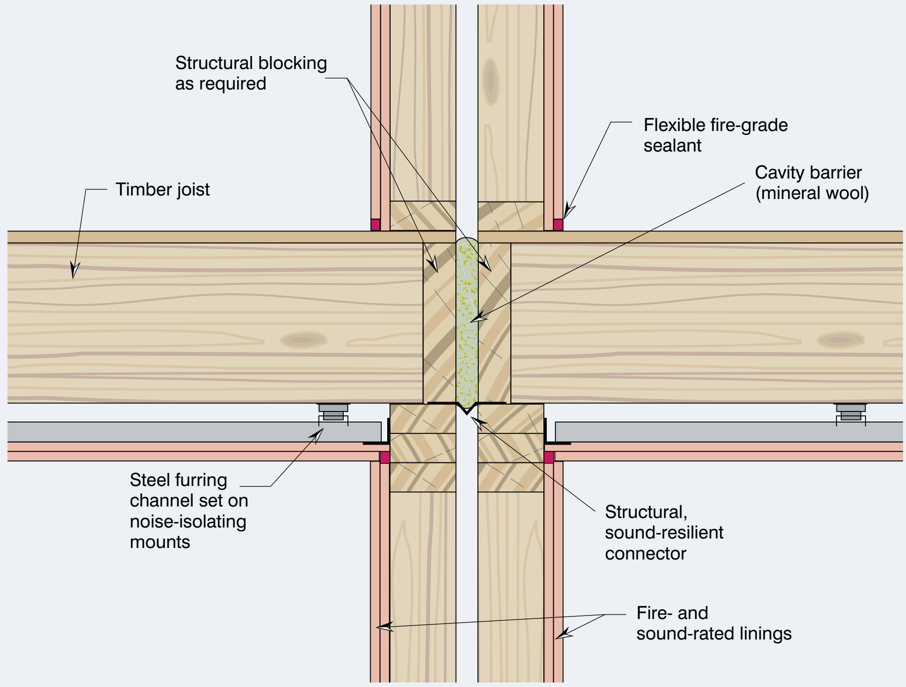


Figure 19: Truncated floor joists and floor sheet to reduce noise transfer.

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.

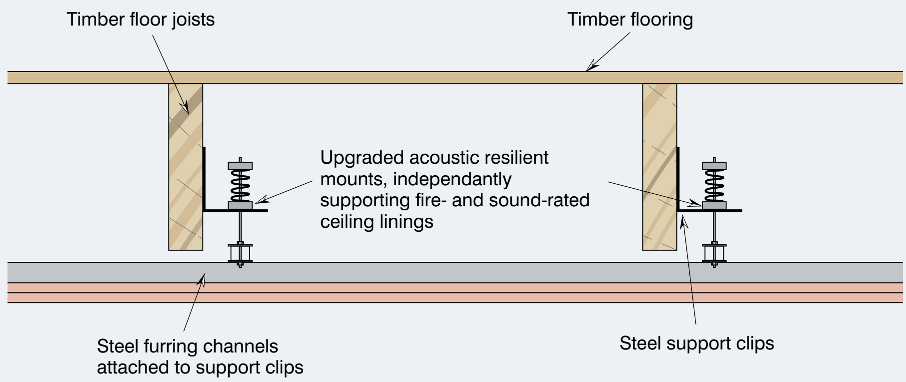


Figure 20: Upgraded sound-resilient ceiling mounts – elevation view.

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.

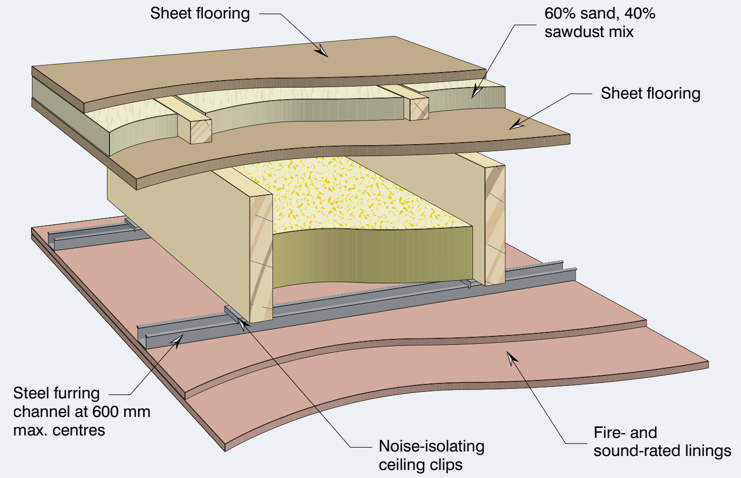


Figure 21: Adding mass to the floor system through the use of a sand/gravel top layer.

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.

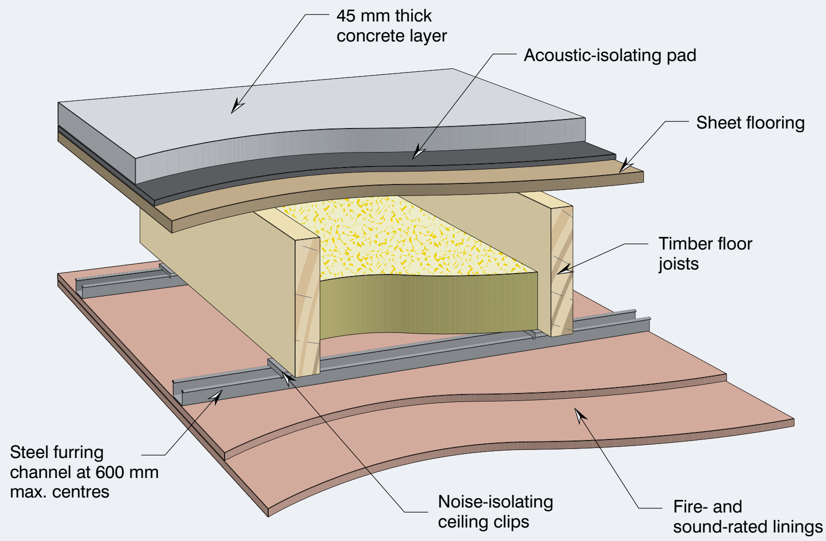


Figure 22: Adding mass to the floor system through the use of concrete topping.

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).

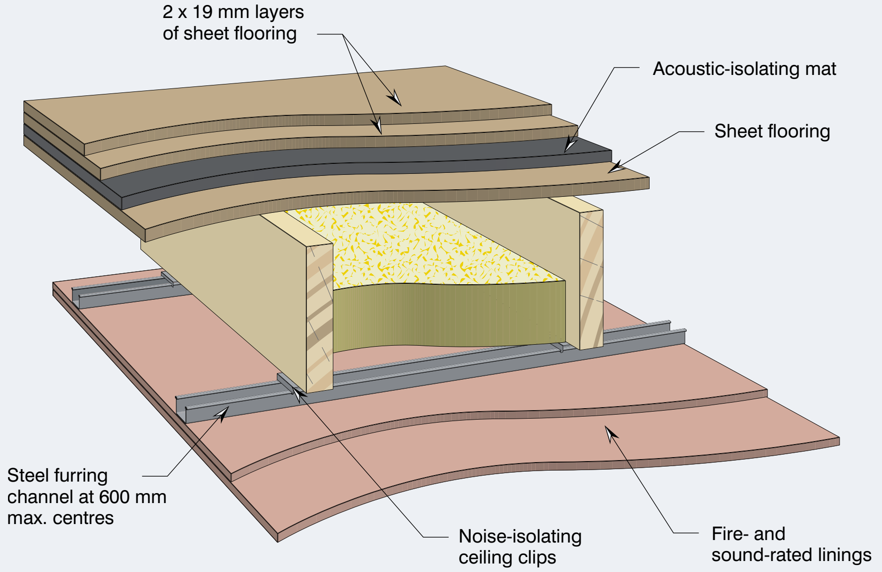


Figure 23: Adding mass to the floor system through the use of additional floor sheets.

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).

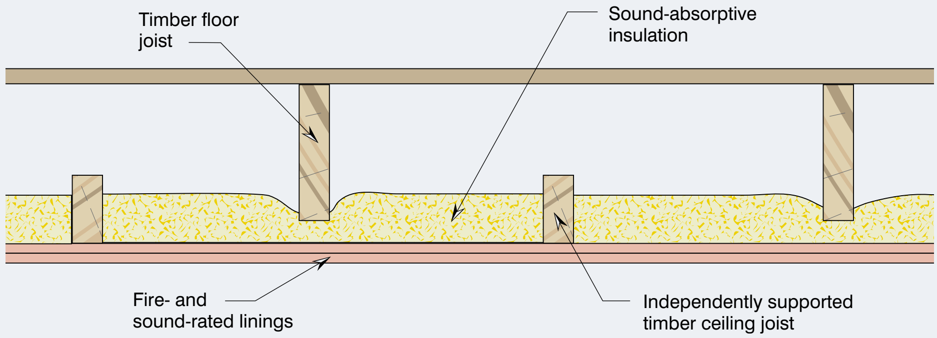


Figure 24: Separate ceiling and floor joist structures.

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!

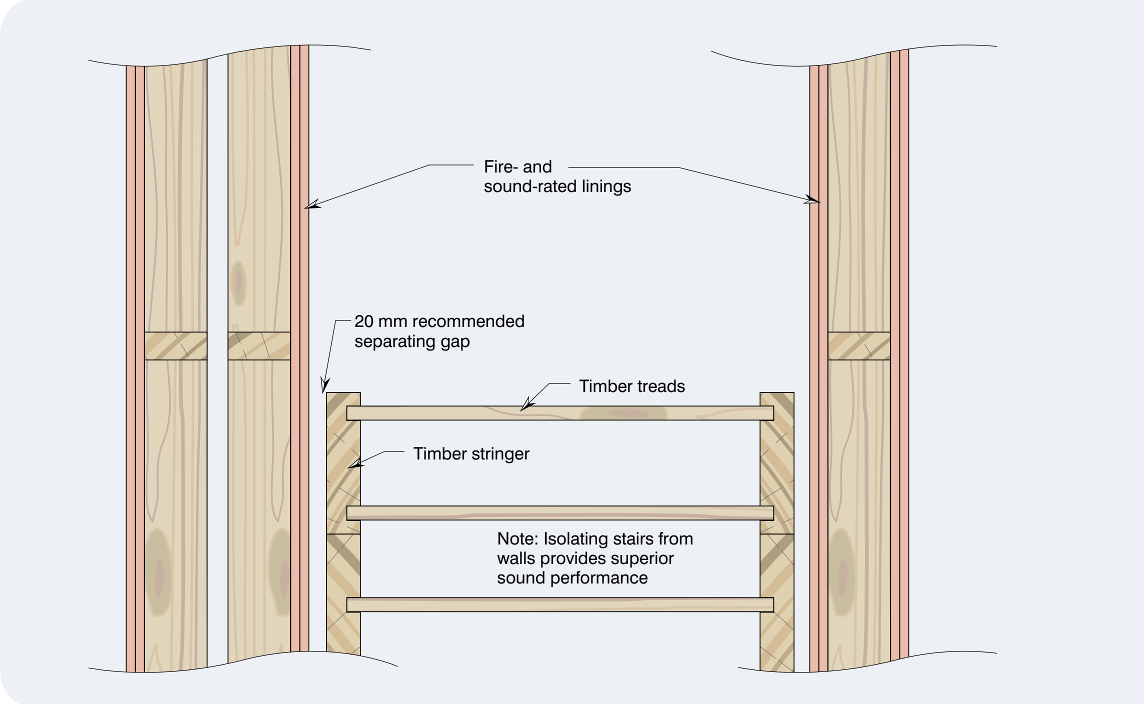


Figure 25: Isolated support for stairs – elevation view.

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).

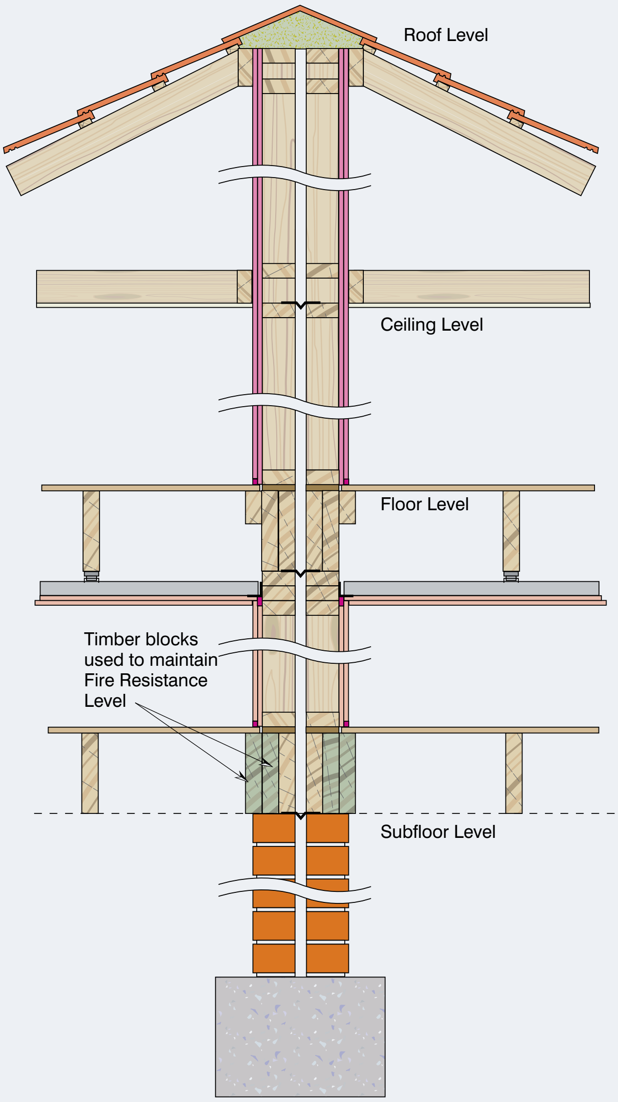


Figure 26: Main elements that make up a fire- and sound-rated timber-framed building – elevation view.

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.

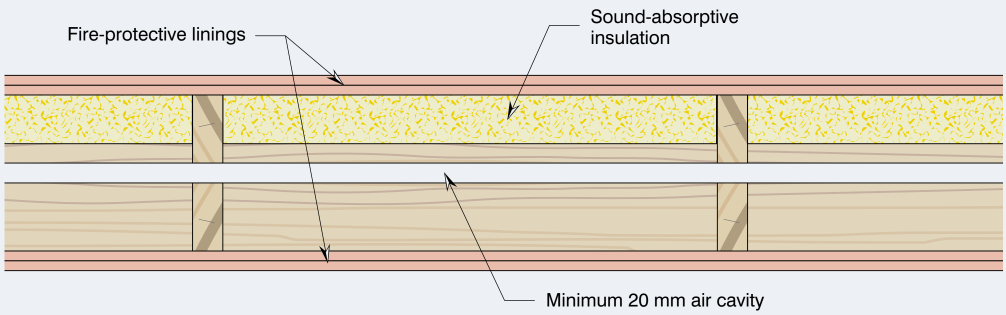


Figure 27: Fire- and sound-rated double stud timber wall – plan view.

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.

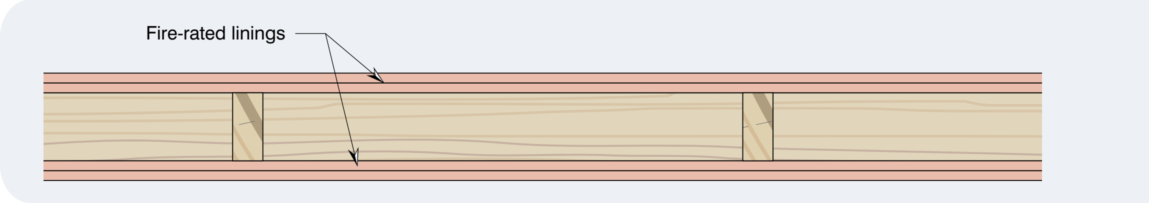


Figure 28: Fire-rated internal timber stud wall – plan view.

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.

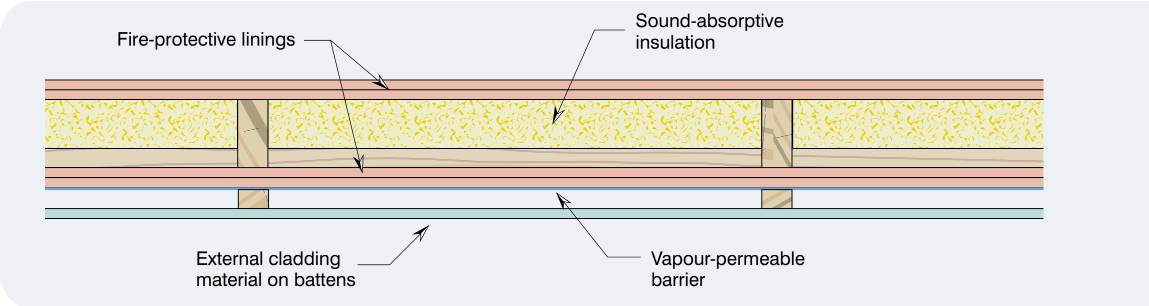


Figure 29: Fire-rated external timber stud wall – plan view.

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

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

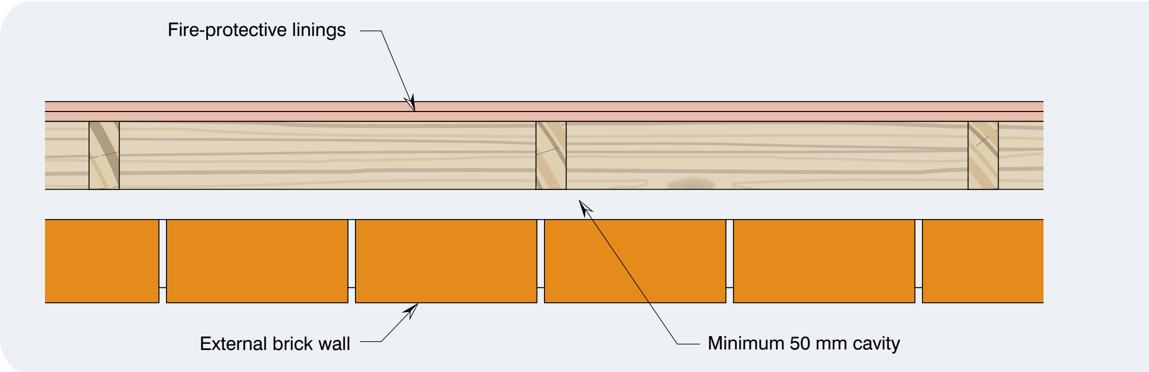


Figure 30: Fire-rated brick veneer wall – plan view.

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.

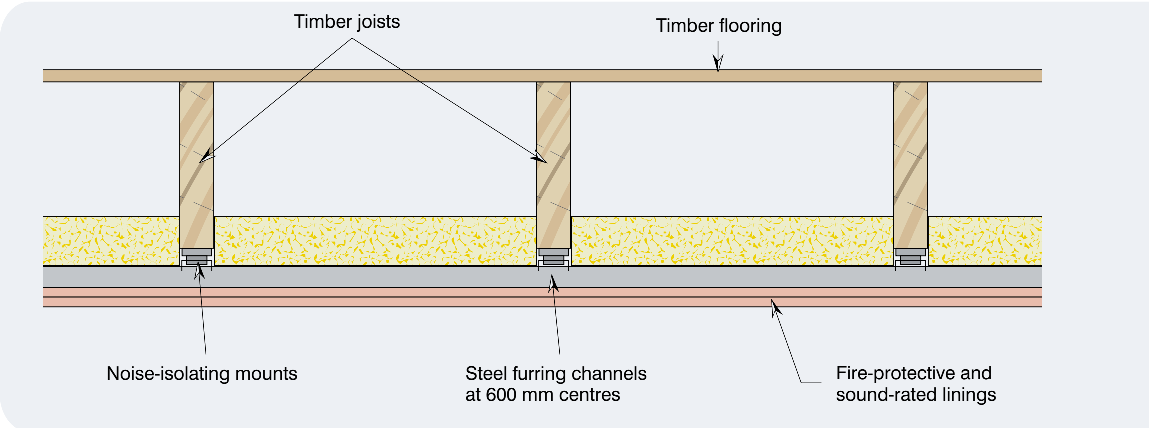


Figure 31: Fire- and sound-rated timber-framed floor – elevation view.

Refer to:
NCC C3.16.

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

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.

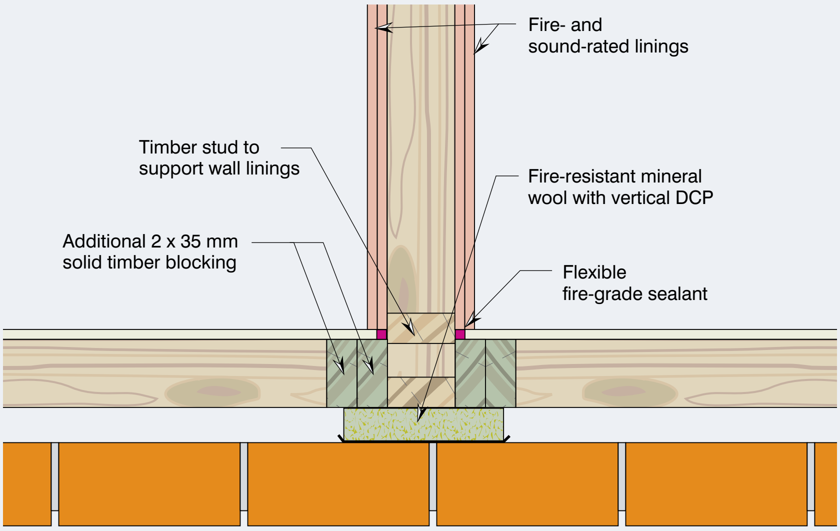


Figure 32: Fire-resistant mineral wool used to close a gap – plan view.

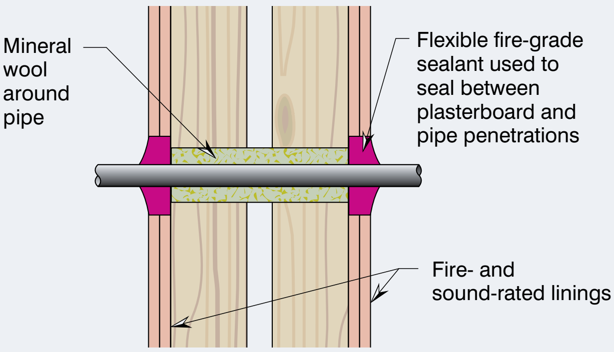


Figure 33: Fire-resistant sealant used to close a gap.

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.

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

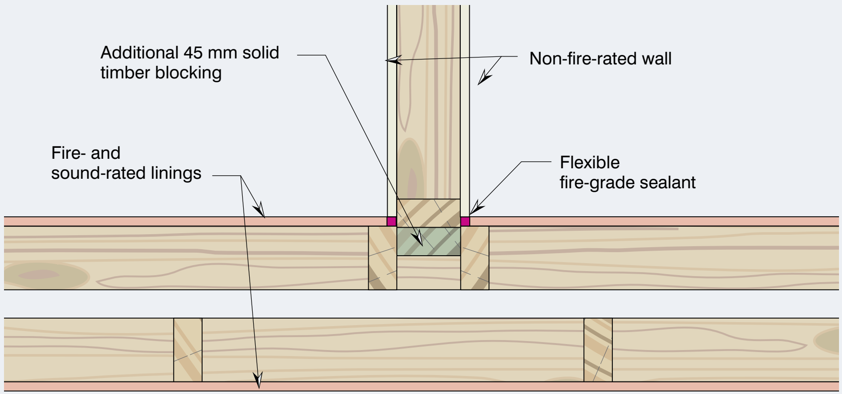


Figure 34: Non-fire-rated wall abutting 60 minutes fire-rated walls using timber blocks – plan view.

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).

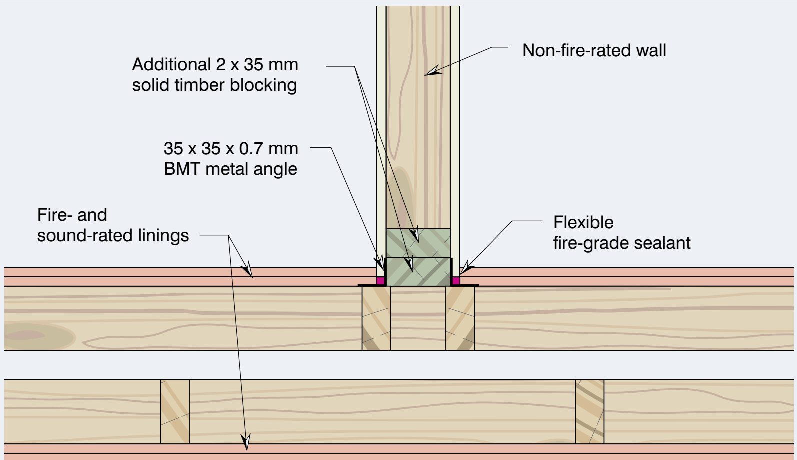


Figure 35: Timber sacrificial blocks used to close a gap for a 90 minutes system – plan view.

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.

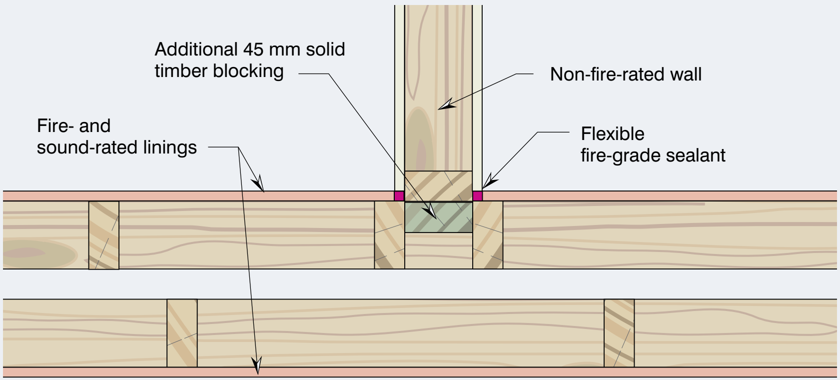


Figure 36: Non-fire-rated walls abutting fire- and sound-rated walls using timber blocks – FRL 60 minutes.

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.

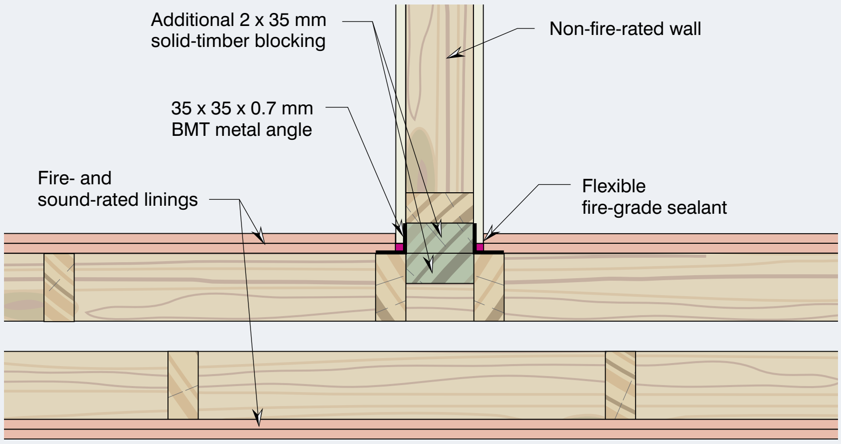


Figure 37: Non-rated wall abutting a fire- and sound-rated wall using metal angles – FRL 90 minutes – plan view.

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).

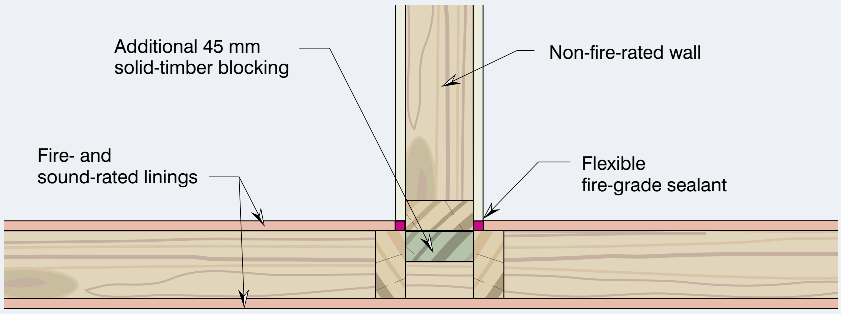


Figure 38: Non-rated wall abutting fire-rated wall using timber blocks – FRL 60 minutes – plan view.

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

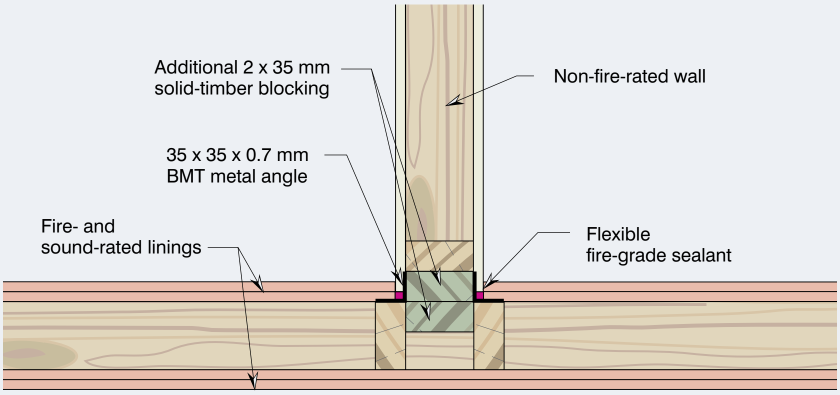


Figure 39: Non-rated wall abutting fire-rated wall using timber blocks and 35 mm metal angle – FRL 90 minutes – plan view.

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.

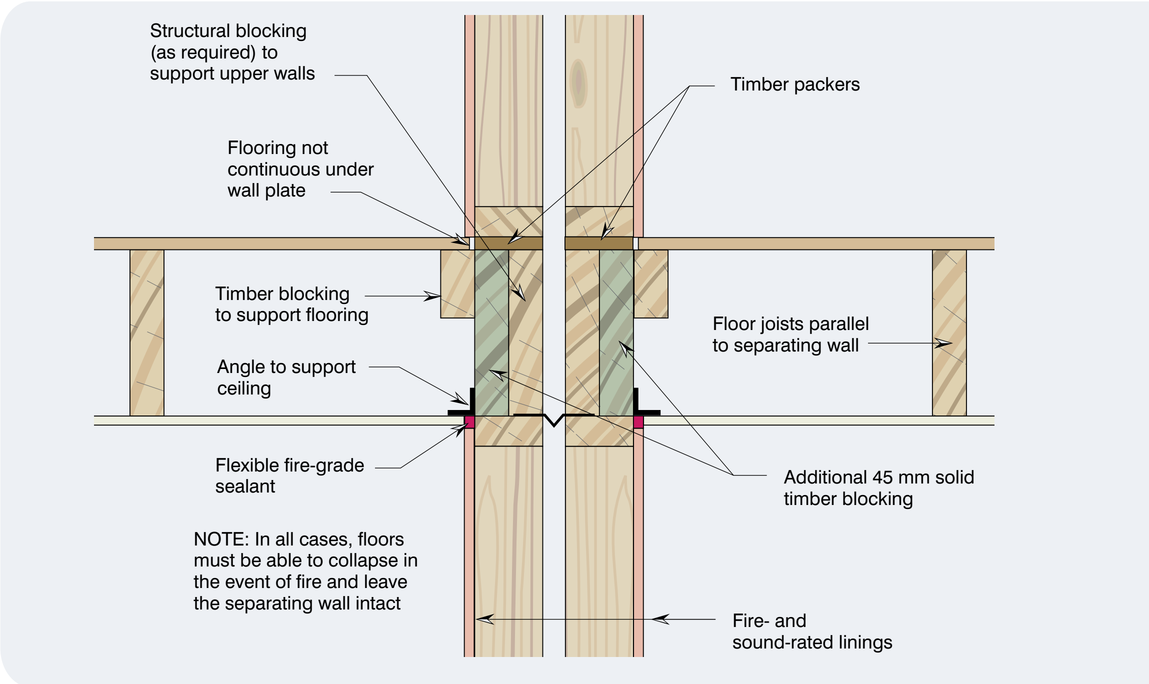


Figure 40: Joist parallel to the wall, wall stud not continuous through junction – FRL 60 minutes – elevation view.

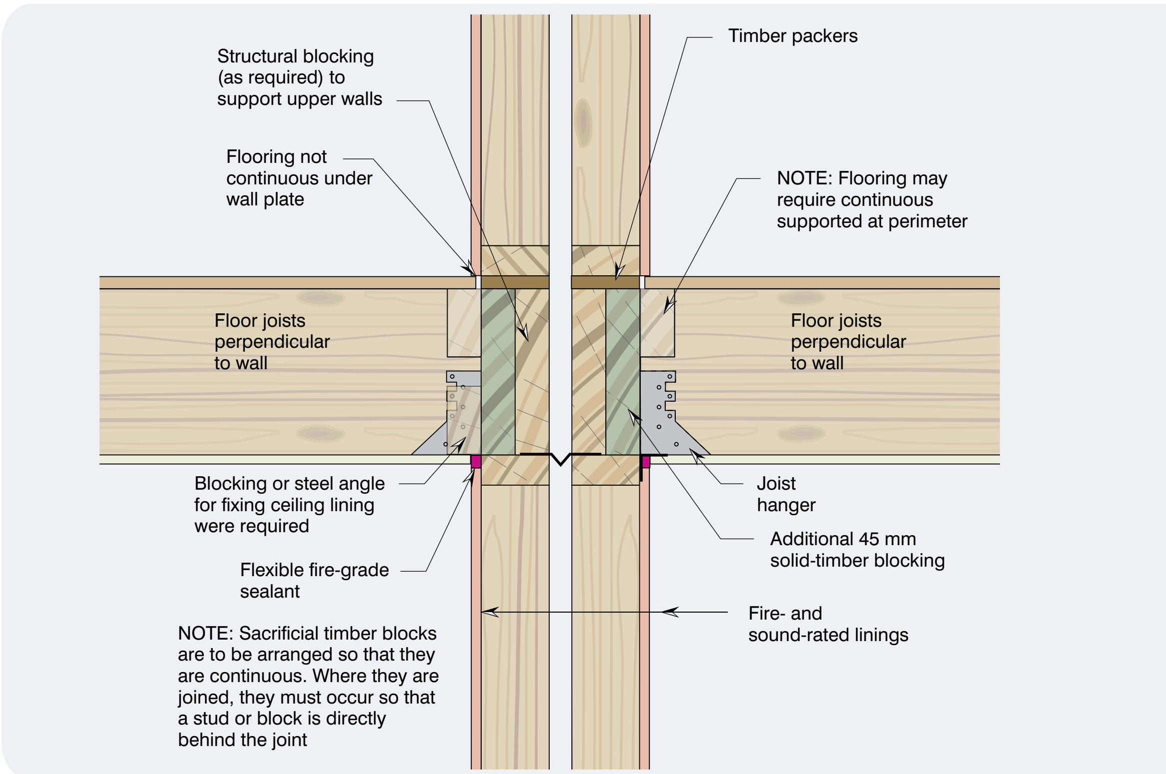


Figure 41: Joist perpendicular to the wall, wall stud not continuous through junction – FRL 60 minutes – elevation view.

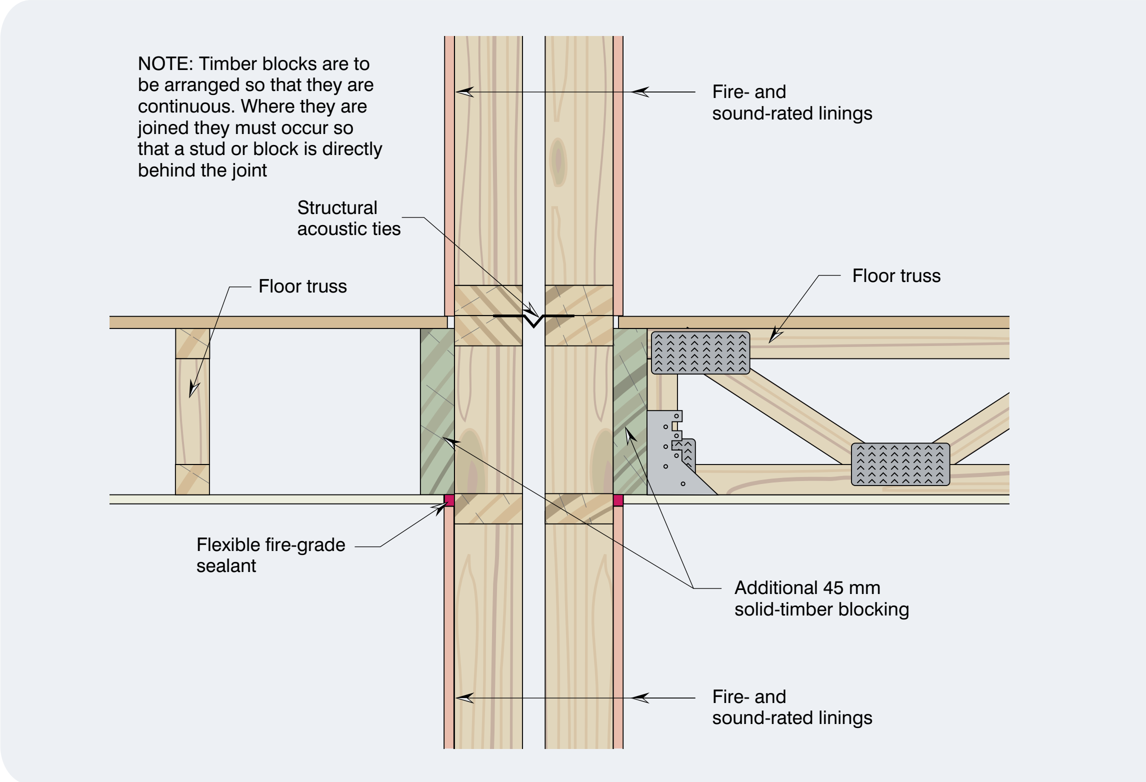


Figure 42: Joist parallel and perpendicular to the wall, wall stud continuous through junction – FRL 60 minutes only – elevation view.

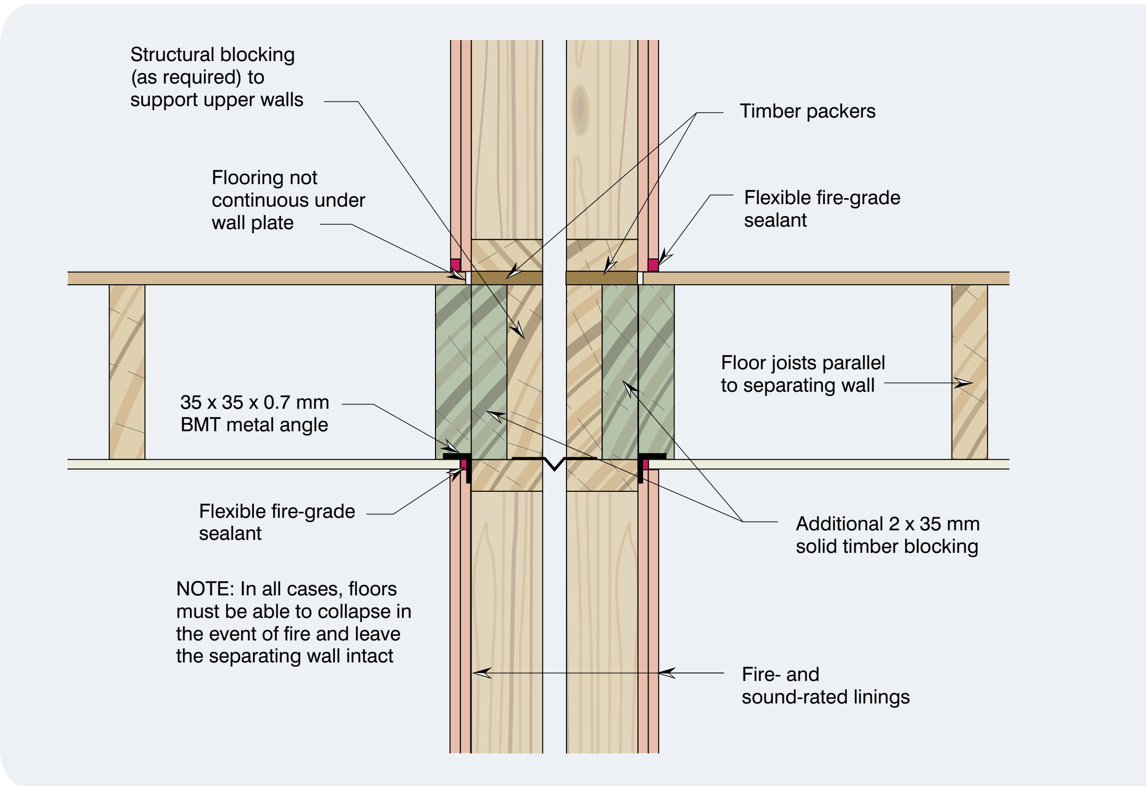


Figure 43: Joist parallel to the wall, wall stud not continuous through junction – FRL 90 minutes – elevation view.

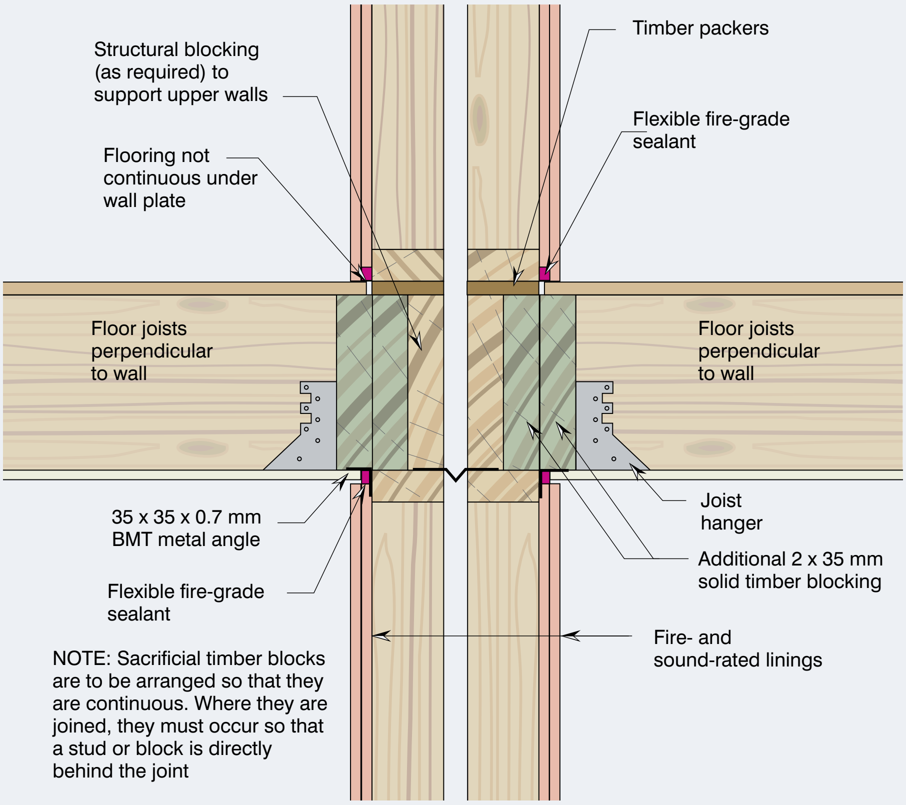


Figure 44: Joist perpendicular to wall, wall stud not continuous through junction – FRL 90 minutes – elevation view.

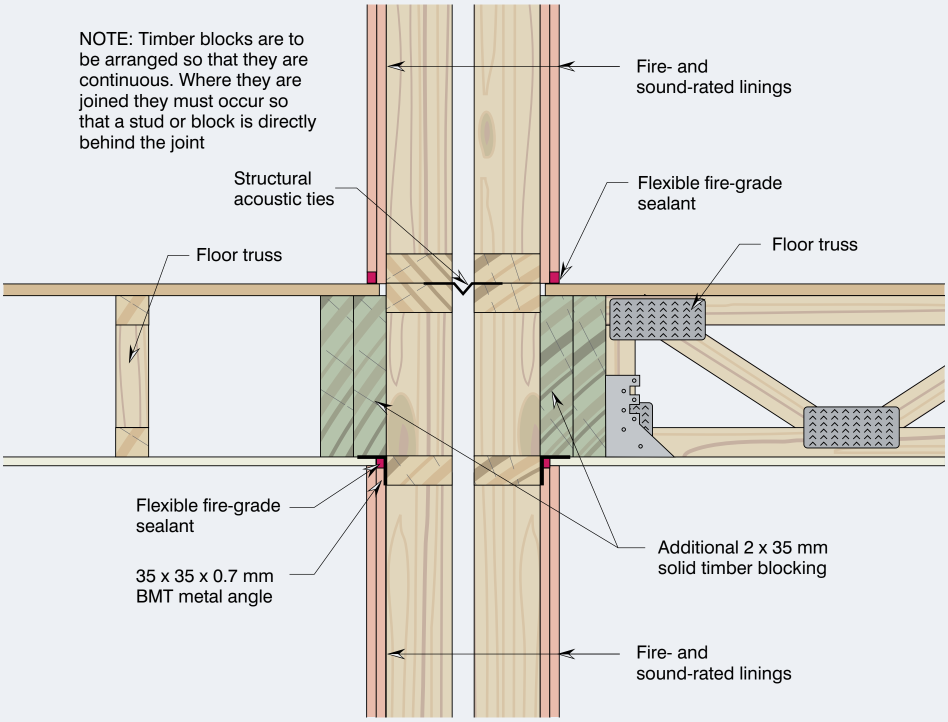


Figure 45: Joist parallel and perpendicular to the wall, wall stud continuous through junction – FRL 90 minutes only – elevation view.

Mineral wool fills many needs and spaces.

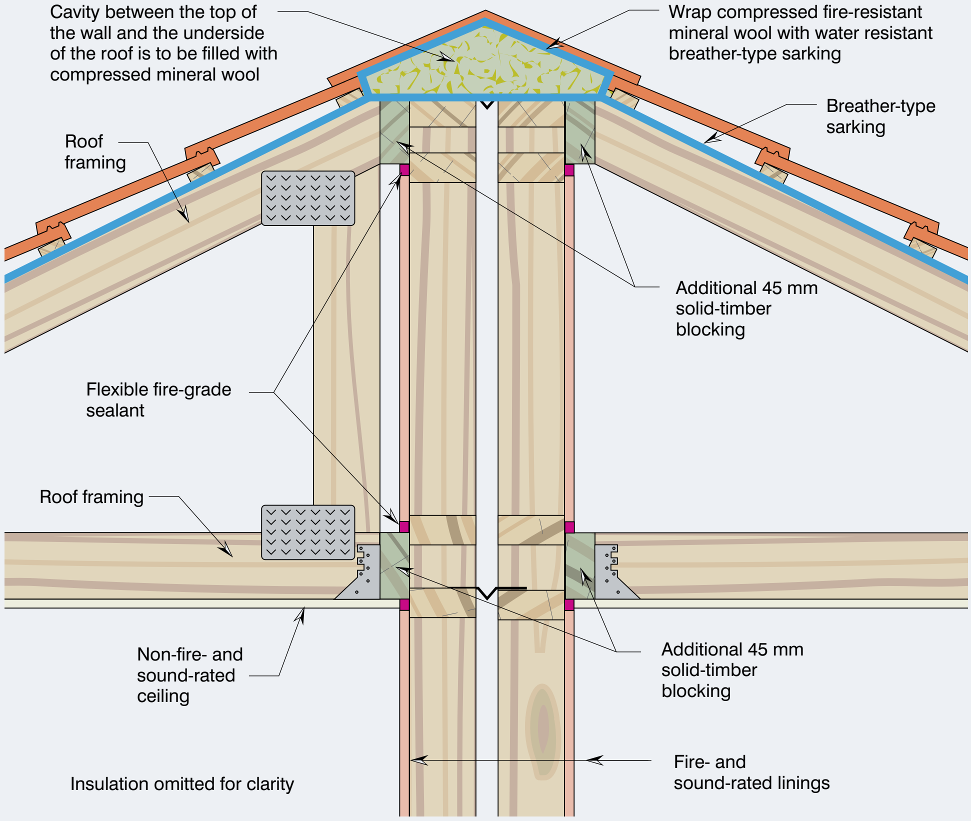


Figure 46: Timber blocks used to maintain fire-resistance – FRL 60 minutes in roof void – elevation view.

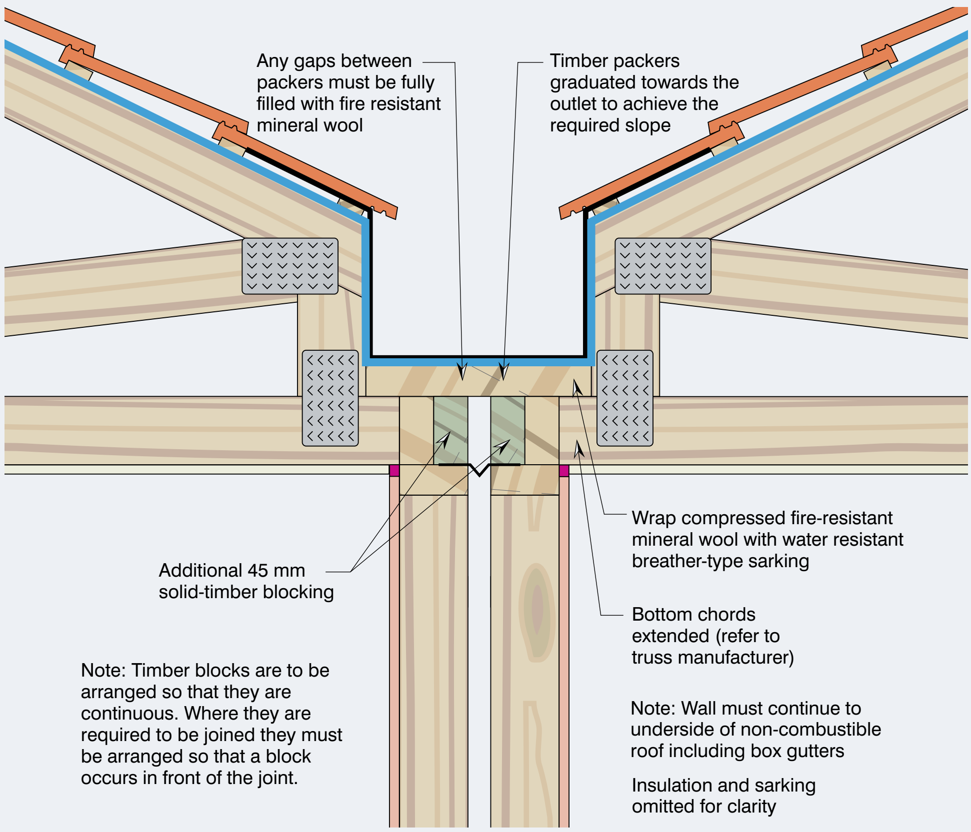


Figure 47: Timber blocks used to maintain fire-resistance – FRL 60 minutes under box gutter – elevation view.

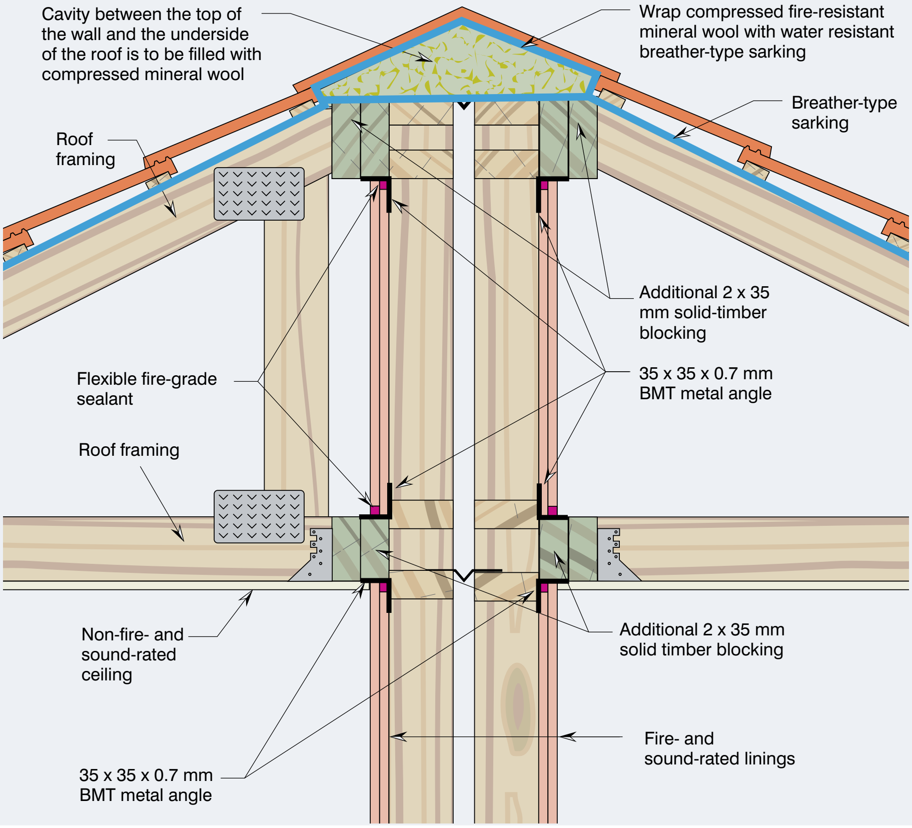


Figure 48: Timber blocks used to maintain fire-resistance – FRL 60 minutes in roof void – elevation view.

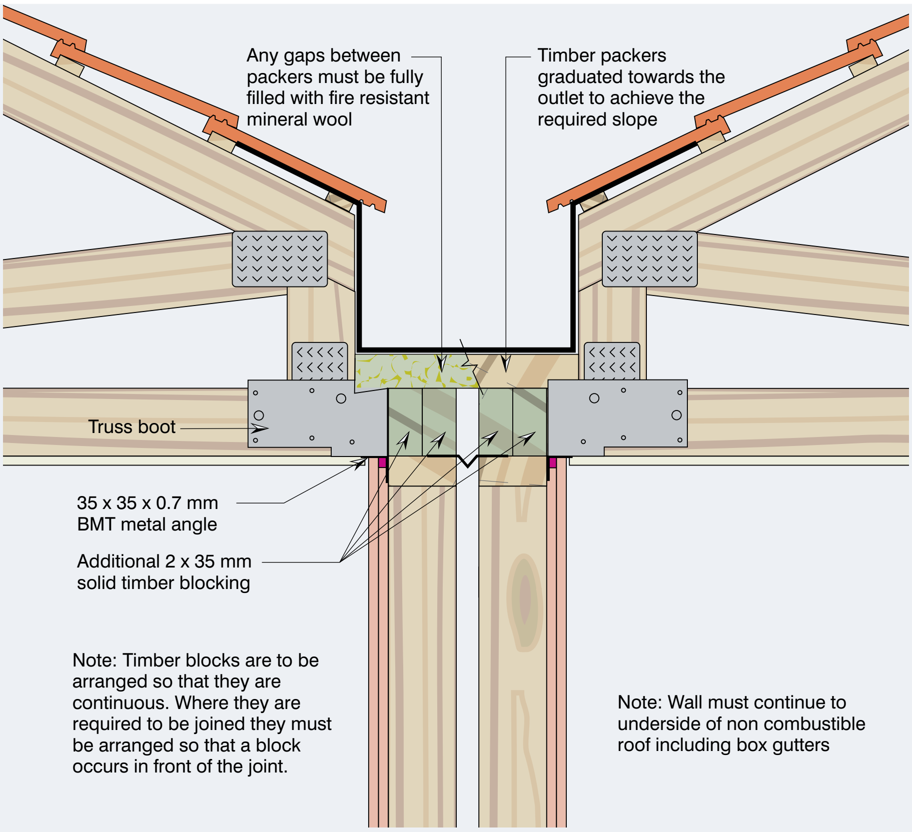


Figure 49: Timber blocks used to maintain fire-resistance – FRL 90 minutes under box gutter – elevation view.

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).

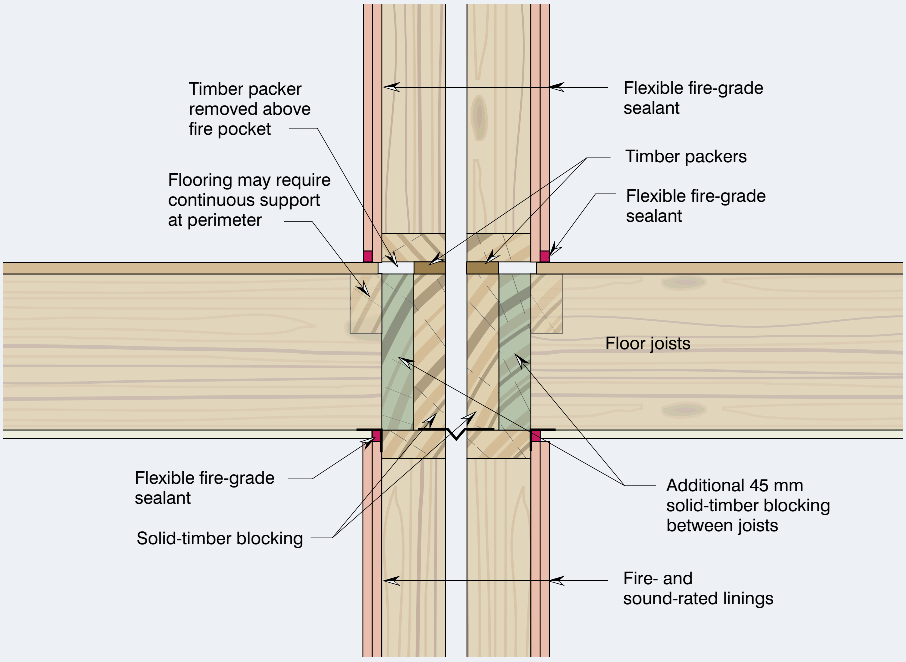


Figure 50: Pockets created in separating wall to accommodate floor joists – FRL 60 minutes only – elevation view.

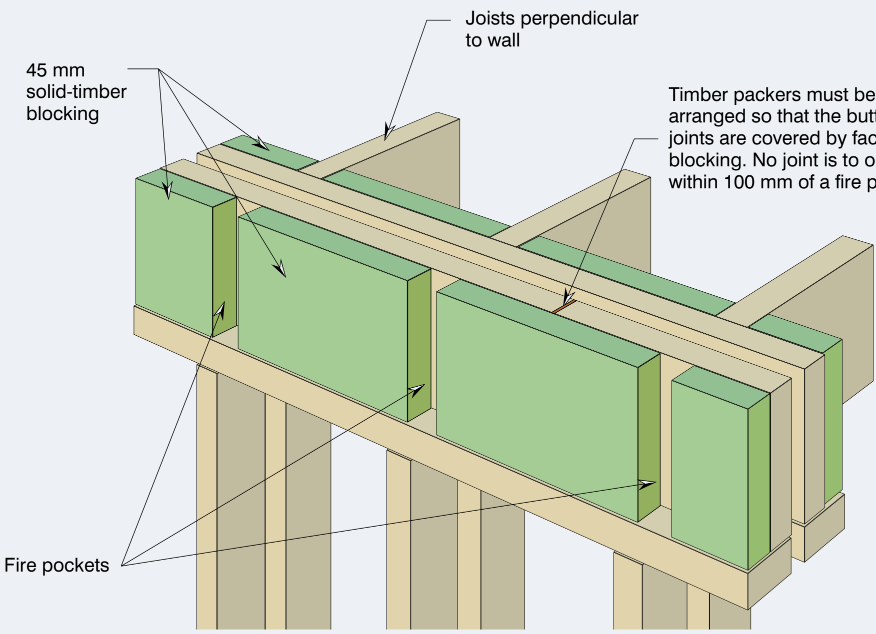


Figure 51: Pockets created in separating wall to accommodate floor joists – FRL 60 minutes only – perspective view.

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.

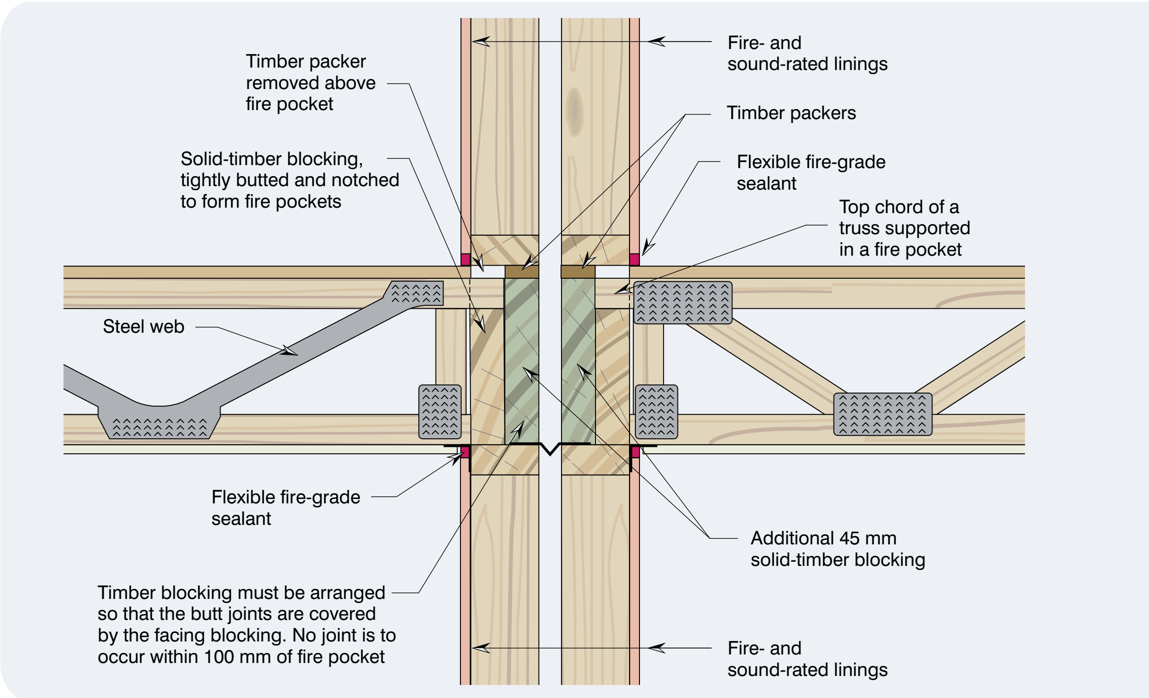


Figure 52: Floor-truss top chord supported in the pocket – FRL 60 minutes – elevation view.

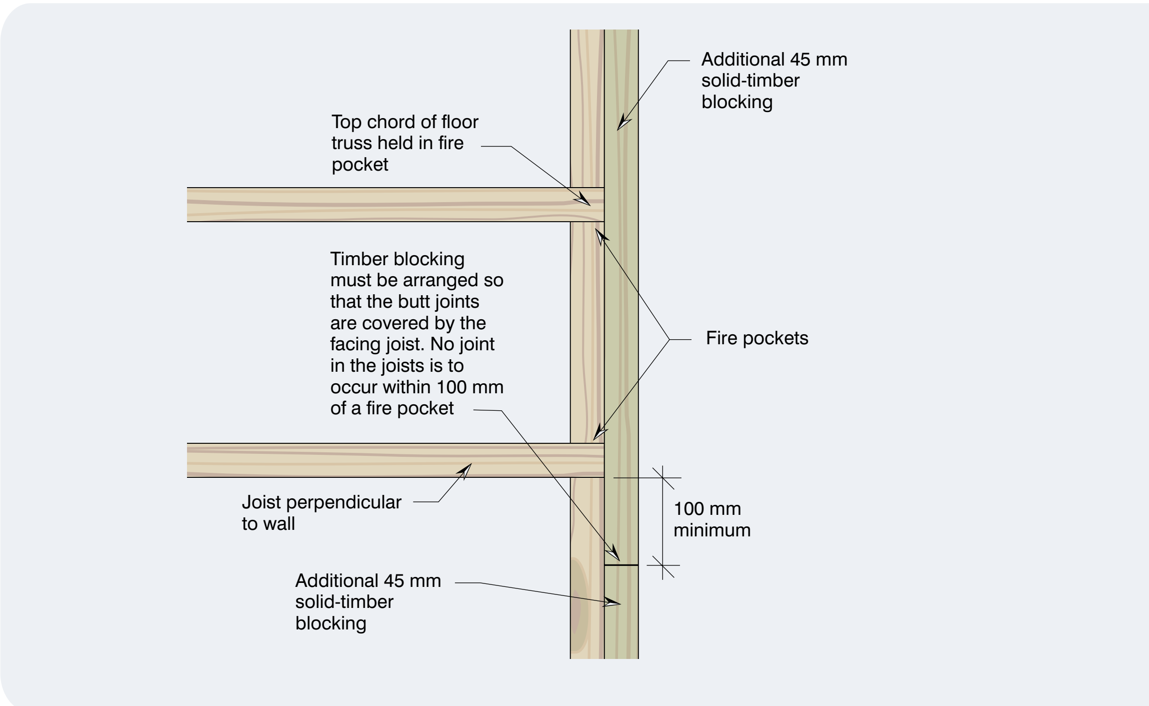


Figure 53: Floor-truss top chord supported in the pocket – FRL 60 minutes – plan view.

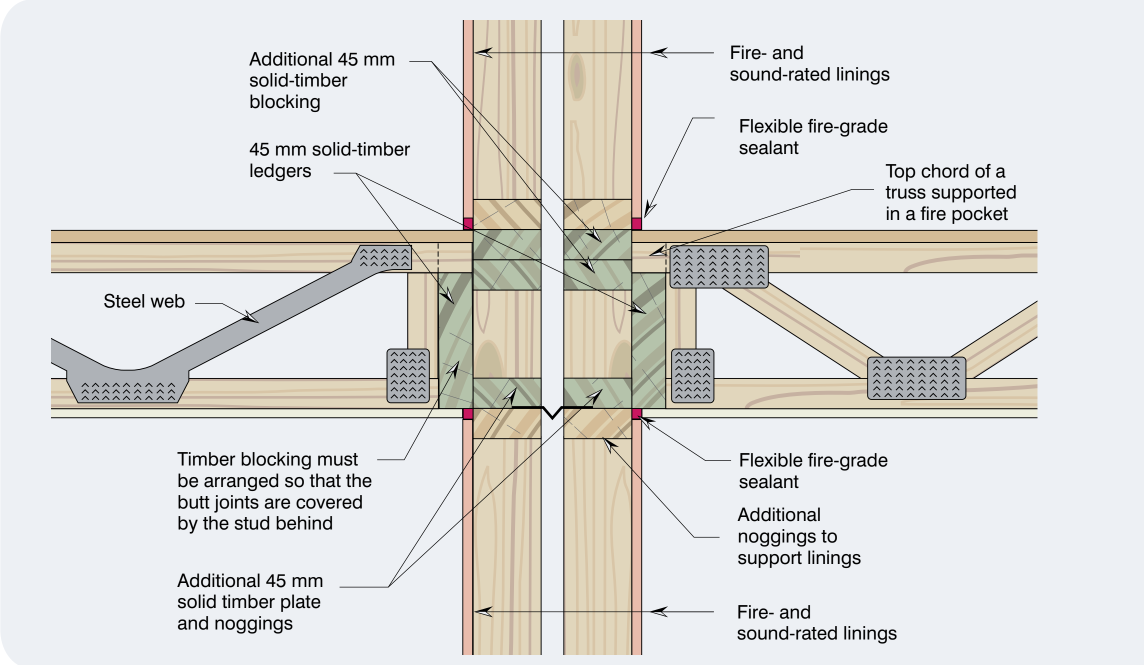


Figure 54: Alternative floor-truss top chord support – FRL 60 minutes – elevation view.

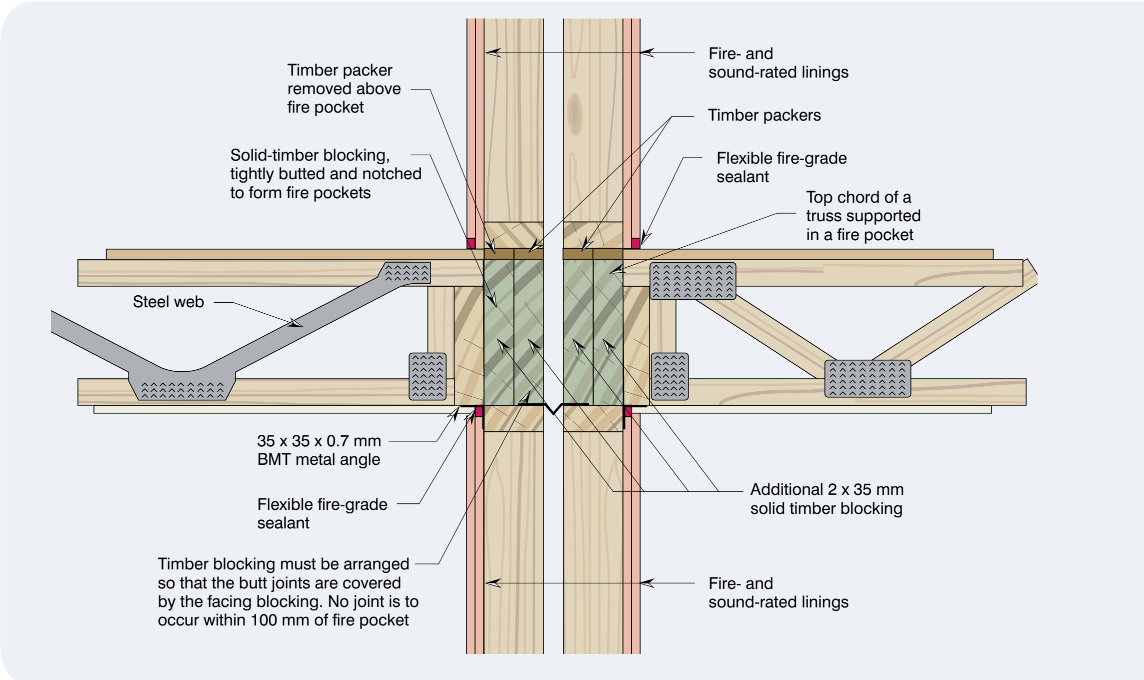


Figure 55: Floor-truss top chord supported in pocket – FRL 90 minutes – elevation view.

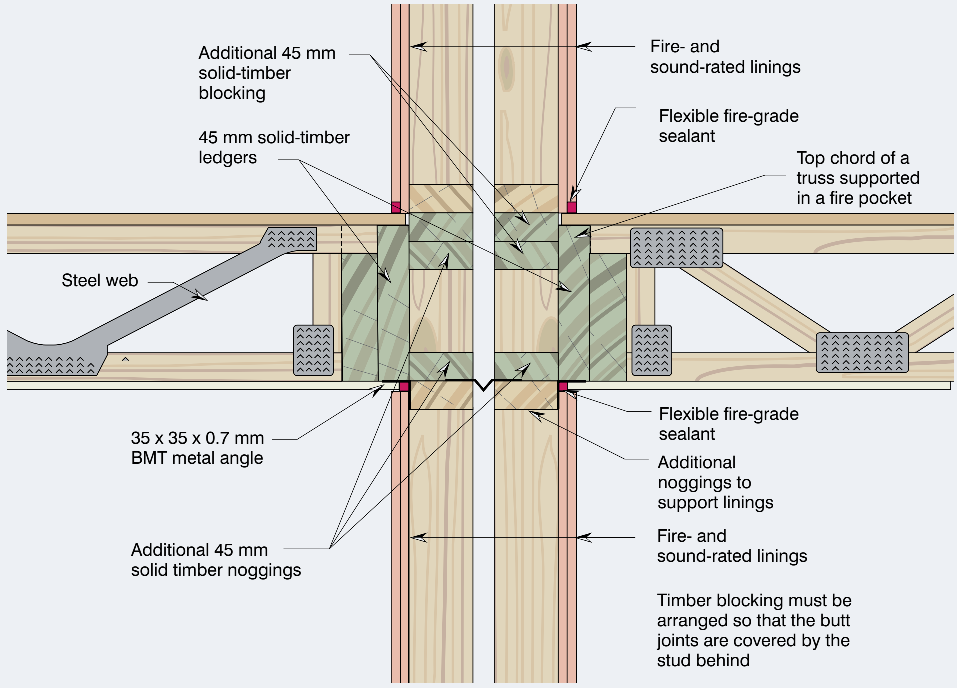


Figure 56: Alternative floor-truss top chord support – FRL 90 minutes – elevation view.

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.

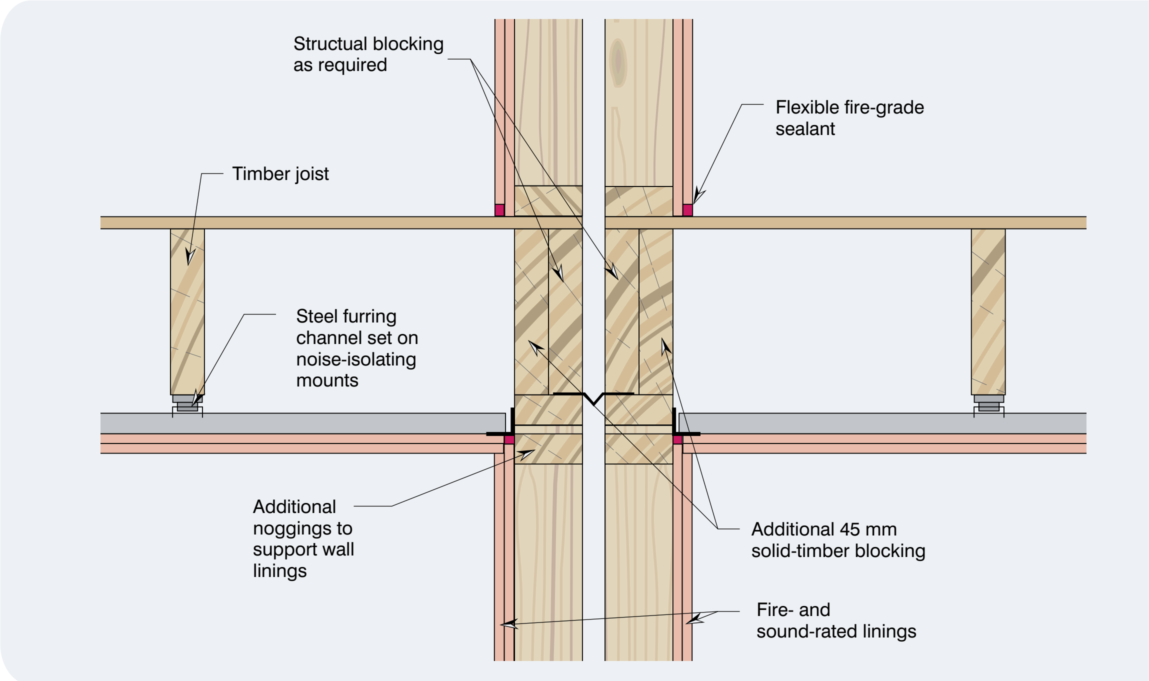


Figure 57: Typical junction of elements with the same FRL – fire-rated floors abutting fire-rated walls – elevation view.

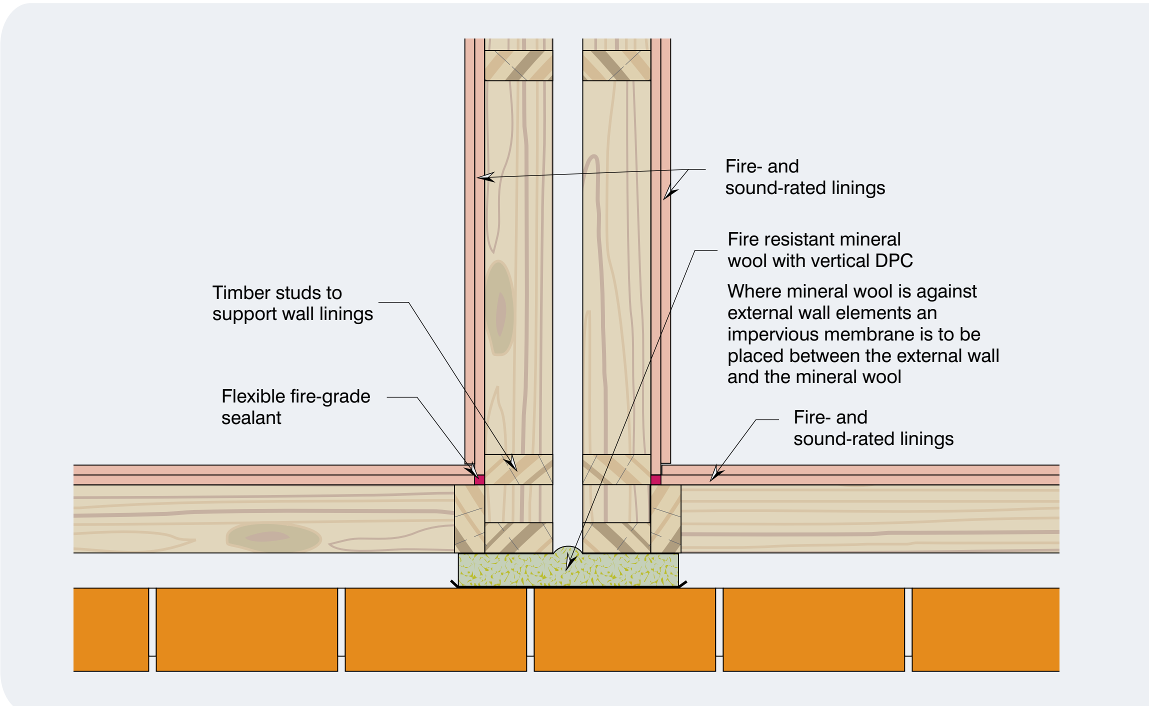


Figure 58: Typical junction of elements with the same FRL – fire-rated bounding wall abutting fire-rated external wall – plan view.

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

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

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

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.

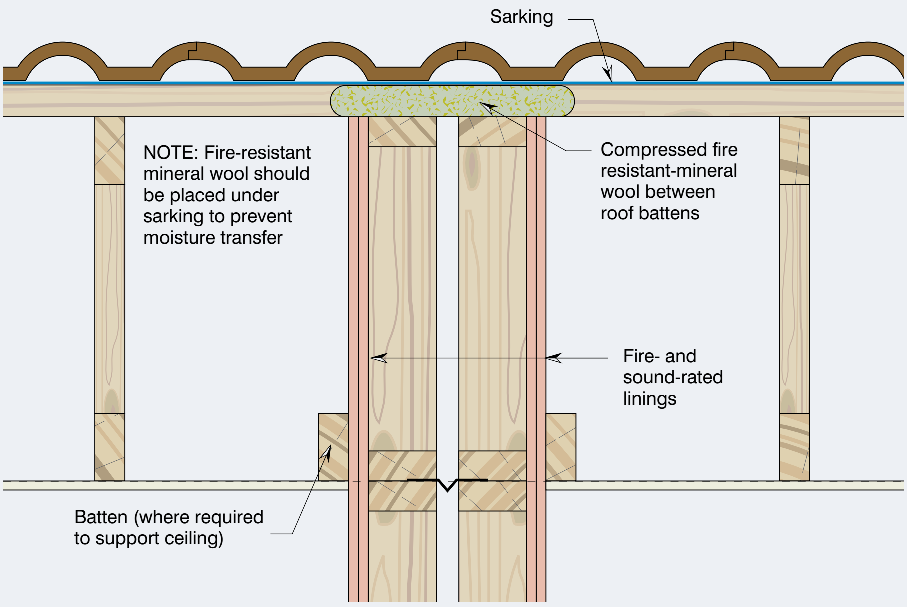


Figure 59: Fire- and sound-rated wall through to the underside of the roof – FRL 90 minutes – elevation view.

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.

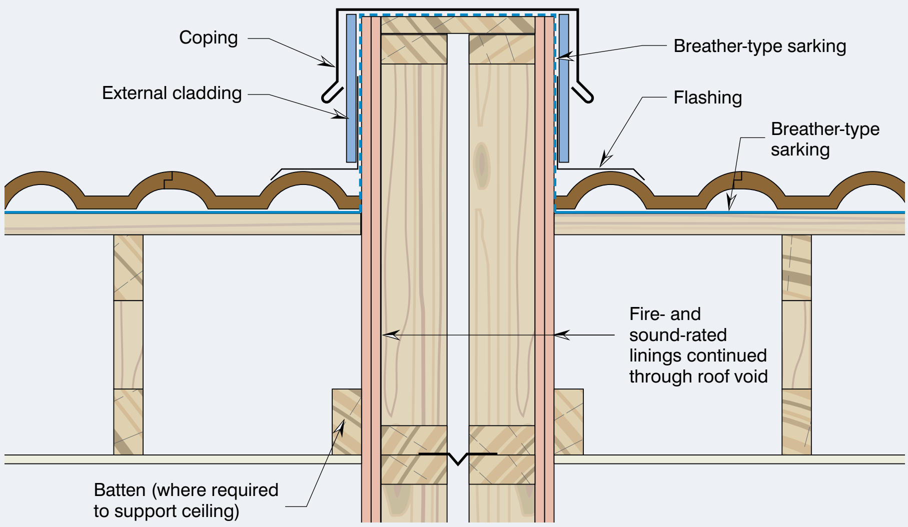


Figure 60: Fire- and Sound-rated wall in the roof void to form parapet – FRL 90 minutes – elevation view.

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).

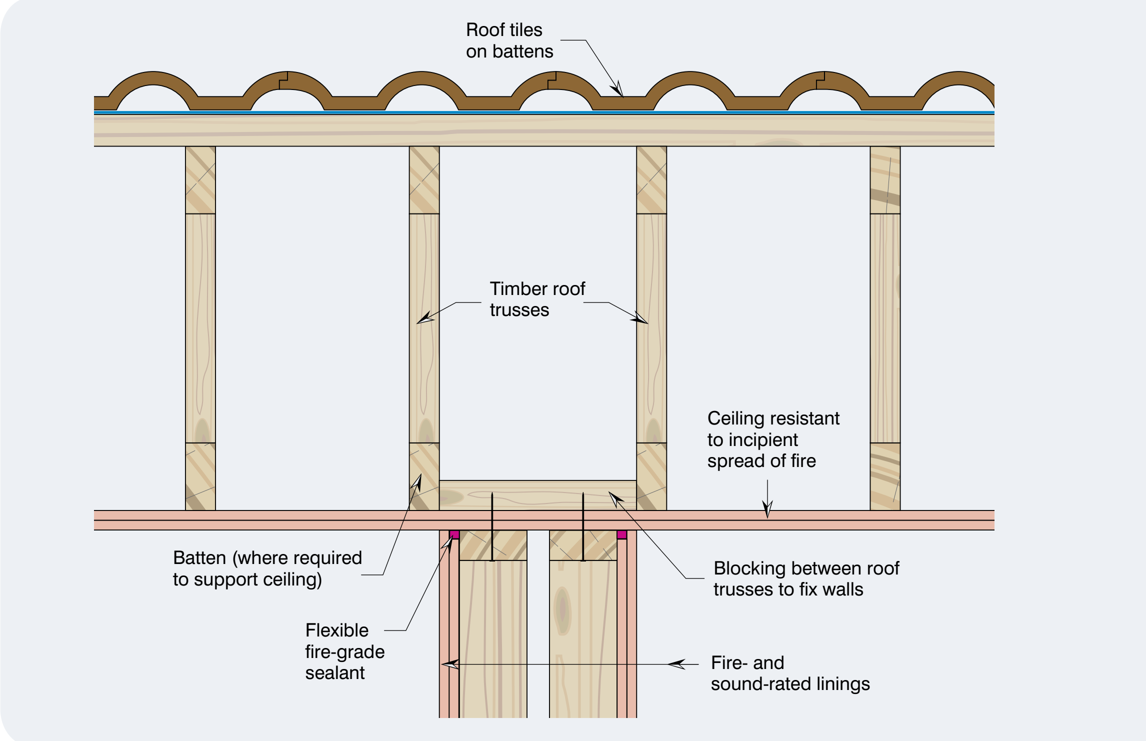


Figure 61: Fire- and sound-rated wall abutting a Resistant to Incipient Spread of Fire ceiling of 60 minutes.

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.

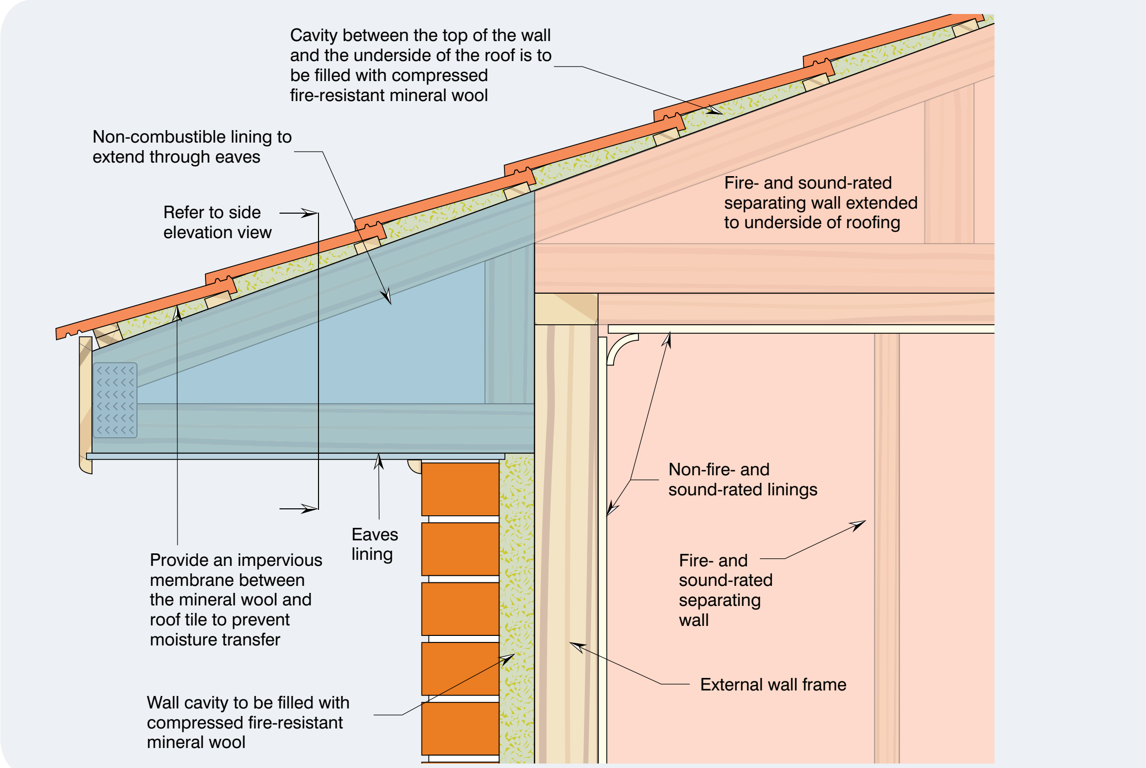


Figure 62: Non-combustible linings blocking off eaves void – front elevation view.

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

Many wall systems can't handle shafts unaided.

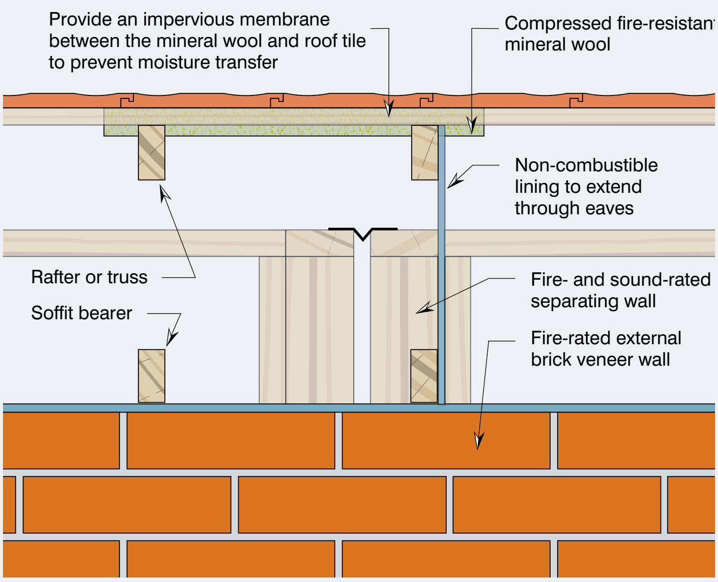


Figure 63: Non-combustible linings blocking off eaves void – side elevation view.

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.

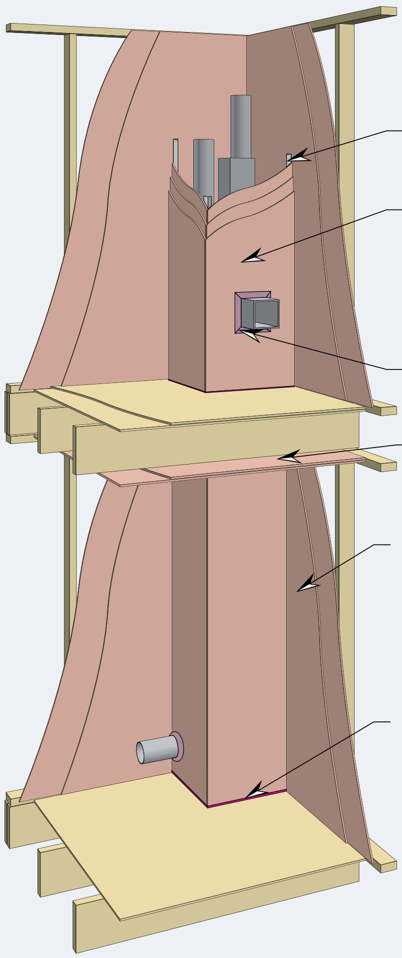


Figure 57: Fire-rated service duct.

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.

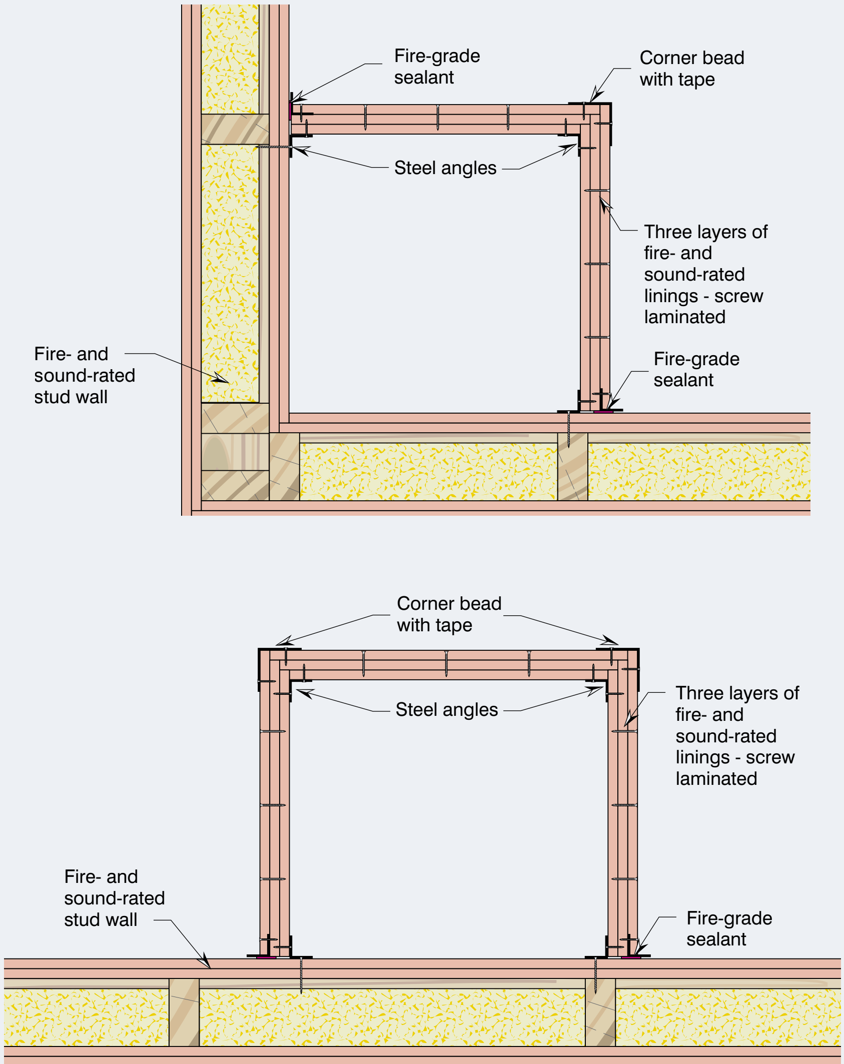


Figure 65: Laminated fire-rated plasterboard used to create a service shaft.

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.

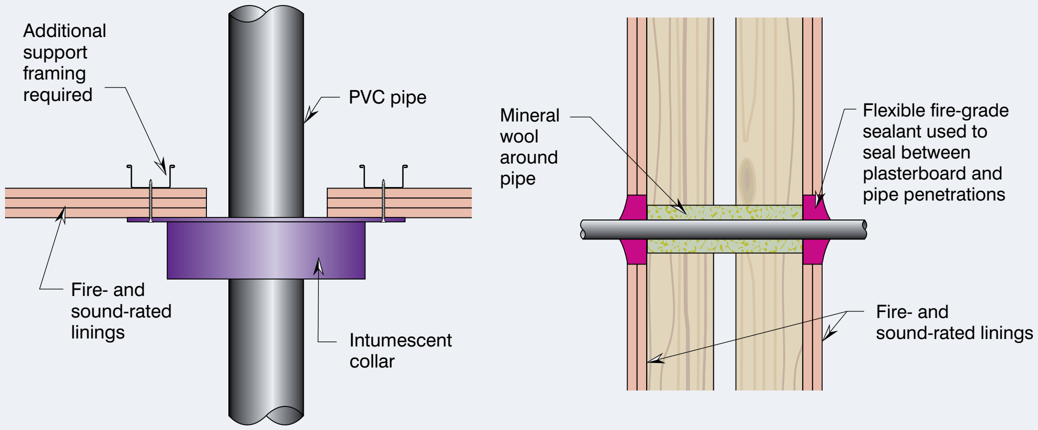


Figure 66: Plumbing service penetration in fire- and sound-rated wall and floor/ceiling – elevation view.

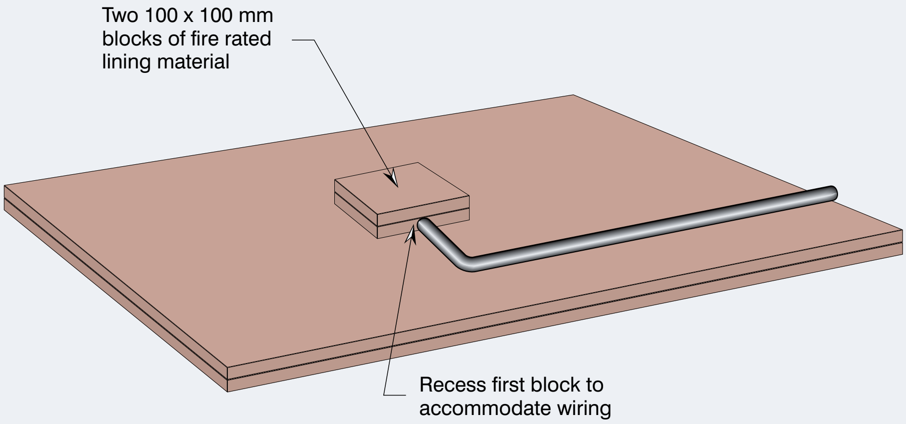


Figure 67: Electrical service penetration in fire- and sound-rated wall and floor/ceiling.

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.

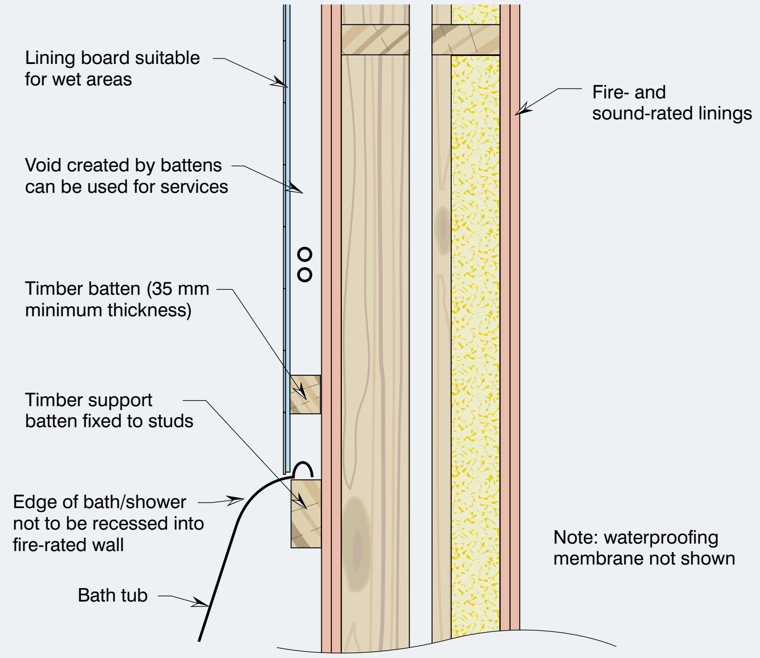


Figure 68: False wall for services (bathroom detail) – elevation view.

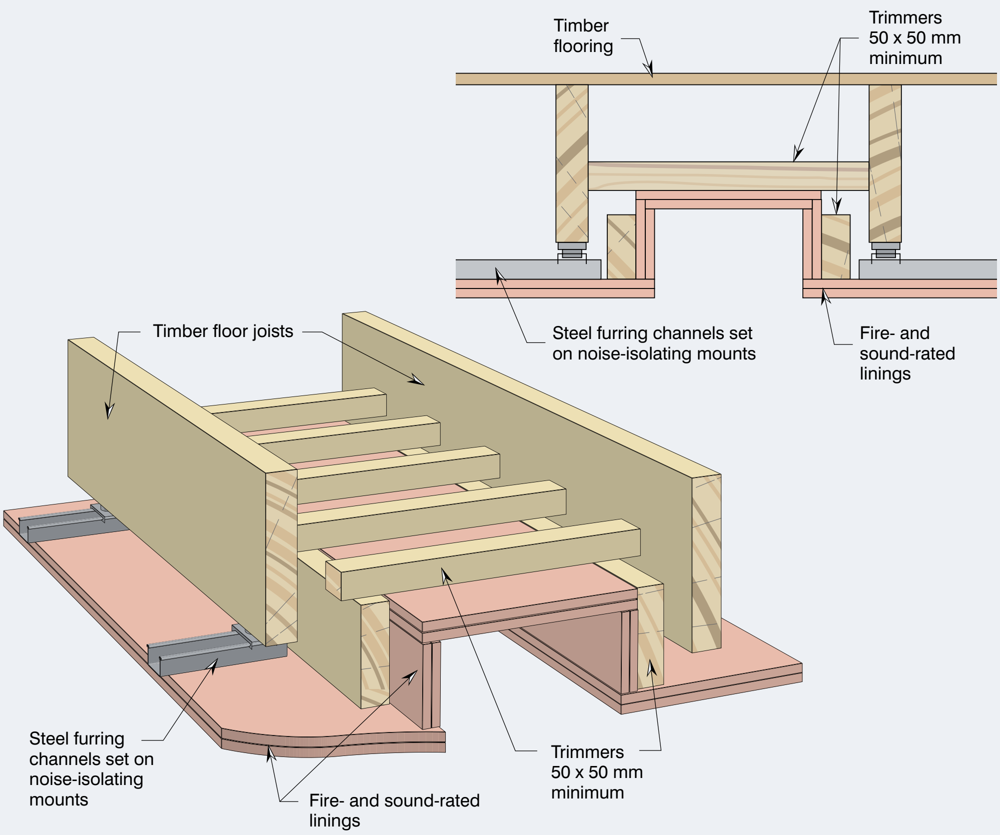


Figure 69: Framing details for recessed light in fire-rated floor/ceiling.

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).

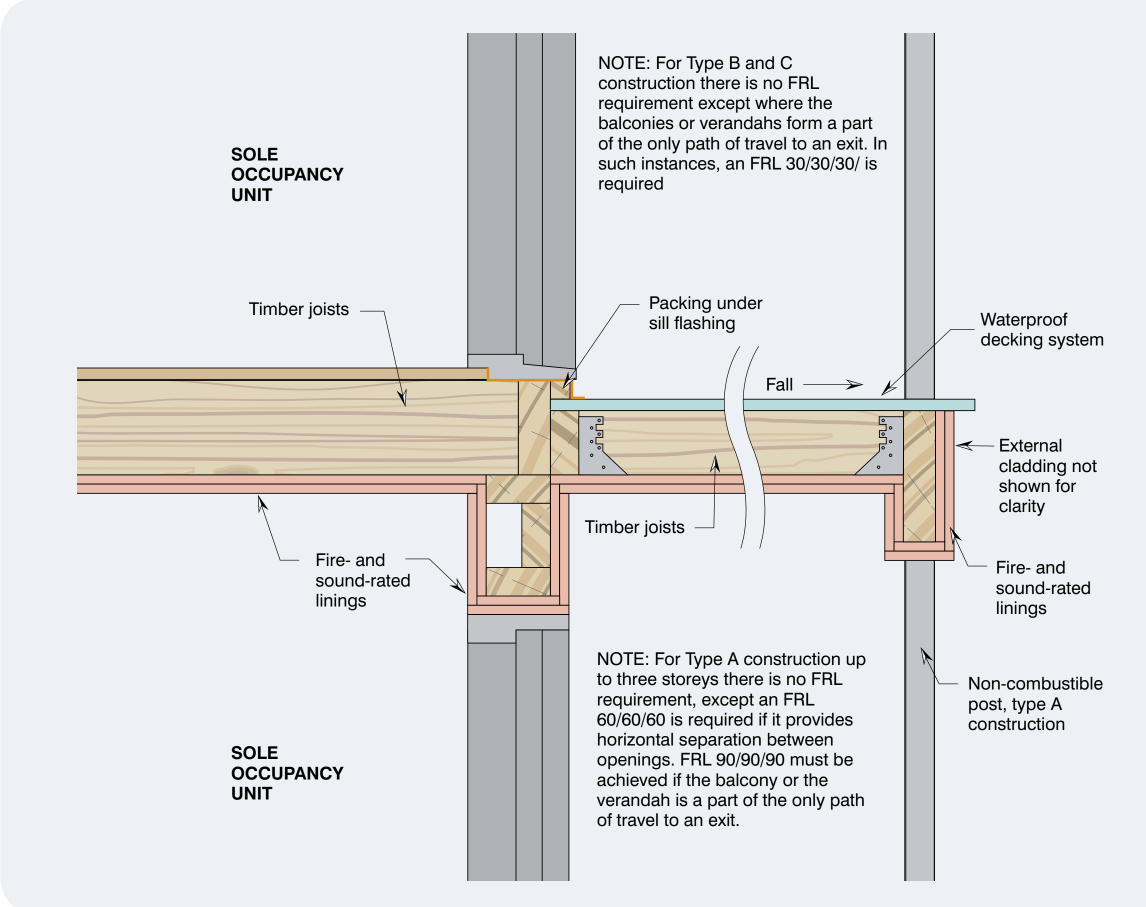


Figure 70: Protection of openings in external walls – elevation view.

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).

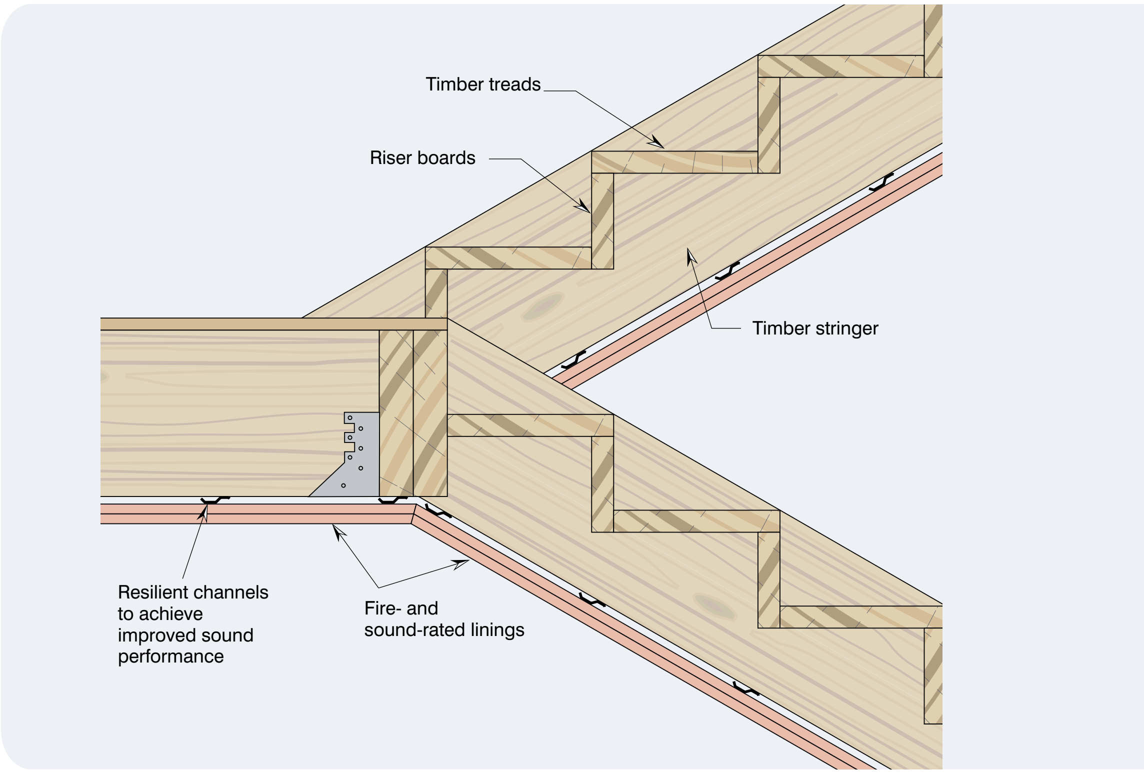


Figure 71: Fire-resistant linings used as Performance Solution for stairs.

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).

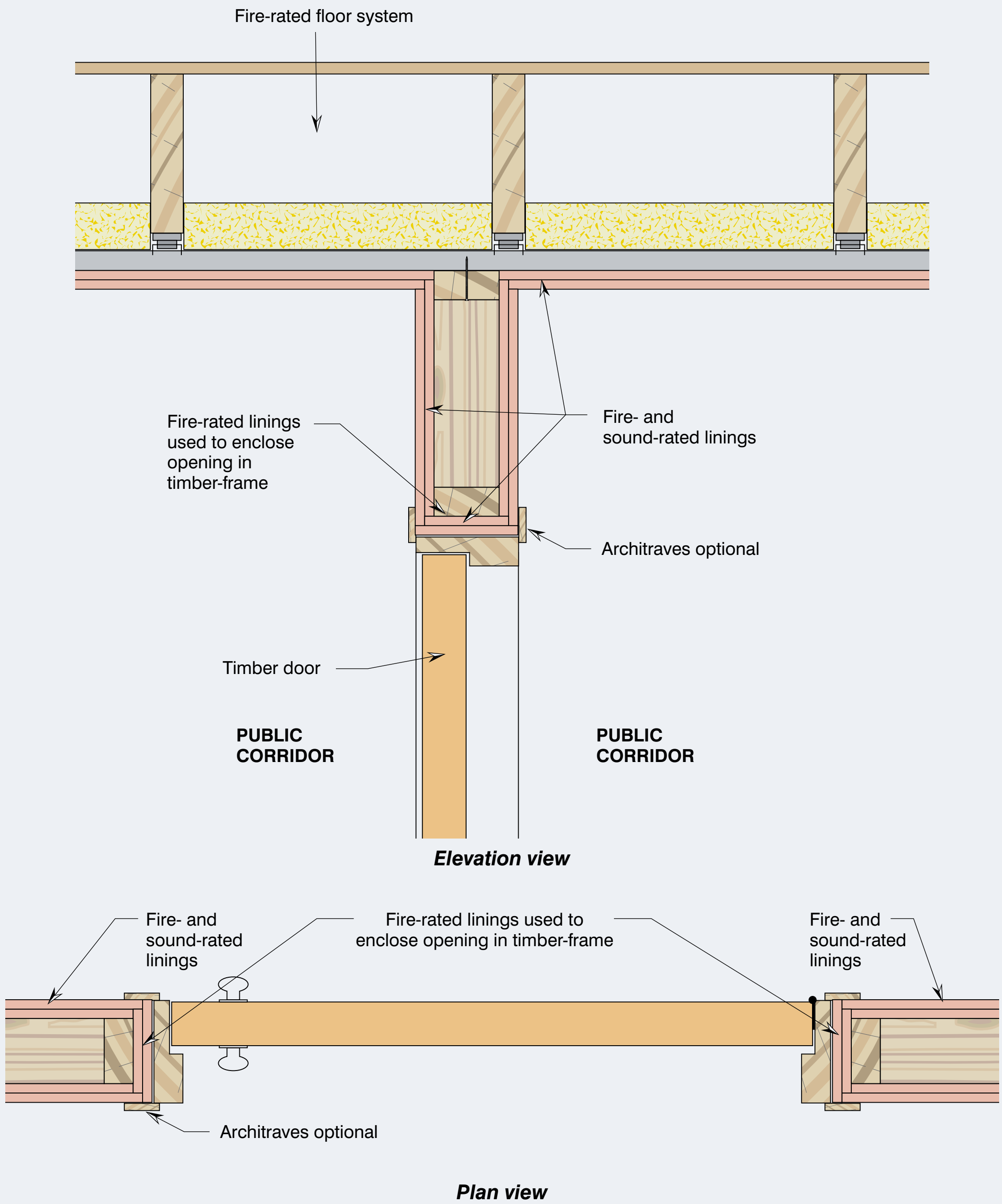


Figure 72: Door openings in fire-rated walls.

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).

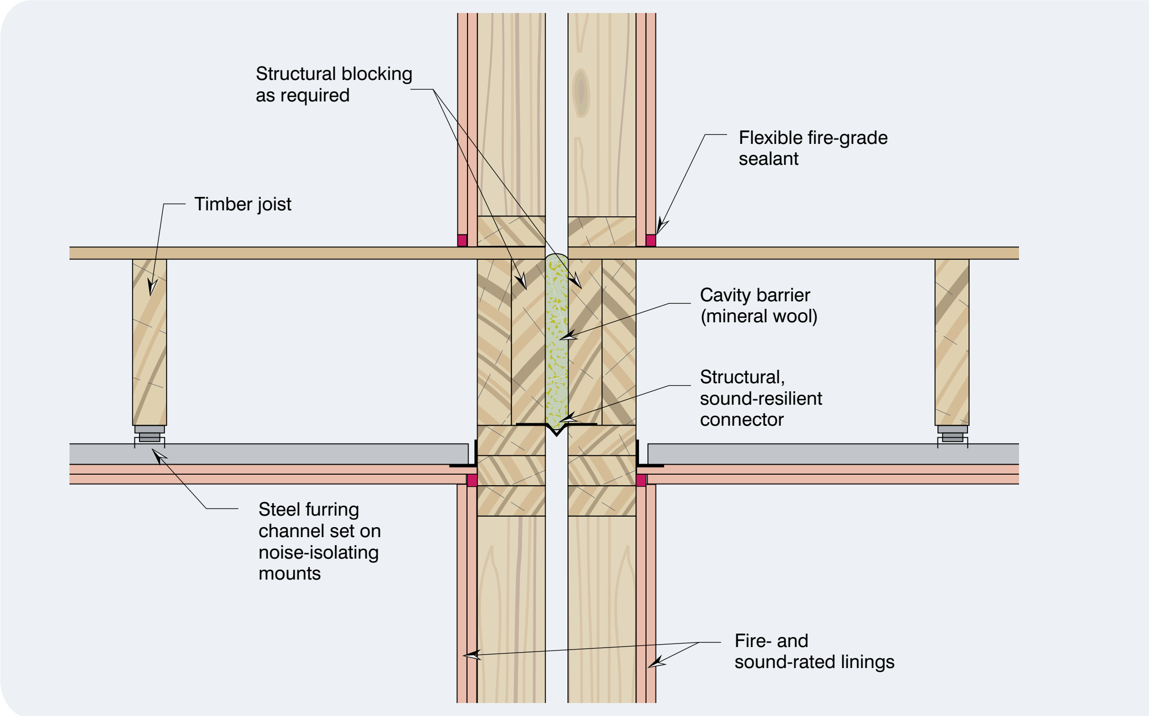


Figure 73: Cavity barrier at the junction of fire-rated floor and fire-rated wall – elevation view.

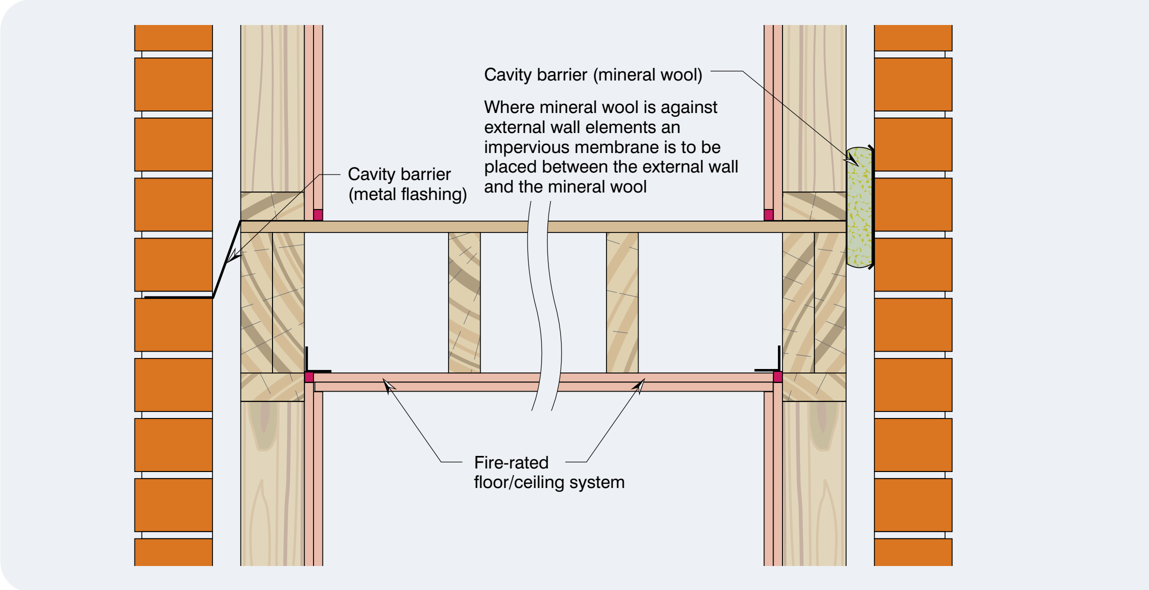


Figure 74: Junction between fire-rated floor and fire-rated external walls – elevation view.

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

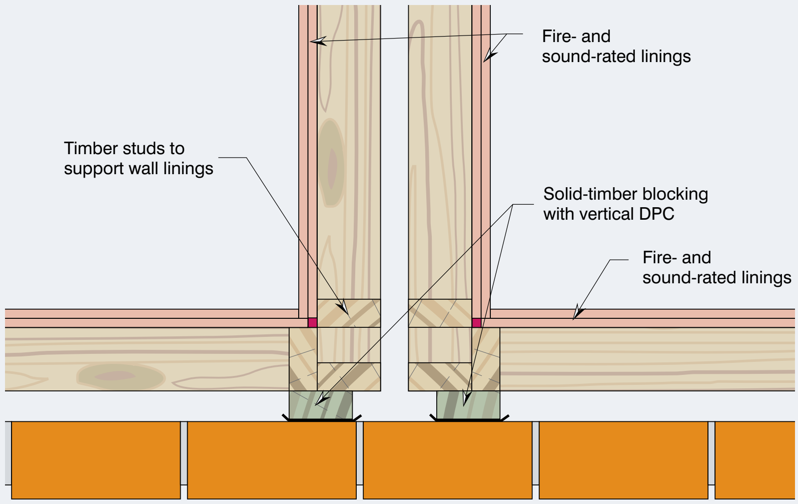


Figure 75: Cavity barrier (using timber blocking) at the junction of fire-rated bounding wall and external wall – plan view.

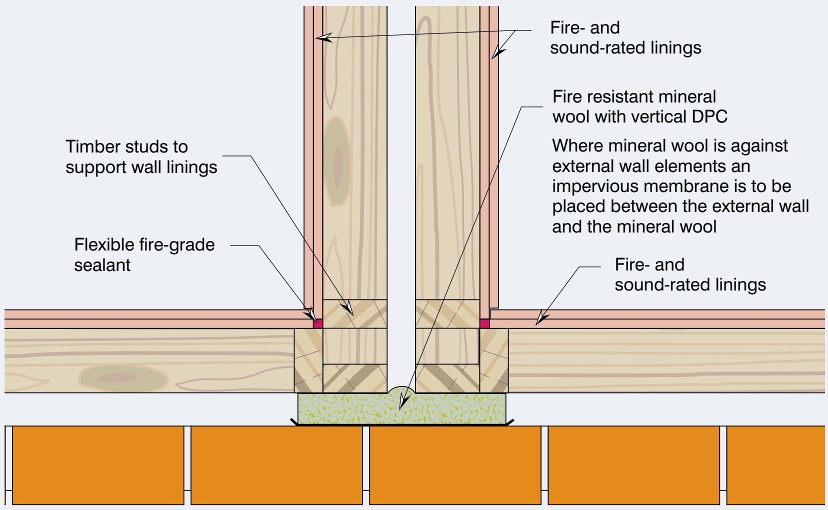


Figure 76: Cavity barrier (using mineral wool) at the junction of fire-rated bounding wall and external wall – plan view.

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.

Free resources are available at woodsolutions.com.au

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.

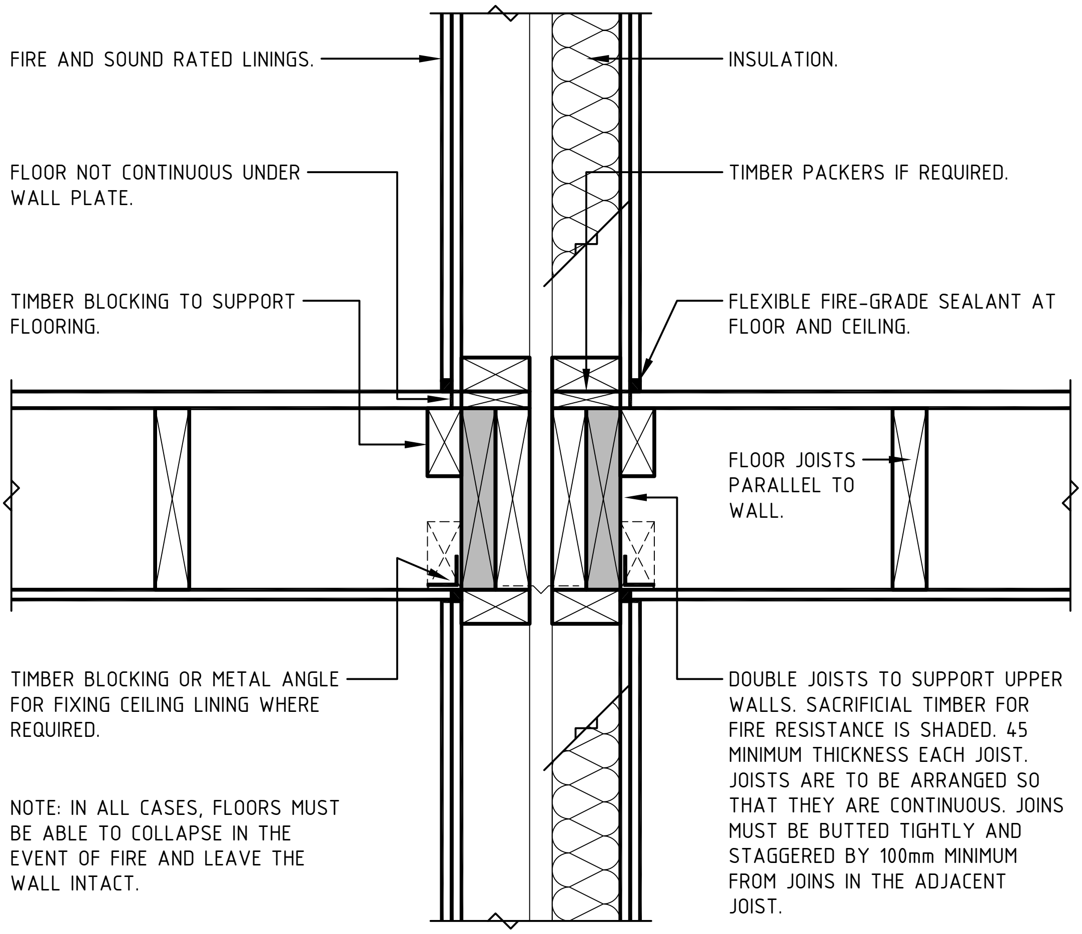
CROSS REFERENCING BETWEEN WOODSOLUTIONS TECHNICAL DESIGN GUIDES & WOODSOLUTIONS CAD DETAILS

REVISION DATE: 4/09/2014

TDG #	FIGURE #	CAD DETAIL #	REMARK
2	01 -	-	Not drawn. TDG detail is diagrammatic.
2	02 -	-	Not drawn. TDG detail is diagrammatic.
2	03 -	-	Not drawn. TDG detail is diagrammatic.
2	04 -	-	Not drawn. TDG detail is diagrammatic.
2	05 -	-	Not drawn. TDG detail is diagrammatic.
2	06 -	-	Not drawn. TDG detail is diagrammatic.
2	07 -	-	Not drawn. TDG detail is diagrammatic.
2	08 -	FD0017	-
2	09 -	FD0042	CAD detail drawn as an orthogonal plan view to simplify project customisation if necessary.
2	10 -	-	Not drawn. TDG detail is diagrammatic.
2	11 a	-	Not drawn. TDG detail is diagrammatic.
2	11 b	-	Not drawn. TDG detail is diagrammatic.
2	12 a	-	Not drawn. TDG detail is diagrammatic.
2	12 b	-	Not drawn. TDG detail is diagrammatic.
2	13 -	-	Not drawn. TDG detail is diagrammatic.
2	14 -	-	Not drawn. TDG detail is diagrammatic.
2	15 -	-	Not drawn. TDG detail is diagrammatic.
2	16 -	-	Not drawn to avoid duplication (this detail is an assembly of other details).
2	17 -	-	Not drawn. Not specifically a timber framing detail.
2	18 -	WD0003	-
2	19 -	-	Not drawn. TDG detail is diagrammatic.
2	20 -	WD0002	-
2	21 -	FD0017	-
2	22 -	FD0041	CAD detail varied to depict a different type of upgraded acoustic isolating mount.
2	23 -	FD0043	CAD detail drawn as an orthogonal plan view to simplify project customisation if necessary.
2	24 -	FD0042	CAD detail drawn as an orthogonal plan view to simplify project customisation if necessary.
2	25 -	FD0044	CAD detail drawn as an orthogonal plan view to simplify project customisation if necessary.
2	26 -	FD0045	CAD detail drawn as an orthogonal plan view to simplify project customisation if necessary. CAD detail varied to increase height between underside of ceiling joist and underside of floor joist so that sound insulation doesn't need to be compressed under floor joists.
2	27 -	WD0001	CAD detail varied to be more generic by showing only one side of stair.

TDG #	FIGURE #	CAD DETAIL #	REMARK
2	28 -	-	Not drawn to avoid duplication (this detail is an assembly of other details).
2	29 -	-	Not drawn. Considered that a plan detail of a short section of straight wall is not as useful as a vertical section to depict wall construction systems.
2	30 -	-	Not drawn. Considered that a plan detail of a short section of straight wall is not as useful as a vertical section to depict wall construction systems.
2	31 -	-	Not drawn. Considered that a plan detail of a short section of straight wall is not as useful as a vertical section to depict wall construction systems.
2	32 -	-	Not drawn. Considered that a plan detail of a short section of straight wall is not as useful as a vertical section to depict wall construction systems.
2	33 -	FD0040	-
2	34 -	FD0051	-
2	35 -	WD0030	-
2	36 -	WD0003	-
2	37 -	WD0023	-
2	38 -	WD0024	-
2	39 -	WD0023	-
2	40 -	WD0024	-
2	41 -	WD0031	-
2	42 -	WD0032	-
2	43 -	FD0054	-
2	44 -	RD0002	-
2	46 -	RD0004	CAD detail amended to show sarking and anti-ponding board to comply with BCA.
2	47 -	RD0005	CAD detail amended to show sarking and anti-ponding board to comply with BCA.
2	48 a	FD0001	-
2	48 b	FD0002	-
2	49 -	FD0012	-
2	50 a	FD0007	Refer FD0008 for plan detail.
2	50 b	FD0008	CAD detail drawn as an orthogonal plan view to simplify project customisation if necessary.
2	51 a	FD0009	CAD detail varied to be more realistic by showing same style of floor truss both sides of separating wall. Refer FD0008 for plan detail.
2	51 b	FD0010	-
2	52 -	FD0011	CAD detail varied to be more realistic by showing same style of floor truss both sides of separating wall.
2	53 a	FD0018	CAD detail varied to show additional noggings to fix wall linings from the lower floor. Variation from Technical Design Guide due to depth of acoustic ceiling relative to underside of floor joists.
2	53 b	WD0021	-
2	54 -	RD0001	CAD detail varied to be more realistic by showing trusses both sides instead of trusses on one side, and rafters and ceiling joists on the other.
2	55 -	RD0007	-
2	56 -	RD0022	CAD detail varied to be more generic by omitting the upper half of the roof.
2	57 a	RD0020	CAD detail amended to show sarking and anti-ponding board where required by the BCA. Refer RD0021 for elevation detail.
2	57 b	RD0021	CAD detail amended to show sarking.
2	58 -	-	Not drawn. This perspective view is not very generic, and is unlikely to be applicable to specific project documentation.
2	59 bottom	WD0013	-

TDG #	FIGURE #	CAD DETAIL #	REMARK
2	59 top	WD0012	-
2	60 LHS	FD0056	CAD detail drawn with 2 layers of plasterboard instead of 3 (considered to be the more common case).
2	60 RHS	WD0003	-
2	61 -	FD0057	CAD detail drawn as an orthogonal plan and section view to simplify project customisation if necessary.
2	62 -	WD0002	-
2	63 -	FD0058	CAD detail has omitted the perspective view. CAD detail varied to show isolating mounts to the top of the recessed plasterboard.
2	64 -	FD0059	CAD detail varied to be more generic by showing a break line over the doorhead. CAD detail varied to show exterior cladding over the external sections of fire and sound rated linings (assuming they are not weatherproof).
2	65 -	FD0060	CAD detail varied to be more generic by omitting the stair flight in the background. Furring channels to the underside of the floor joists omitted.
2	65 -	FD0061	Variation of FD0060 with furring channels on sound isolating mounts.
2	66 -	FD0050	CAD detail varied to be more generic by showing a break line over the doorhead.
2	67 -	FD0051	-
2	68 -	-	Not drawn. Considered that the "shaftliner" lining product is not a generic solution to this case.
2	68 -	FD0052	-
2	69 -	FD0053	CAD detail varied to be more generic by showing break lines over the doorhead and across the ceiling space. CAD detail shows false ceiling direct fixed to ceiling joists to address issue of supporting a suspended ceiling from fire and sound rated linings above.
2	70 -	FD0017	-
2	71 LHS	FD0070	-
2	71 RHS	FD0071	-
2	72 a	WD0022	-
2	72 b	WD0021	-



SECTION DETAIL – FLOOR TO DOUBLE STUD WALL, JOISTS PARALLEL, FRL 60/60/60 OR –/60/60 FD0001A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

FD0001A

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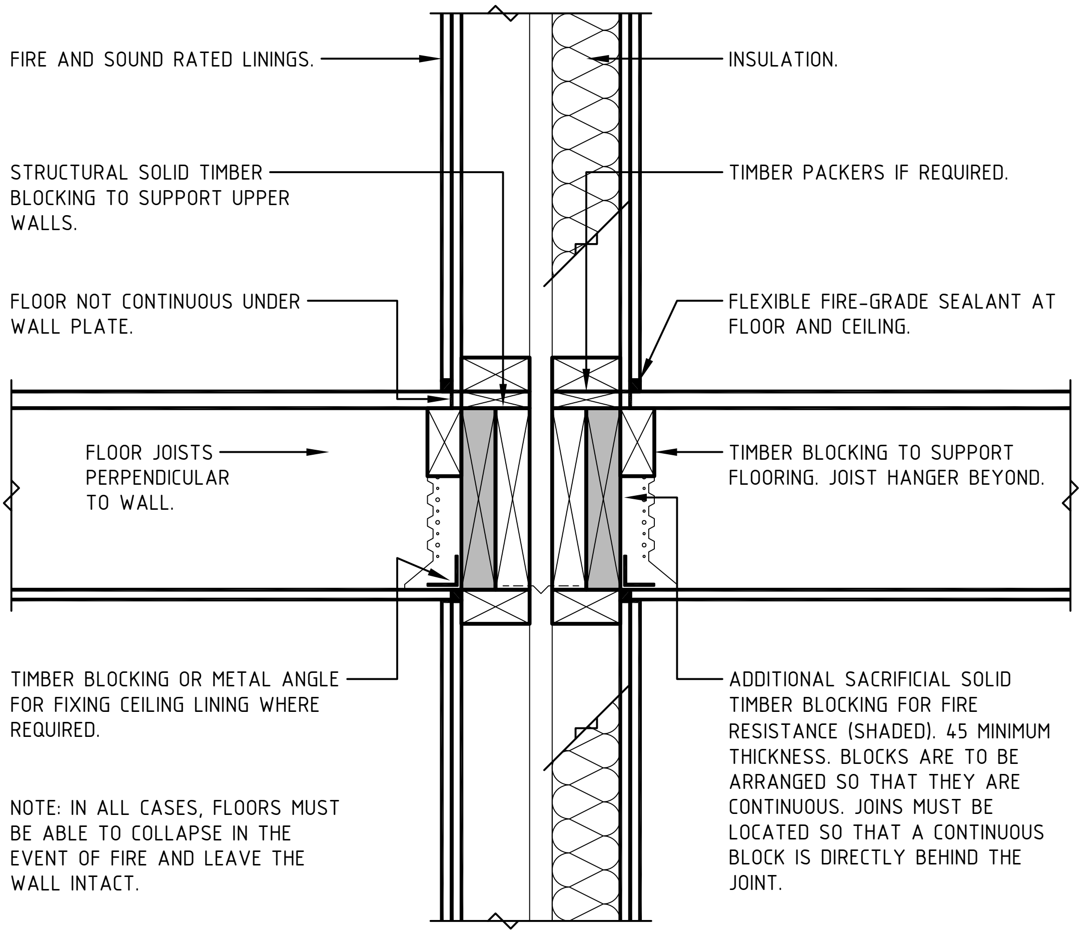

SECTION DETAIL - FLOOR TO DOUBLE STUD WALL, JOISTS PERPENDICULAR, FRL 60/60/60 OR -/60/60 FD0002A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.
FD0002A

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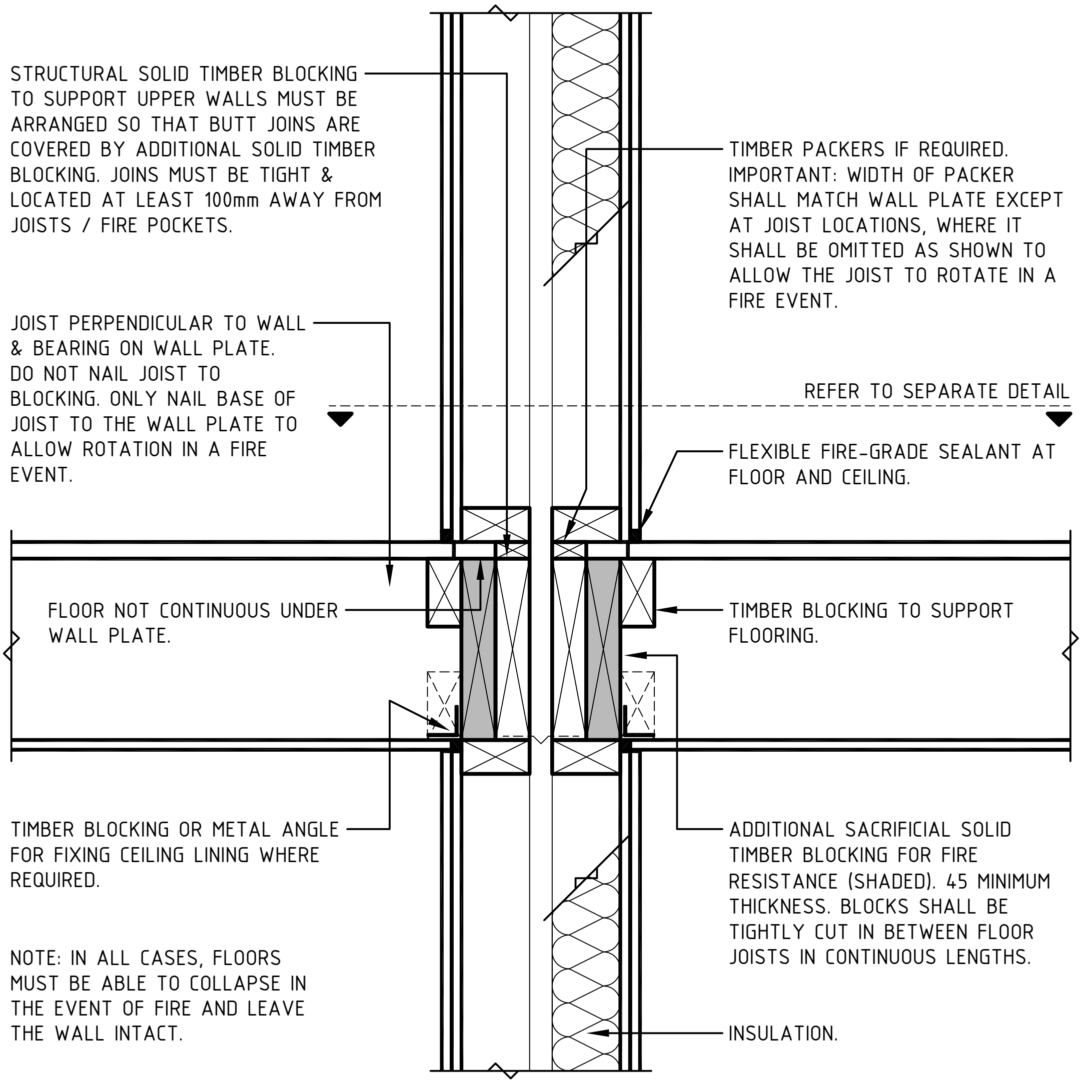

SECTION DETAIL – FLOOR TO DOUBLE STUD WALL, PERPENDICULAR JOISTS BEARING ON WALL PLATE, FRL 60/60/60 OR –/60/60

FD0007A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

FD0007A

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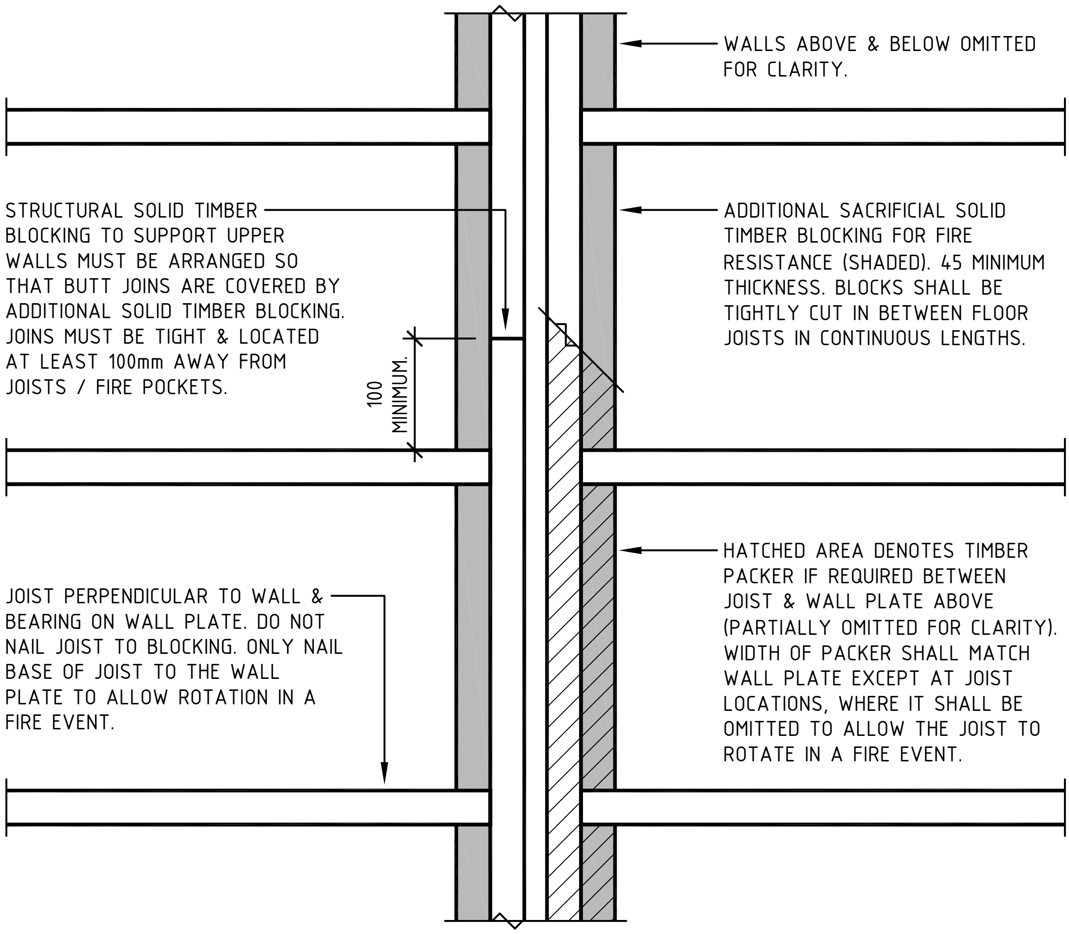

PLAN DETAIL – FLOOR TO DOUBLE STUD WALL, PERPENDICULAR JOISTS BEARING ON WALL PLATE, FRL 60/60/60 OR FRL –/60/60 FD0008A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

FD0008A

REVISION STATUS

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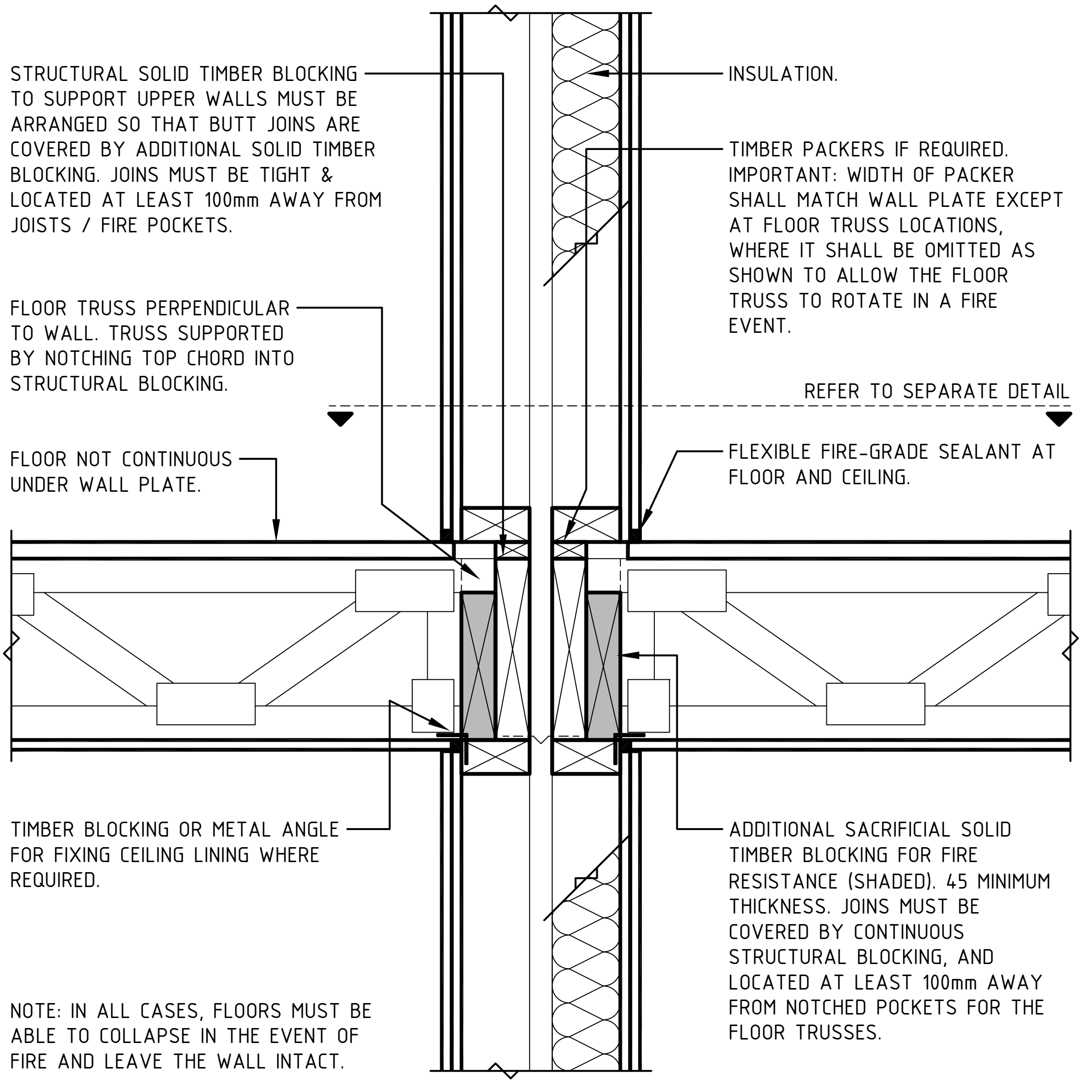

SECTION DETAIL - FLOOR TO DOUBLE STUD WALL, PERPENDICULAR FLOOR TRUSSES, FRL 60/60/60 OR -/60/60 FD0009A

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Researcher:
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DETAIL REFERENCE NO.

FD0009A

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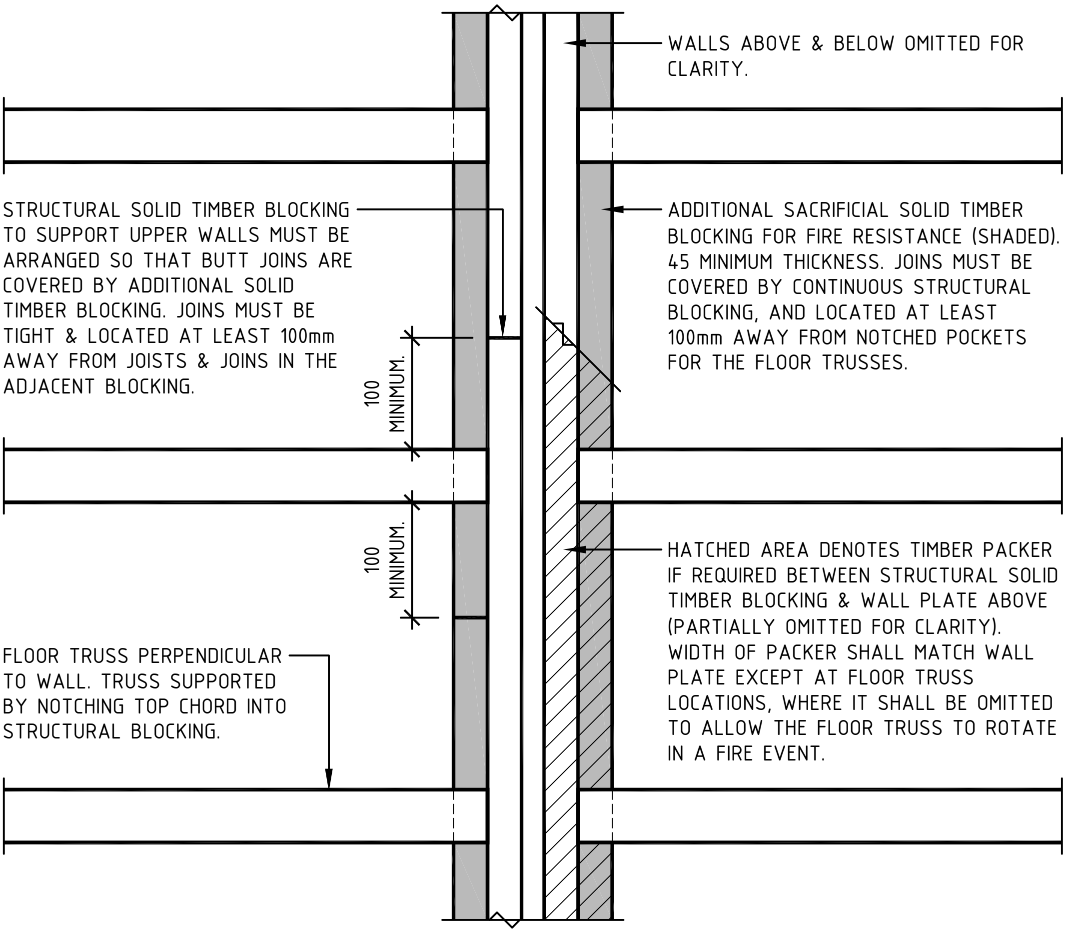

PLAN DETAIL - FLOOR TO DOUBLE STUD WALL, PERPENDICULAR FLOOR TRUSSES, FRL 60/60/60 OR FRL -/60/60 FD0010A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

FD0010A

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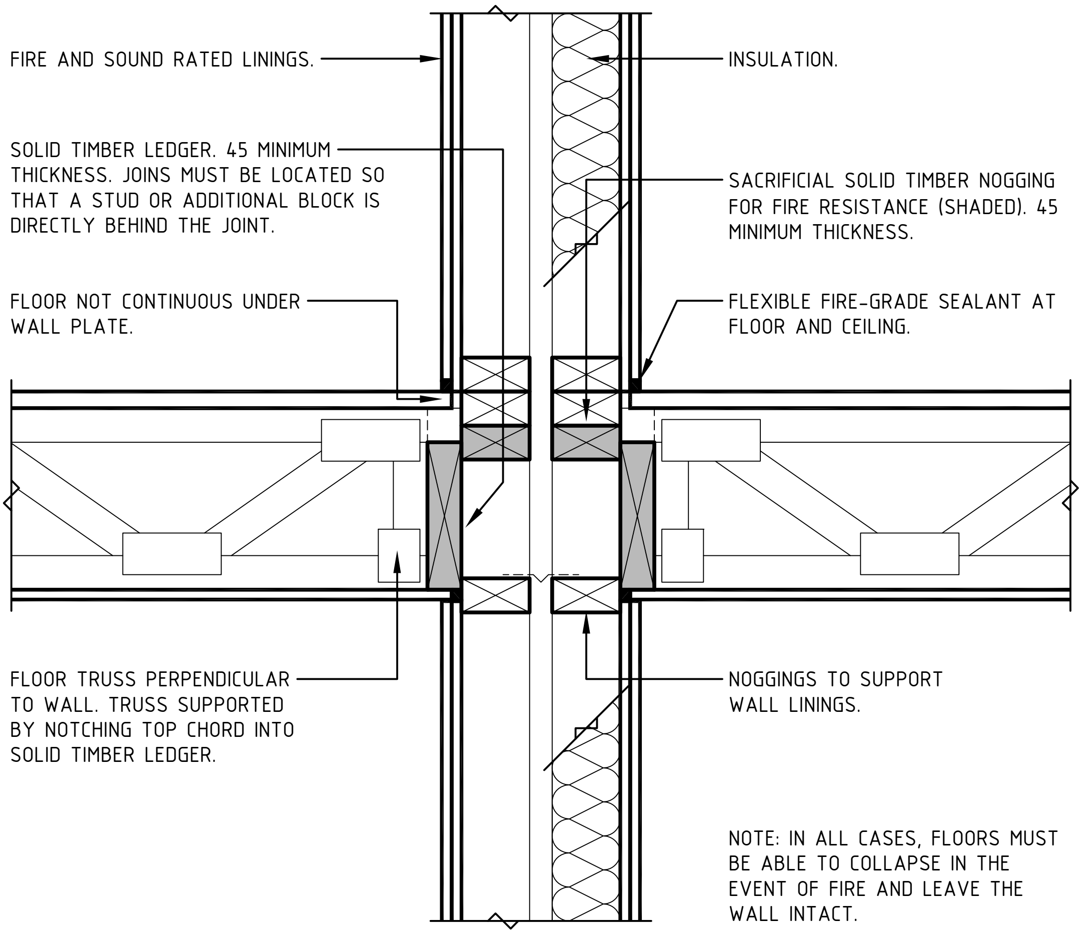

SECTION DETAIL - FLOOR TO CONTINUOUS DOUBLE STUD WALL, PERPENDICULAR FLOOR TRUSSES, FRL 60/60/60 OR -/60/60

FD0011A

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Researcher:
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DETAIL REFERENCE NO.

FD0011A

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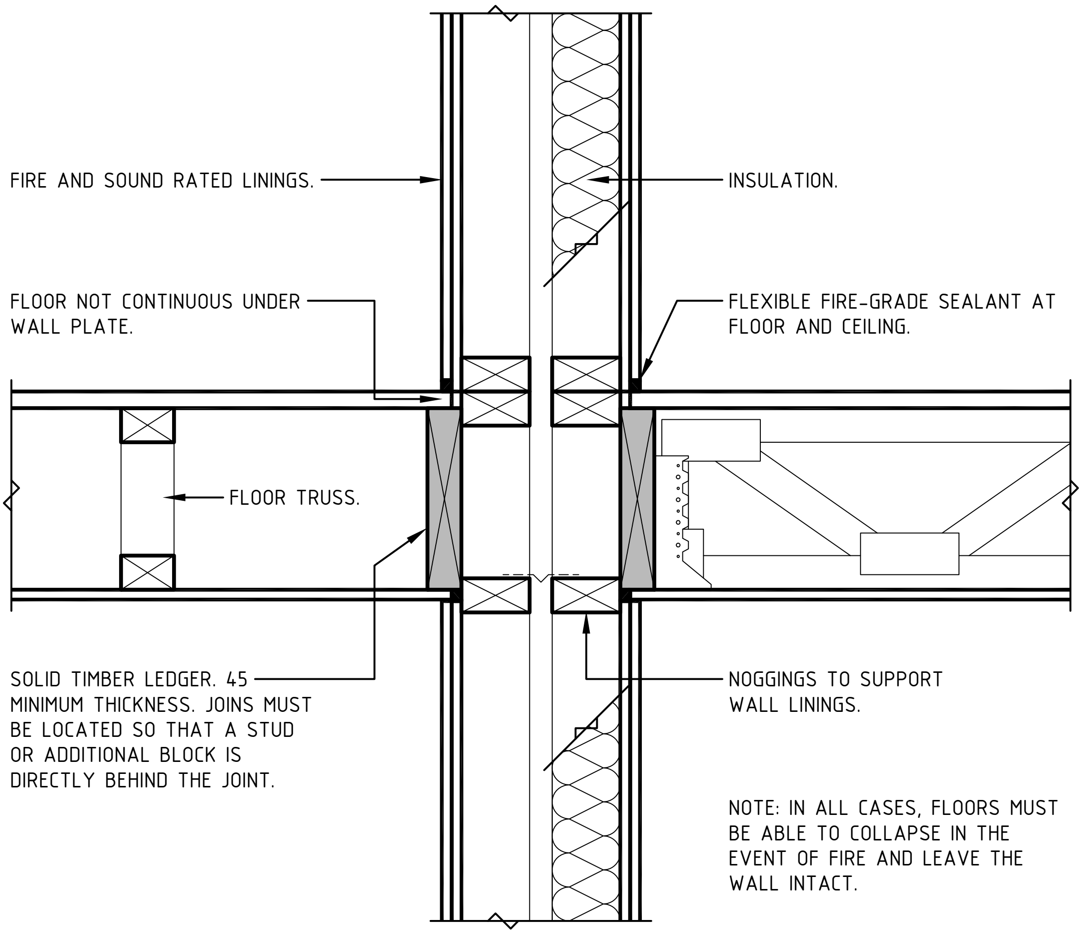

SECTION DETAIL - FLOOR TO CONTINUOUS DOUBLE STUD WALL, PERPENDICULAR & PARALLEL FLOOR TRUSSES, FRL 60/60/60 OR -/60/60 FD0012A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

FD0012A

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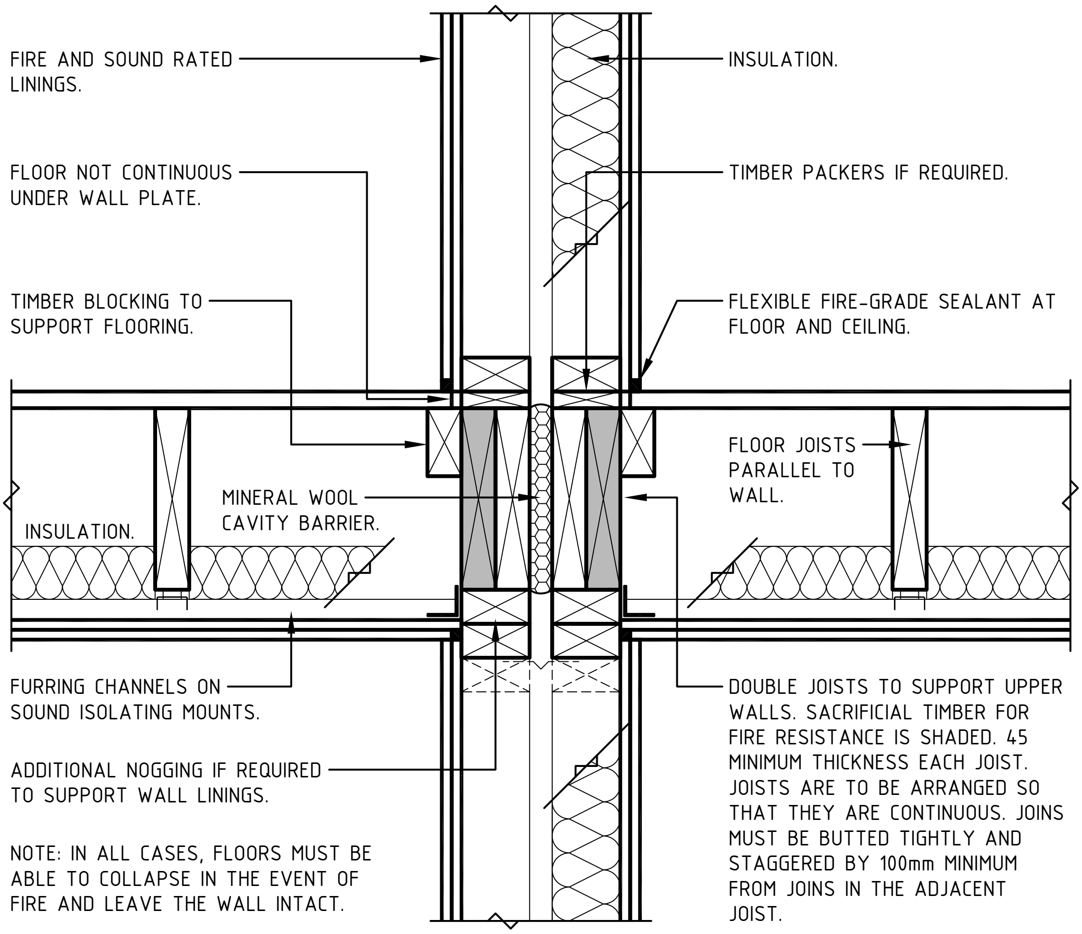

SECTION DETAIL - FLOOR TO DOUBLE STUD WALL, JOISTS PARALLEL, ACOUSTIC CEILING

FD0017A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

FD0017A

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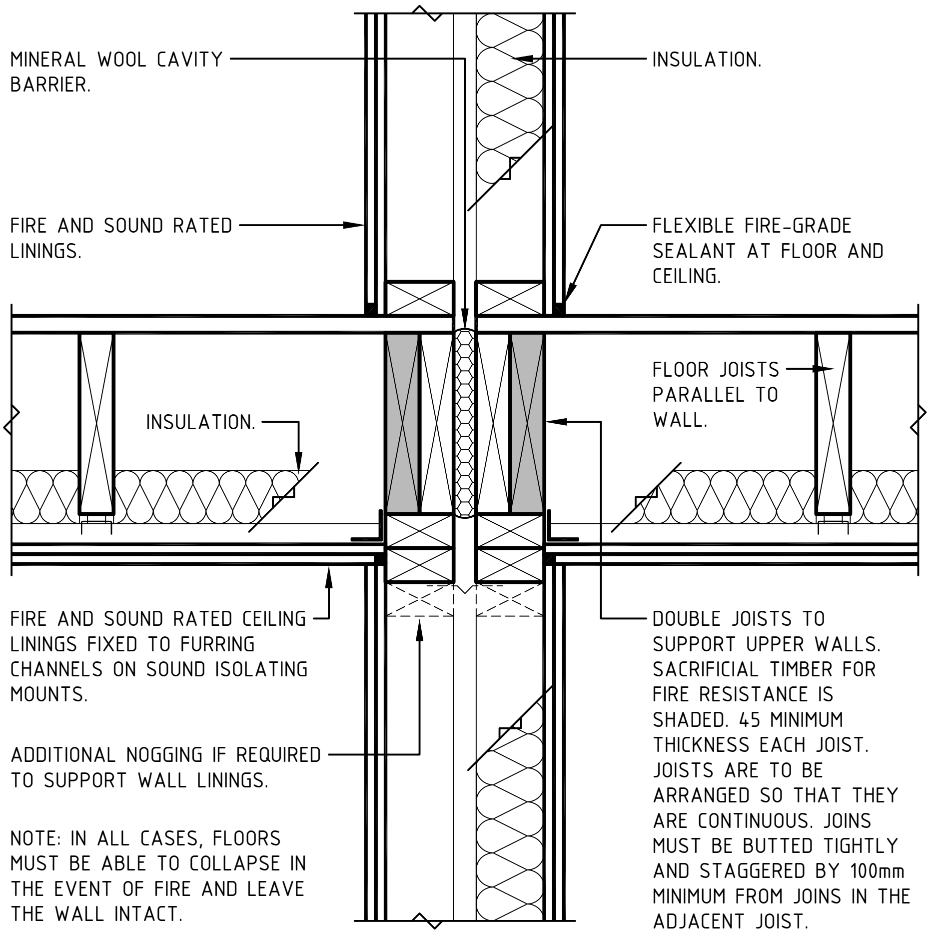

SECTION DETAIL - FLOOR TO DOUBLE STUD WALL, JOISTS PARALLEL, ACOUSTIC CEILING, NON-SOUND RATED WALL

FD0018A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

FD0018A

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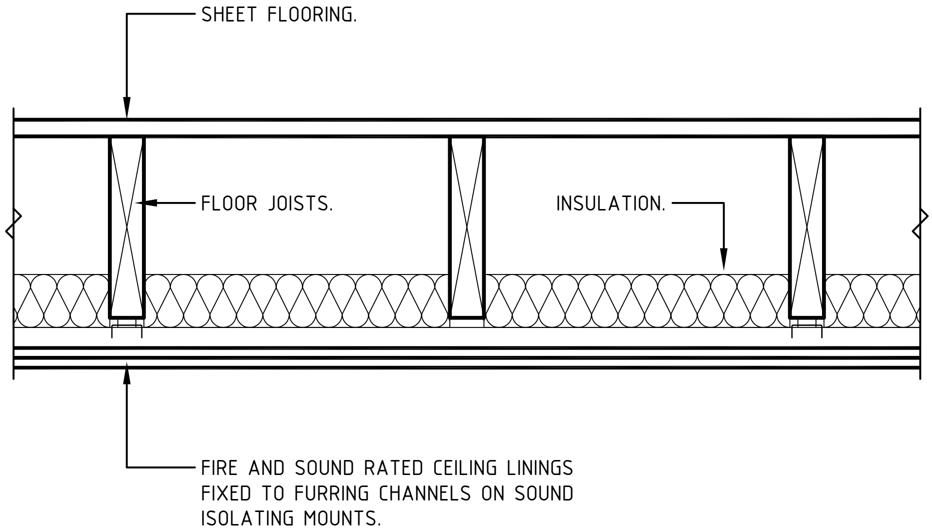

SECTION DETAIL - SHEET FLOOR WITH ACOUSTIC CEILING

FD0040A

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Researcher:
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DETAIL REFERENCE NO.

FD0040A

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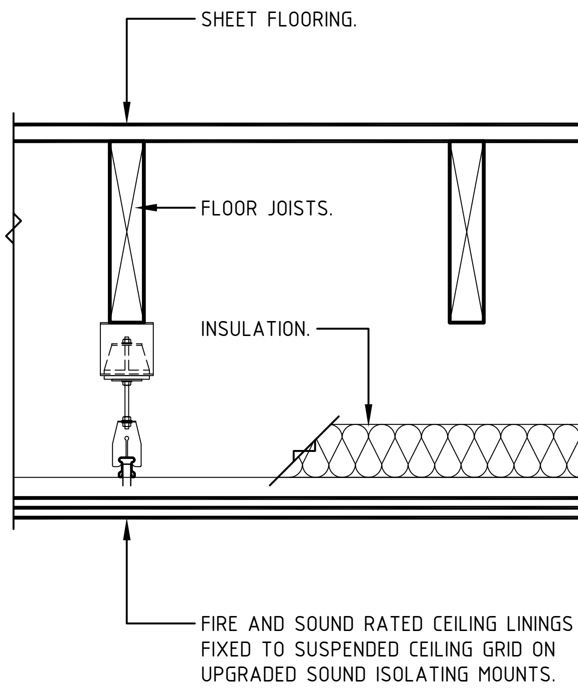

SECTION DETAIL - SHEET FLOOR WITH ACOUSTIC CEILING & UPGRADED ISOLATING MOUNTS

FD0041A

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Researcher:
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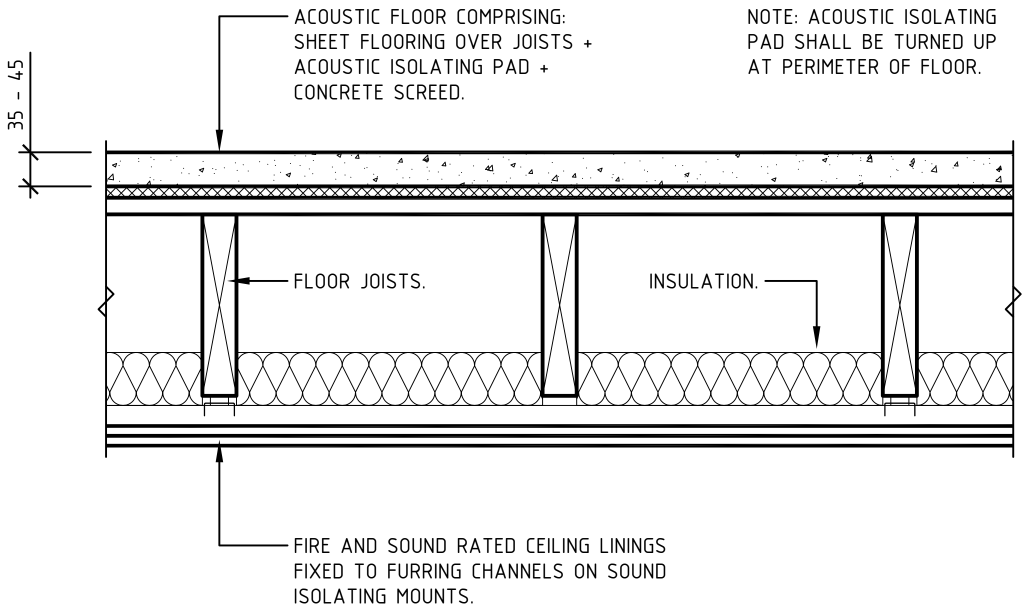

SECTION DETAIL - ACOUSTIC FLOOR WITH CONCRETE SCREED OVER ACOUSTIC MAT, ACOUSTIC CEILING FD0042A

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Researcher:
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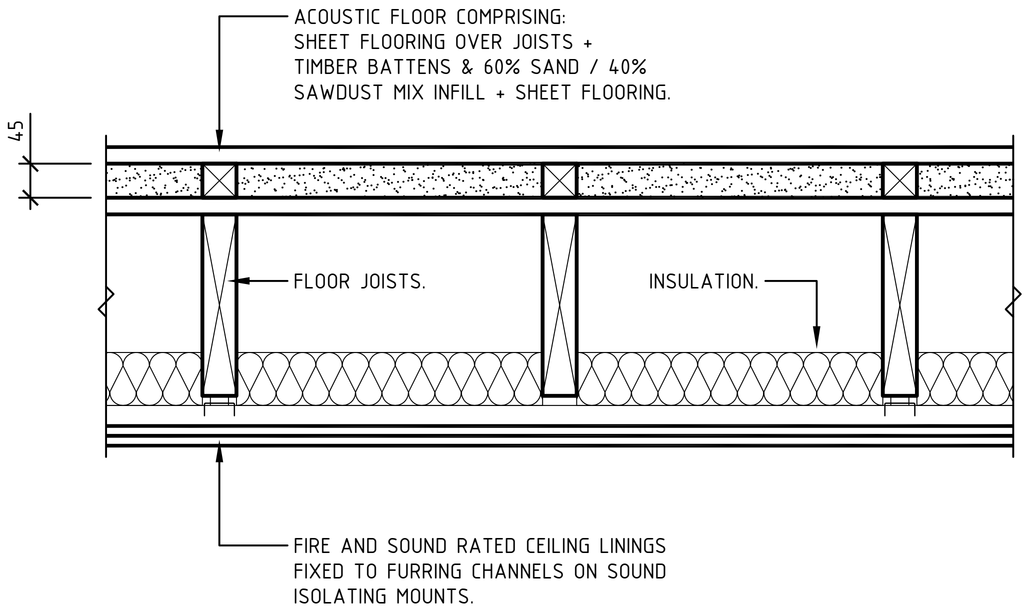

SECTION DETAIL - ACOUSTIC FLOOR WITH ADDED MASS (BATTENS & SAND / SAWDUST INFILL), ACOUSTIC CEILING FD0043A

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Researcher:
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FD0043A

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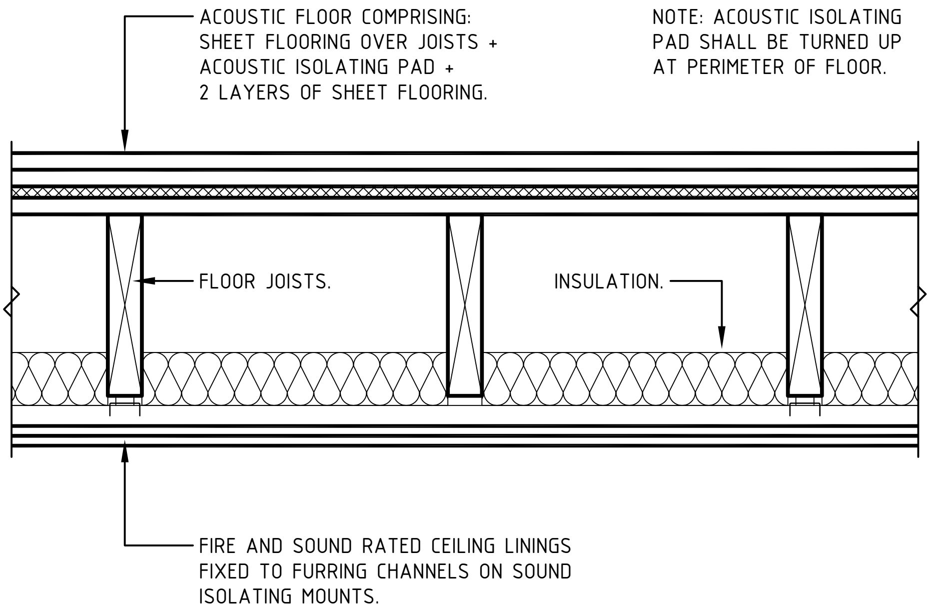

SECTION DETAIL - ACOUSTIC FLOOR WITH DOUBLE LAYER SHEETING OVER ACOUSTIC MAT, ACOUSTIC CEILING FD0044A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

FD0044A

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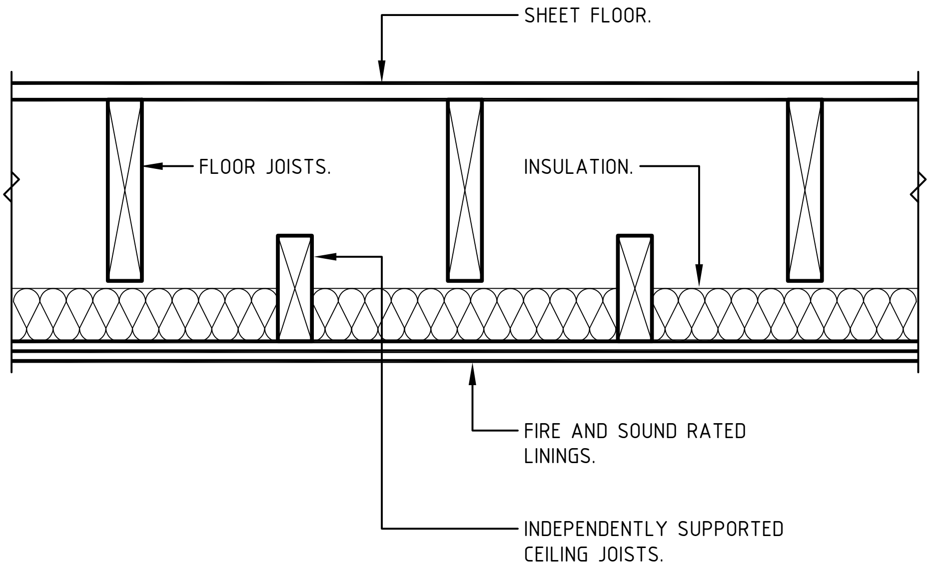

SECTION DETAIL – ACOUSTIC FLOOR WITH SEPARATE FLOOR & CEILING JOISTS FD0045A

DETAIL REFERENCE NO.

FD0045A

REVISION STATUS

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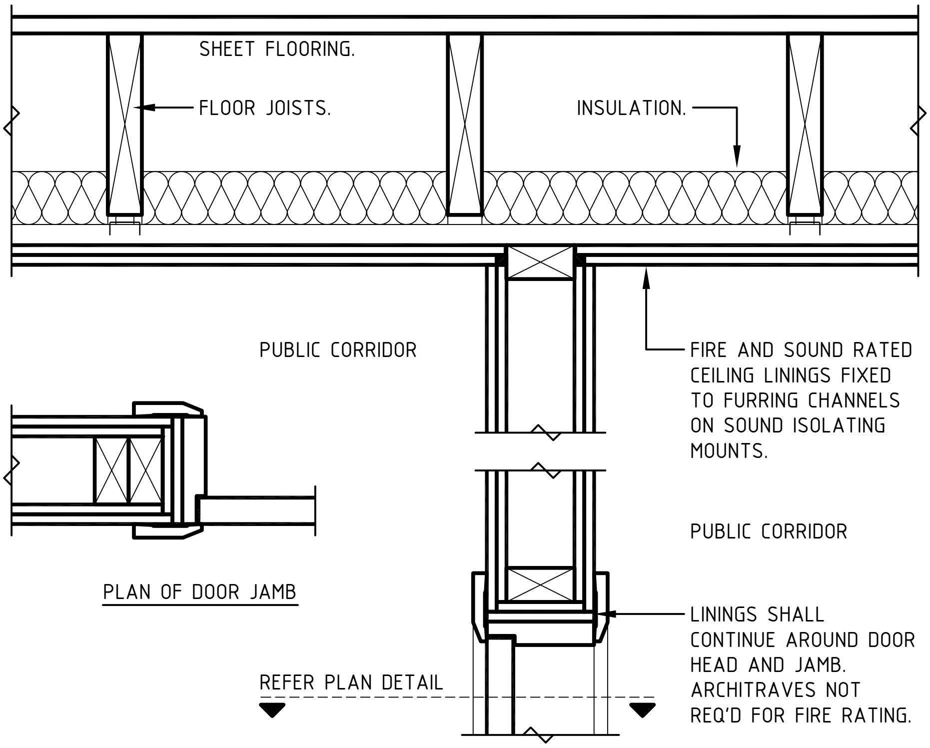

SECTION & PLAN DETAIL - NON-RATED OPENING IN FIRE RATED WALL FD0050A

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Researcher:
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DETAIL REFERENCE NO.

FD0050A

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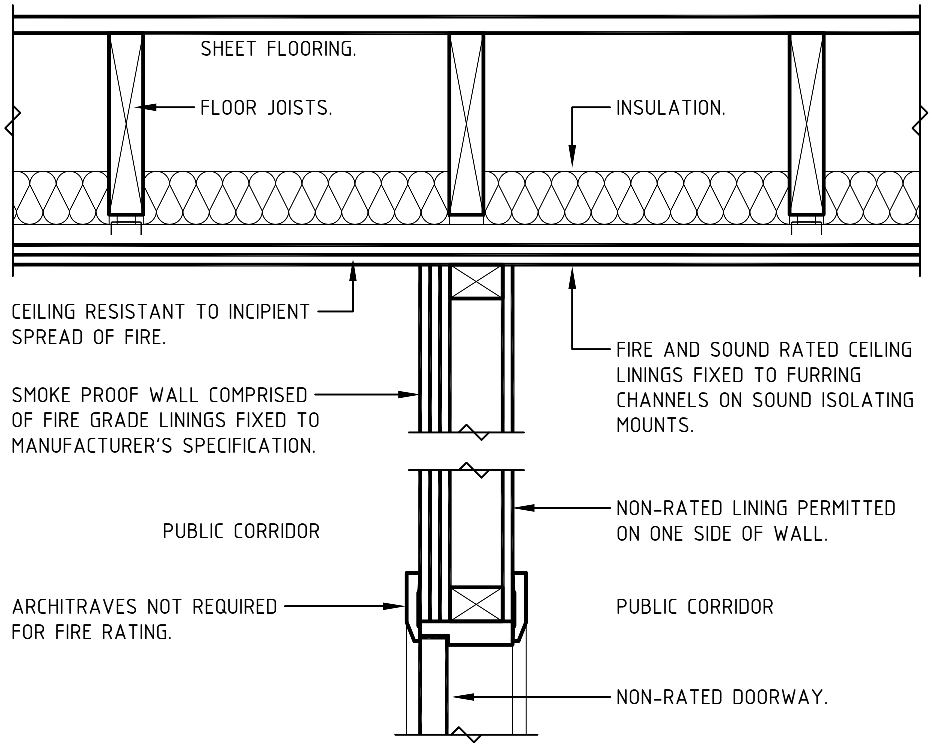

SECTION DETAIL - SMOKE PROOF WALL TO FLOOR ABOVE AT DOORWAY, BUILT FROM LAMINATED PLASTERBOARD FD0051A

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Researcher:
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DETAIL REFERENCE NO.

FD0051A

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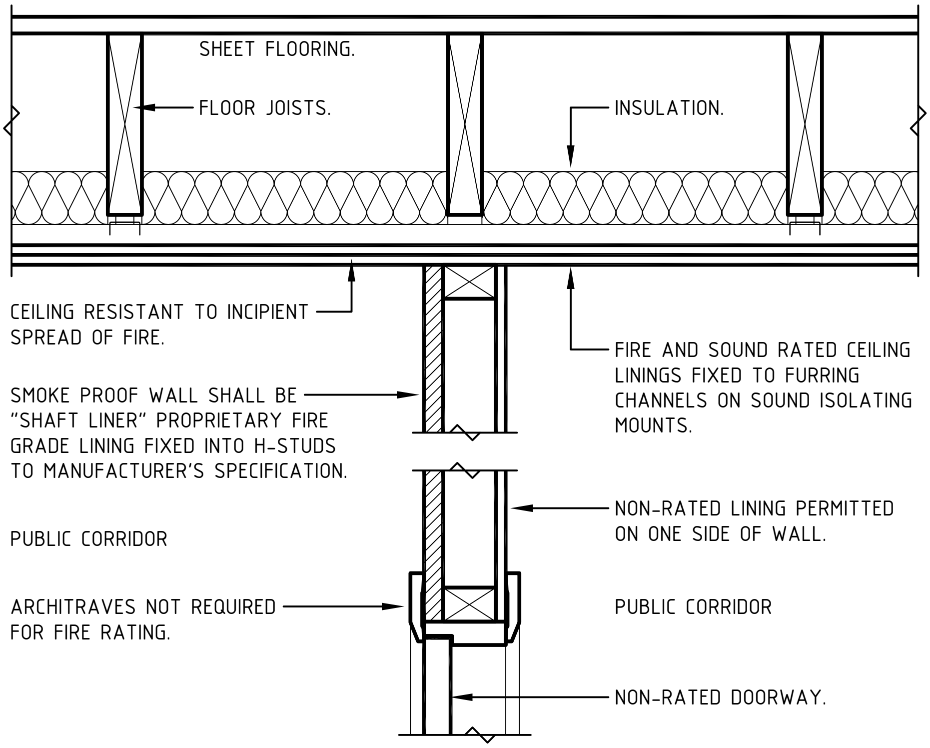

SECTION DETAIL - SMOKE PROOF WALL TO FLOOR ABOVE AT DOORWAY, BUILT FROM "SHAFT LINER" MATERIAL FD0052A

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Researcher:
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DETAIL REFERENCE NO.

FD0052A

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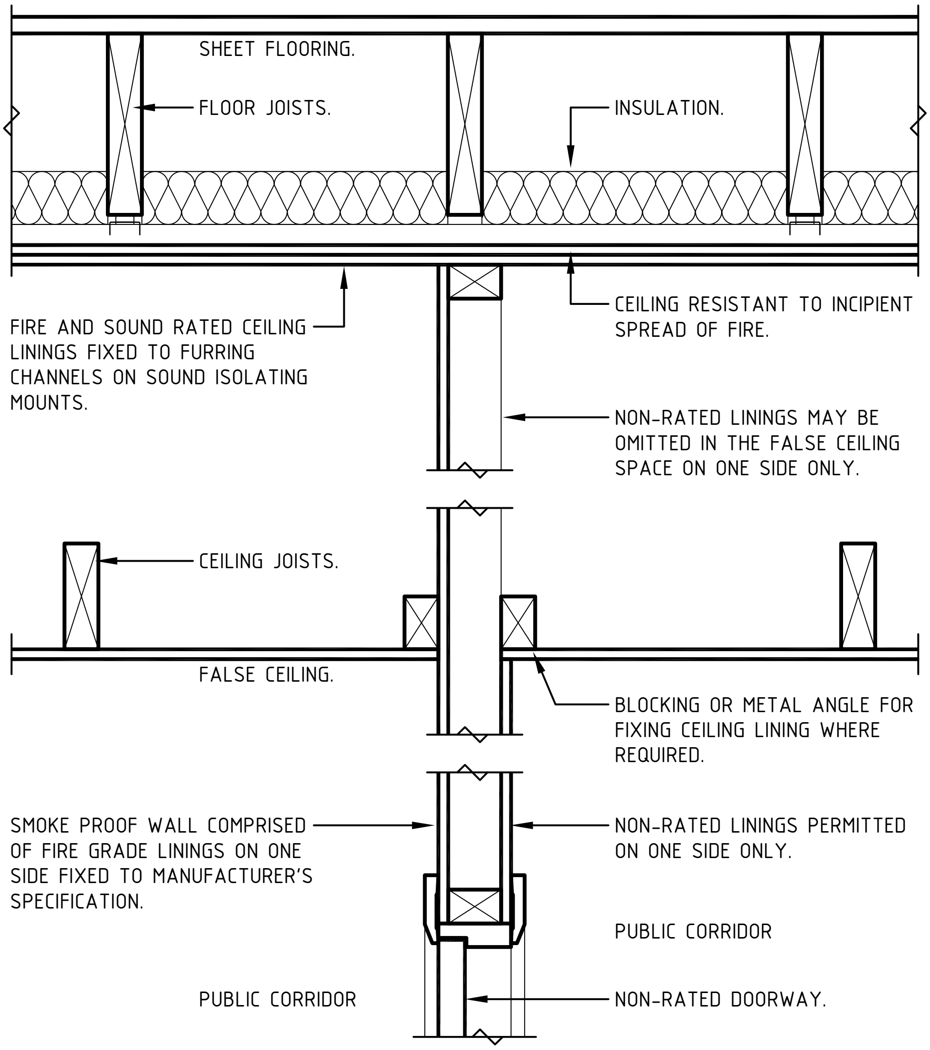

SECTION DETAIL – SMOKE PROOF WALL TO FLOOR ABOVE AT DOORWAY, CLASS 9C BUILDING FD0053A

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Researcher:
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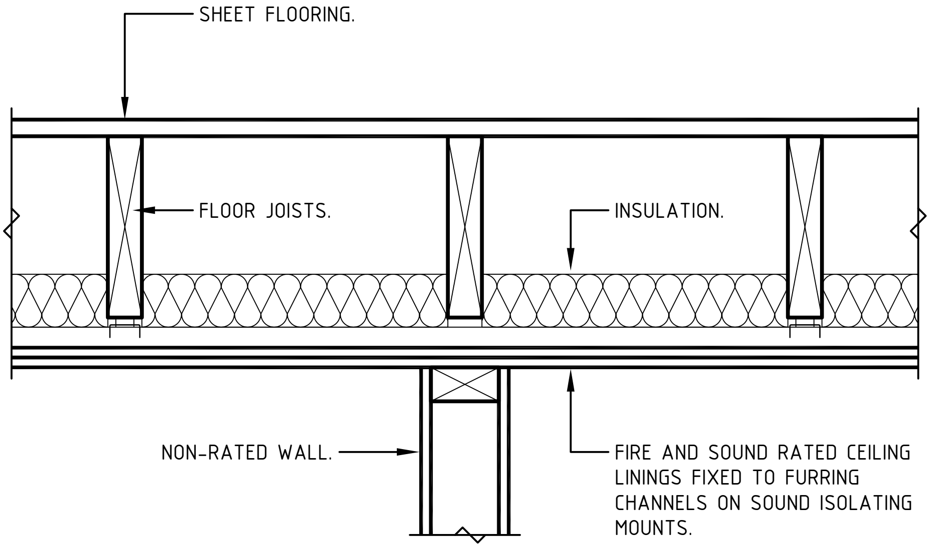

SECTION DETAIL - INTERNAL NON-RATED WALL TO RATED FLOOR ABOVE FD0054A

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Researcher:
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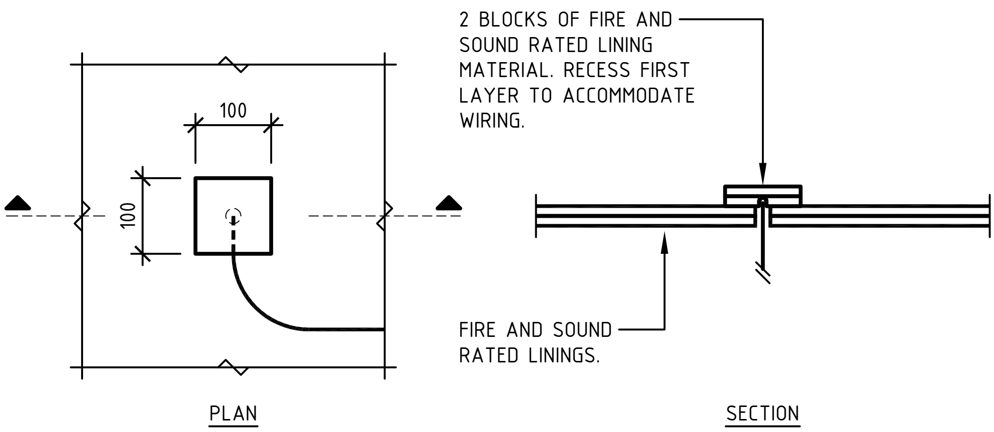

PLAN & SECTION DETAIL - ELECTRICAL WIRING PENETRATION IN RATED PLASTERBOARD LINING FD0057A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

FD0057A

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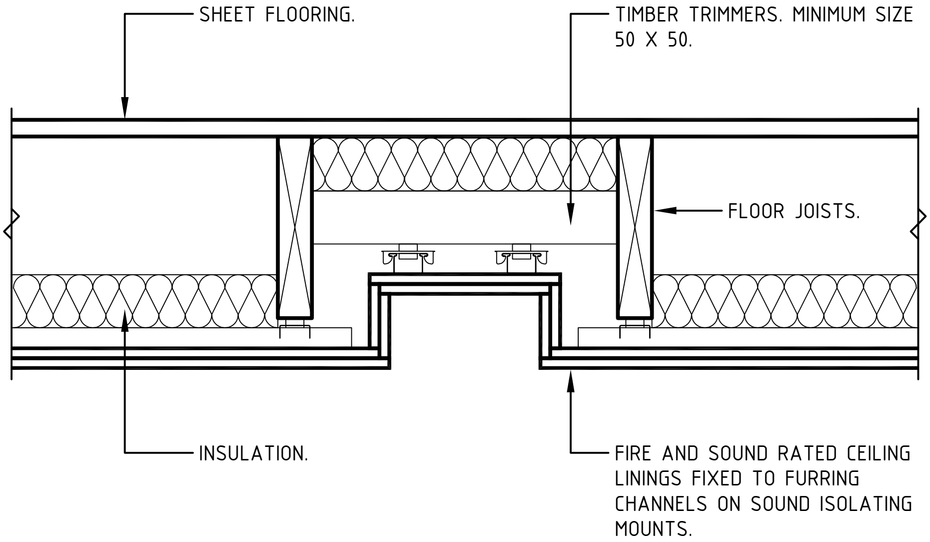

SECTION DETAIL - RECESSED LIGHT INTO FIRE RATED FLOOR
FD0058A

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Researcher:
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DETAIL REFERENCE NO.

FD0058A

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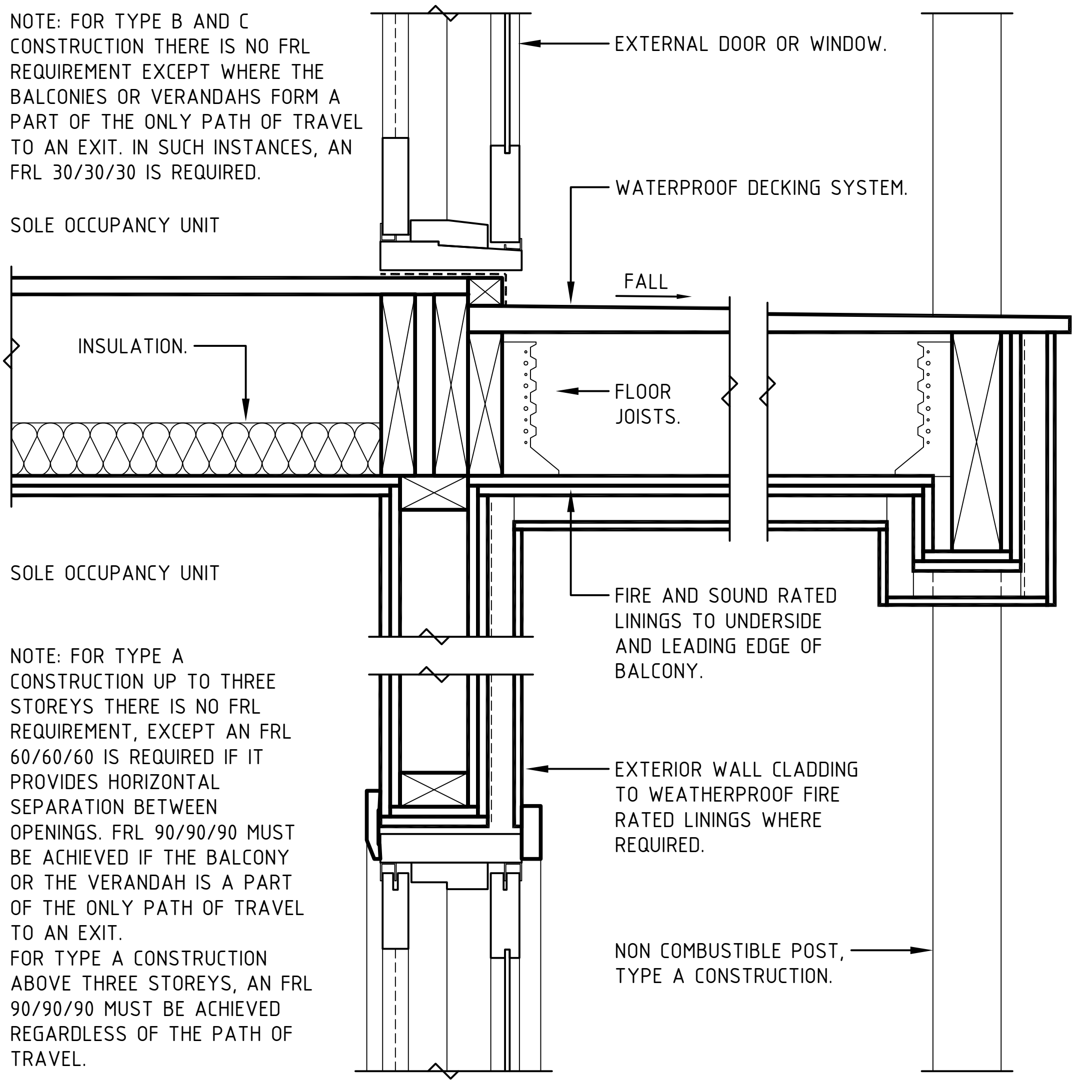

SECTION DETAIL – VERTICAL SEPARATION IN EXTERNAL WALLS TO PROTECT OPENINGS FROM FIRE

FD0059A

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Researcher:
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FD0059A

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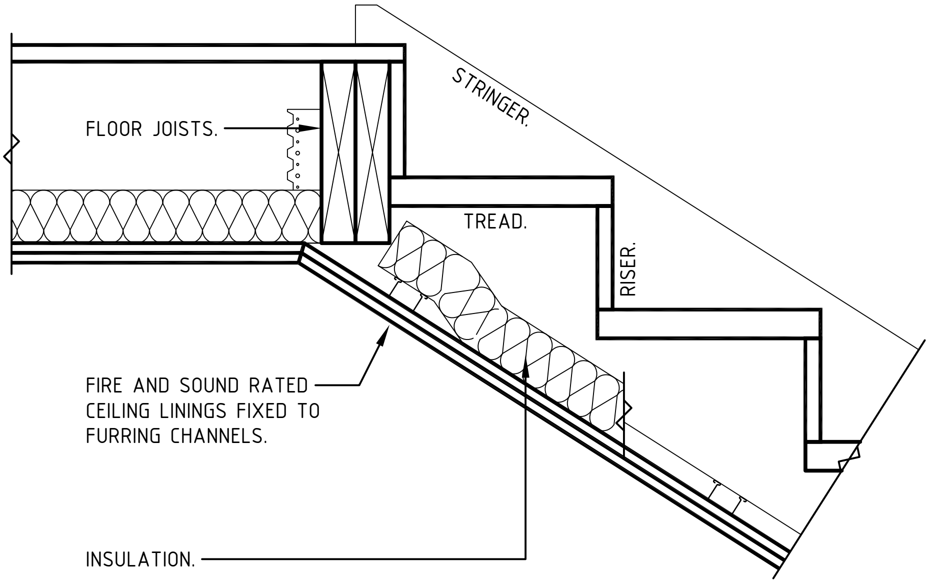

SECTION DETAIL - FIRE RATED LINING TO STAIR SOFFIT

FD0060A

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Researcher:
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DETAIL REFERENCE NO.

FD0060A

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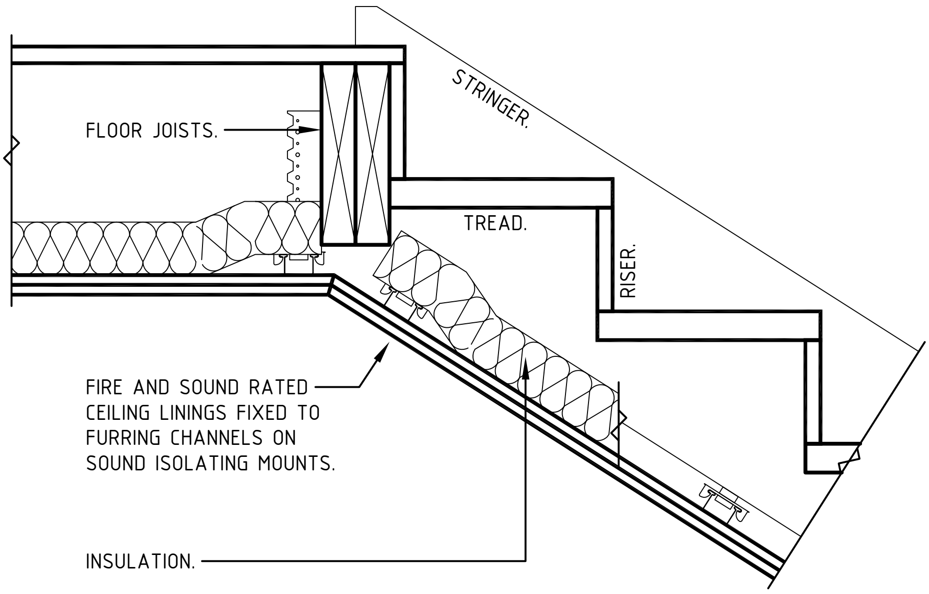

SECTION DETAIL – FIRE & SOUND RATED LINING TO STAIR SOFFIT FD0061A

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Researcher:
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DETAIL REFERENCE NO.
FD0061A

REVISION STATUS
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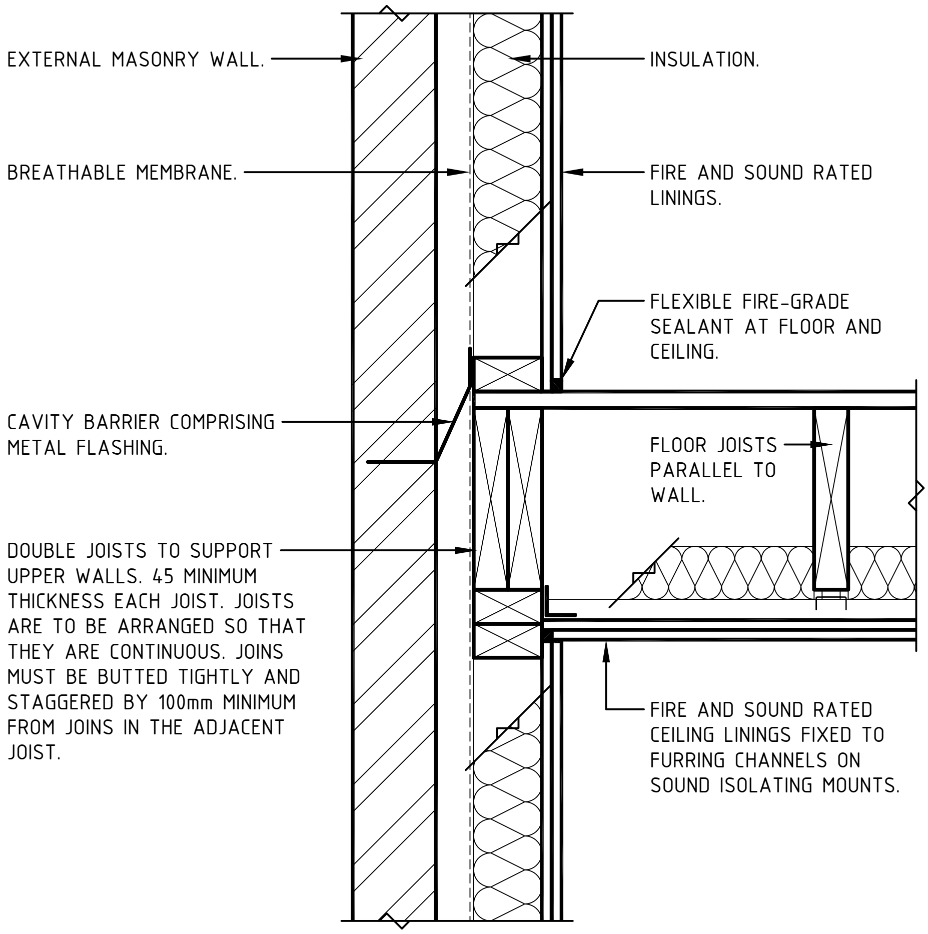

SECTION DETAIL - JUNCTION BETWEEN FIRE-RATED FLOOR AND FIRE-RATED EXTERNAL MASONRY VENEER WALL, METAL FLASHING CAVITY BARRIER, JOISTS PARALLEL

FD0070A

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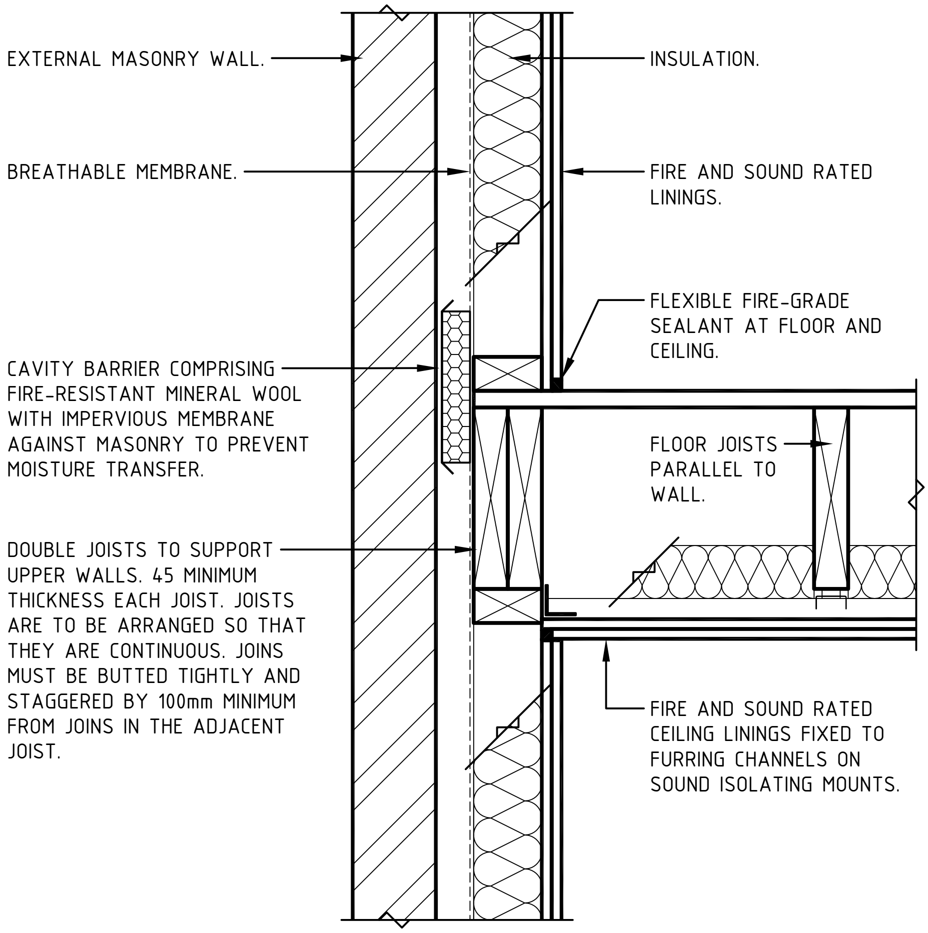
Researcher:
Timber Development Association (NSW)



SECTION DETAIL - JUNCTION BETWEEN FIRE-RATED FLOOR AND FIRE-RATED EXTERNAL MASONRY VENEER WALL, MINERAL WOOL CAVITY BARRIER, JOISTS PARALLEL FD0071A

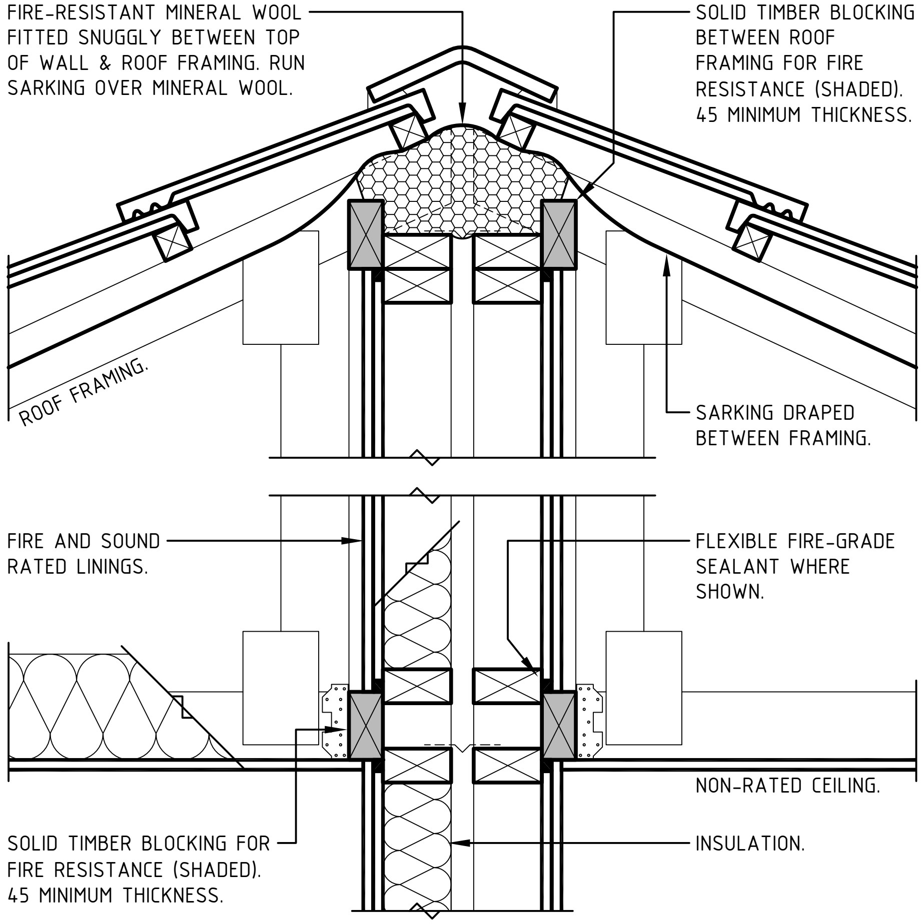
WoodSolutions™ design and build woodsolutions.com.au

Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.
FD0071A

REVISION STATUS
REV A / 01-06-2014 / MS
Original release.

SCALE 1:10 ON A4 SHEET



SECTION DETAIL - ROOF FRAMING TO DOUBLE STUD WALL, TRUSSES PERPENDICULAR, FRL 60/60/60 OR -/60/60 RD0001A

WoodSolutions™ design and build woodsolutions.com.au

Researcher:
Timber Development Association (NSW)

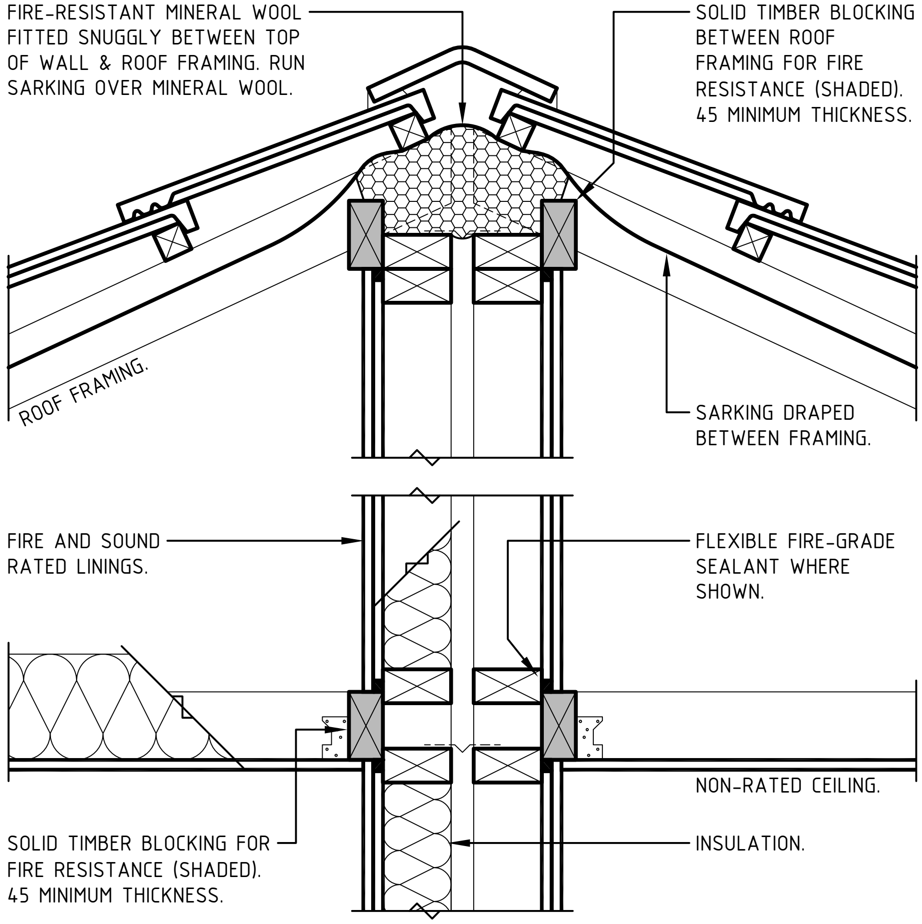
DETAIL REFERENCE NO.

RD0001A

REVISION STATUS

REV A / 01-06-2014 / MS
Original release.

SCALE 1:10 ON A4 SHEET



SECTION DETAIL - ROOF FRAMING TO DOUBLE STUD WALL, RAFTERS PERPENDICULAR, FRL 60/60/60 OR -/60/60 RD0002A

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IMPORTANT NOTICE

DETAIL REFERENCE NO.

RD0002A

REVISION STATUS

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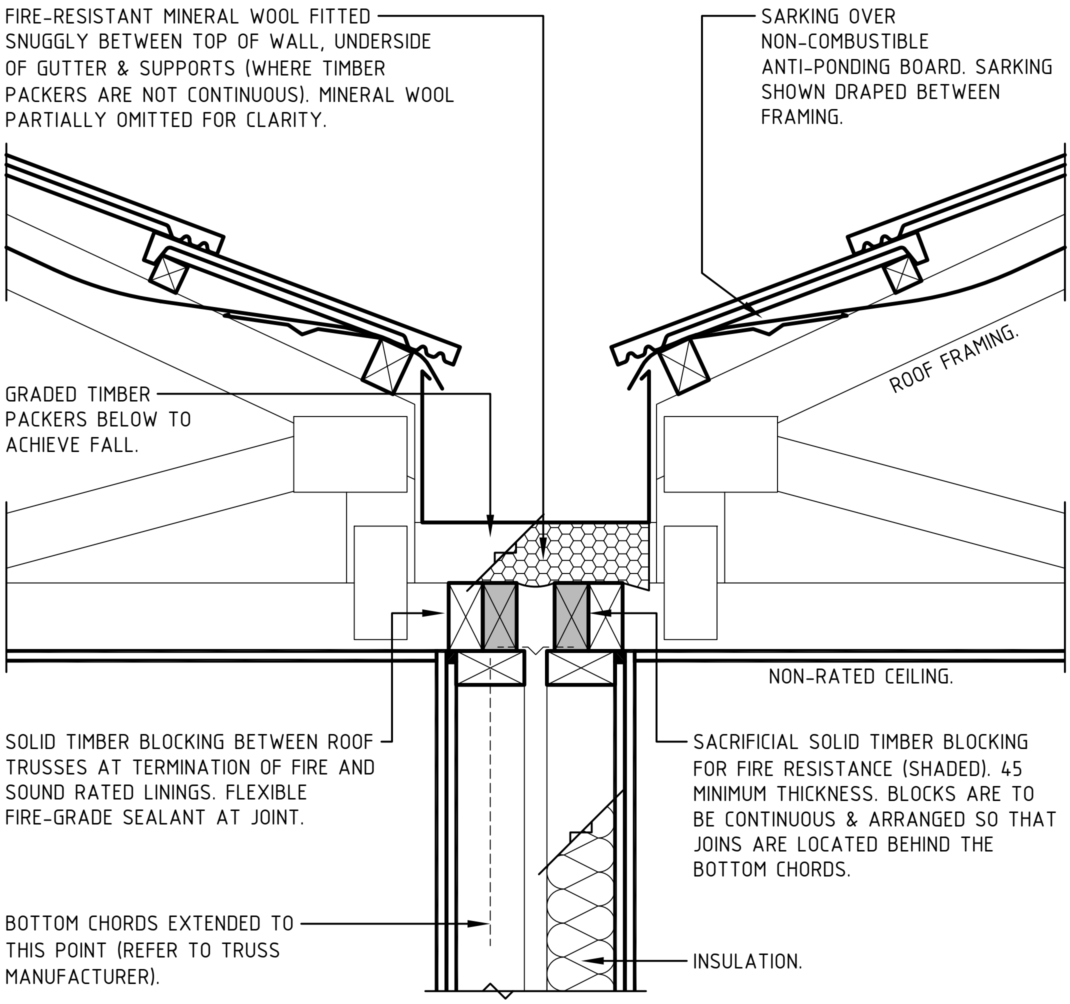
SCALE 1:10 ON A4 SHEET

Researcher:
Timber Development Association (NSW)



SECTION DETAIL – ROOF FRAMING TO DOUBLE STUD WALL, BOX GUTTER & TRUSSES PERPENDICULAR, FRL 60/60/60 OR –/60/60 RD0004A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.
RD0004A

REVISION STATUS
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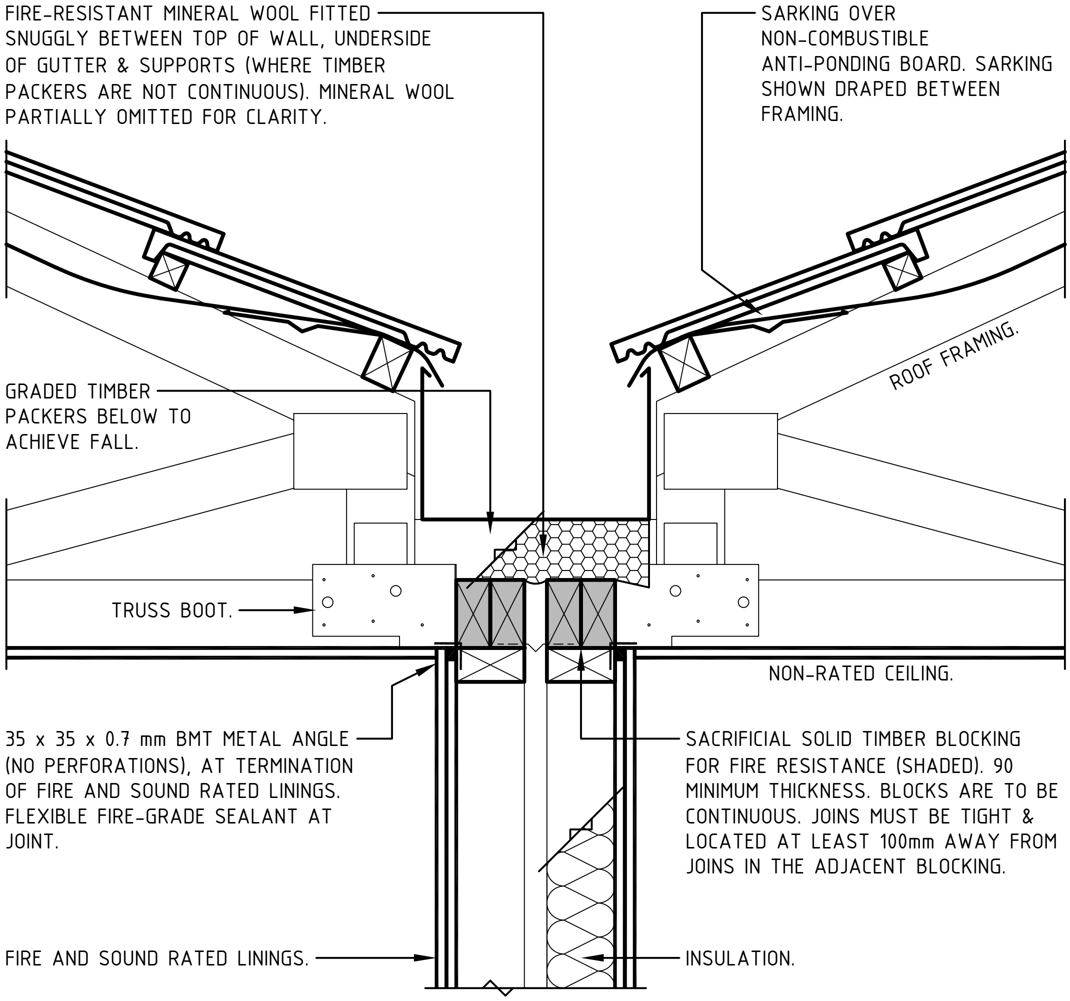

SECTION DETAIL - ROOF FRAMING TO DOUBLE STUD WALL, BOX GUTTER & TRUSSES PERPENDICULAR, FRL 90/90/90 OR -/90/90 RD0005A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

RD0005A

REVISION STATUS

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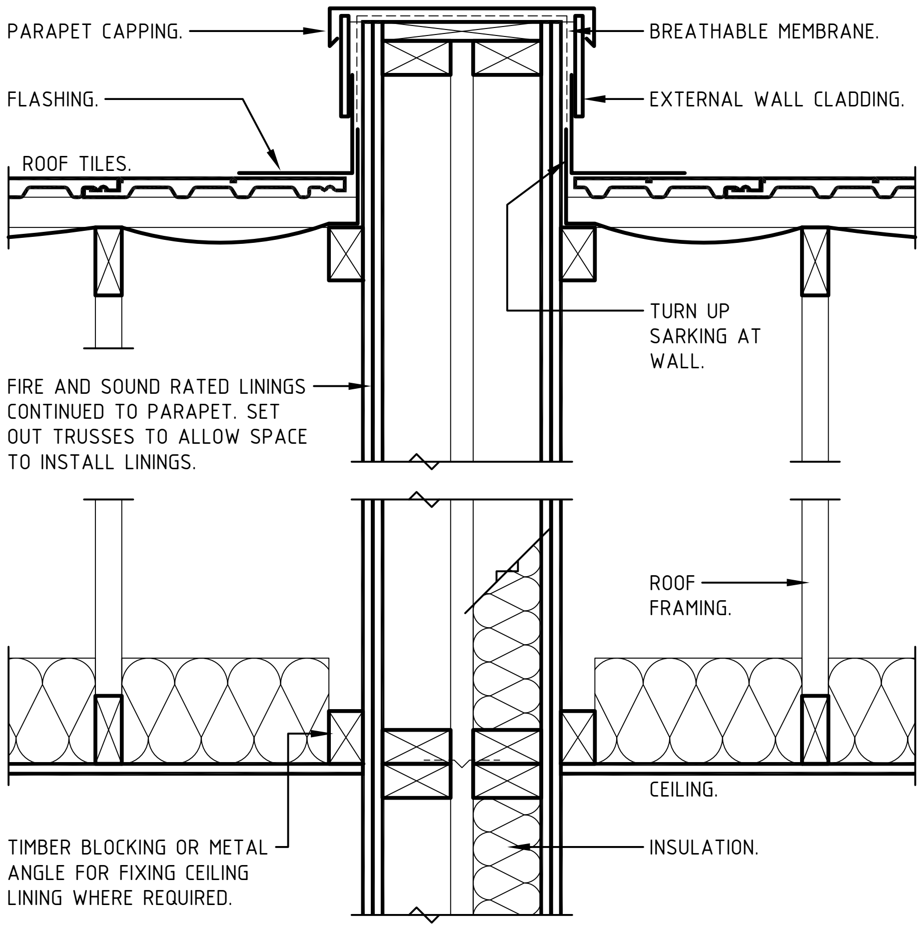

SECTION DETAIL – ROOF FRAMING TO DOUBLE STUD WALL WITH PARAPET, TRUSSES PARALLEL, FRL 60/60/60 OR -/60/60 RD0007A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

RD0007A

REVISION STATUS

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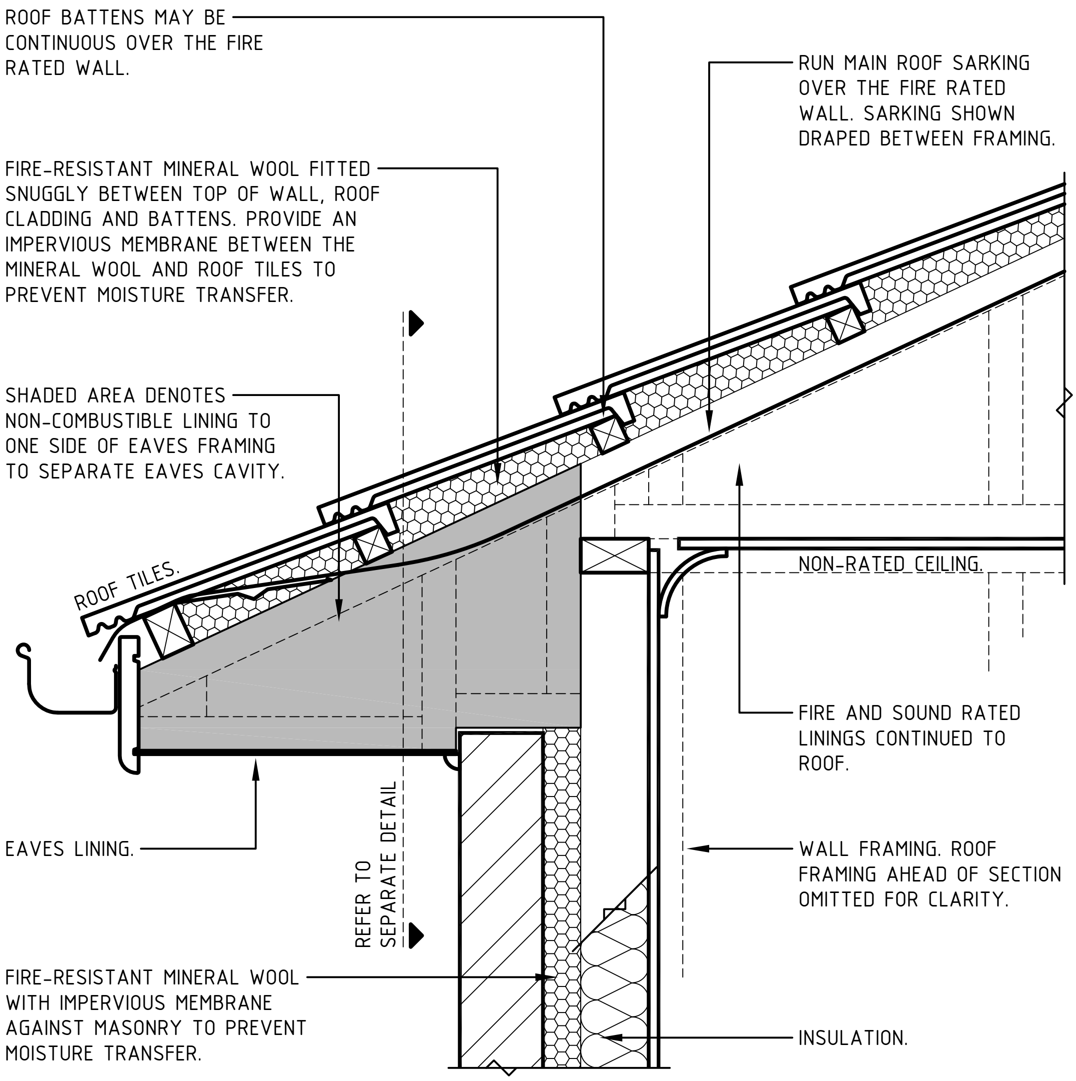
SCALE 1:10 ON A4 SHEET



SECTION DETAIL – EAVES BLOCKING, MASONRY VENEER EXTERNAL WALL
RD0020A

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Researcher:
Timber Development Association (NSW)

IMPORTANT NOTICE

DETAIL REFERENCE NO.
RD0020A

REVISION STATUS
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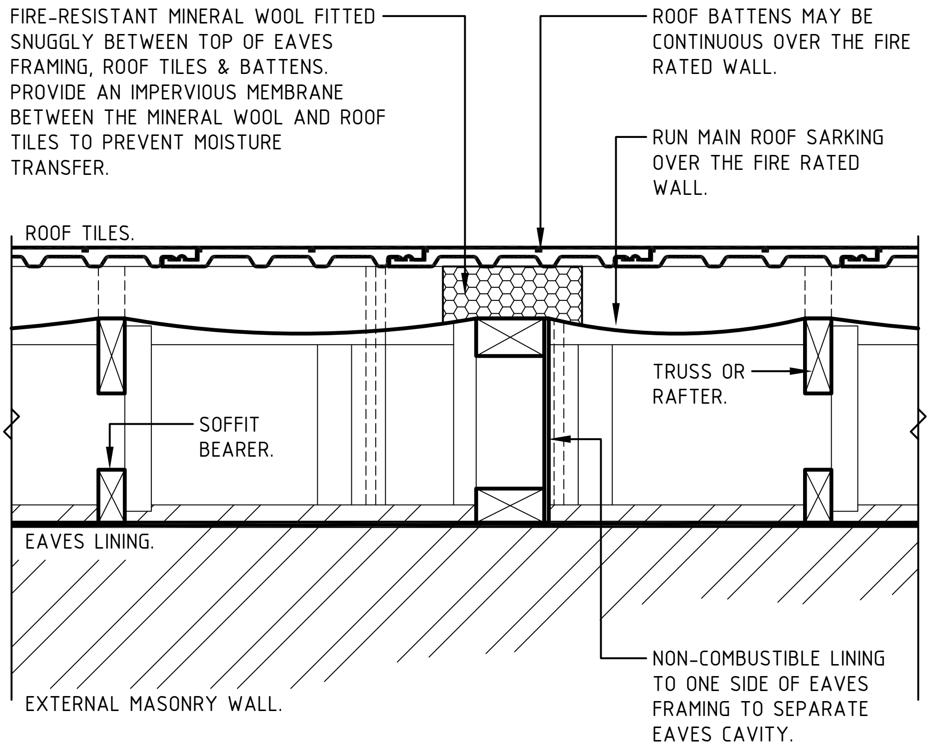
SCALE 1:10 ON A4 SHEET



ELEVATION DETAIL - EAVES BLOCKING AT DOUBLE STUD WALL, MASONRY VENEER EXTERNAL WALL RD0021A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

RD0021A

REVISION STATUS

REV A / 01-06-2014 / MS
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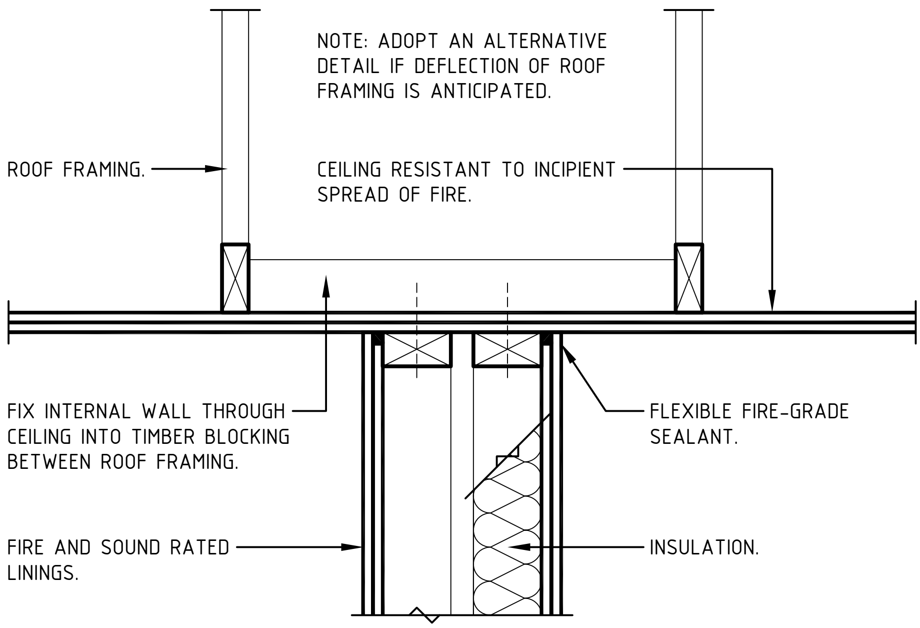
SCALE 1:10 ON A4 SHEET



SECTION DETAIL - INTERNAL RATED WALL TO CEILING RESISTANT TO INCIPIENT SPREAD OF FIRE, TRUSSES PARALLEL RD0022A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

RD0022A

REVISION STATUS

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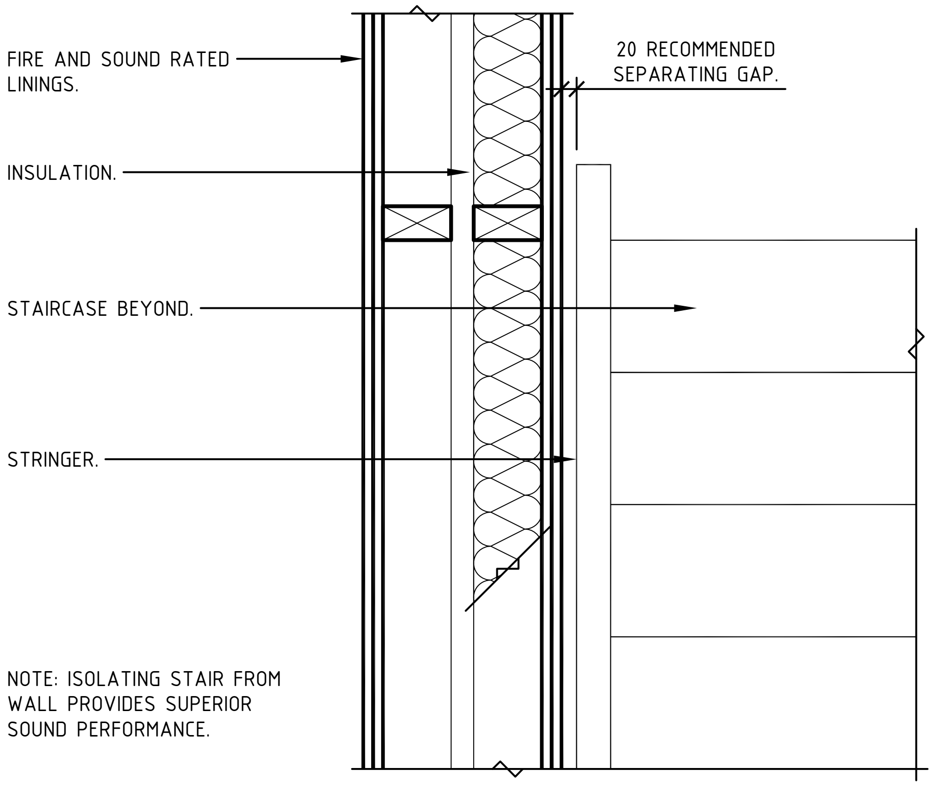
Original release.

SCALE 1:10 ON A4 SHEET



SECTION DETAIL - STAIR ISOLATED FROM WALL
WD0001A

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design and build
woodsolutions.com.au

Researcher:
Timber Development Association (NSW)

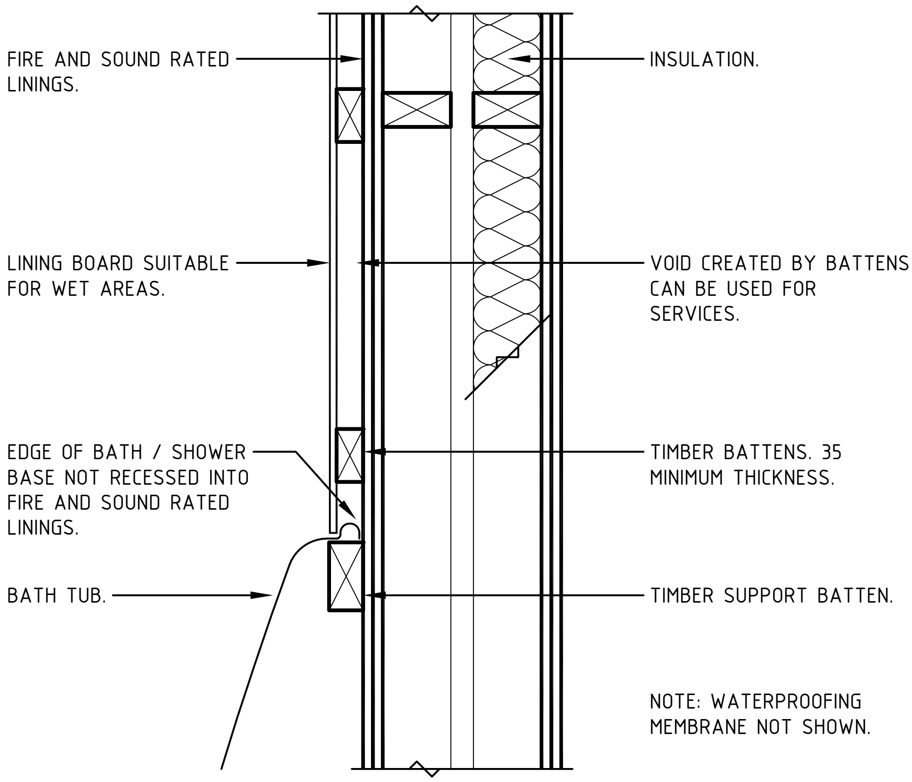
DETAIL REFERENCE NO.

WD0001A

REVISION STATUS

REV A / 01-06-2014 / MS
Original release.

SCALE 1:10 ON A4 SHEET



SECTION DETAIL - DOUBLE STUD WALL BATTENED TO RECEIVE SERVICES & BATH / SHOWER

WD0002A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

WD0002A

REVISION STATUS

REV A / 01-06-2014 / MS
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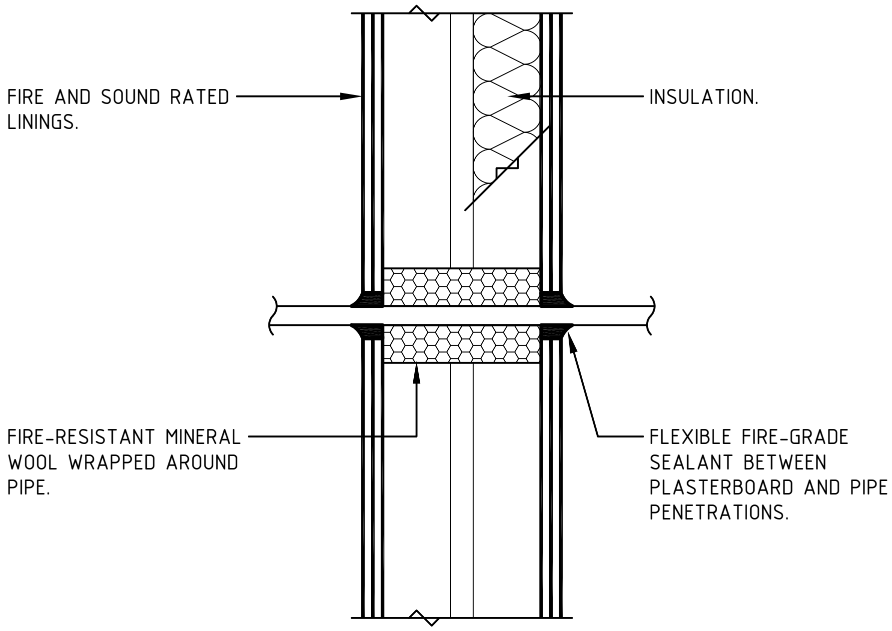
SCALE 1:10 ON A4 SHEET



SECTION DETAIL - PIPE PENETRATION THROUGH DOUBLE STUD WALL WD0003A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

WD0003A

REVISION STATUS

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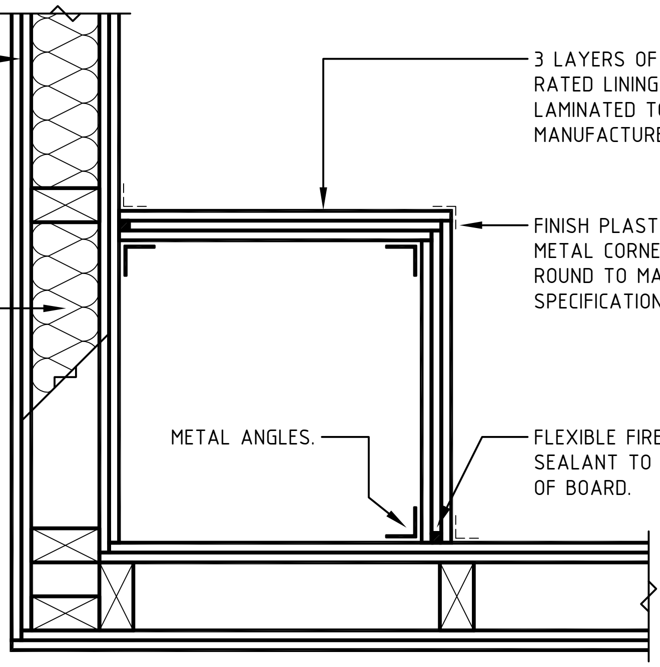

PLAN DETAIL - FIRE RATED SHAFT IN CORNER OF WALL, BUILT FROM LAMINATED PLASTERBOARD WD0012A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

WD0012A

REVISION STATUS

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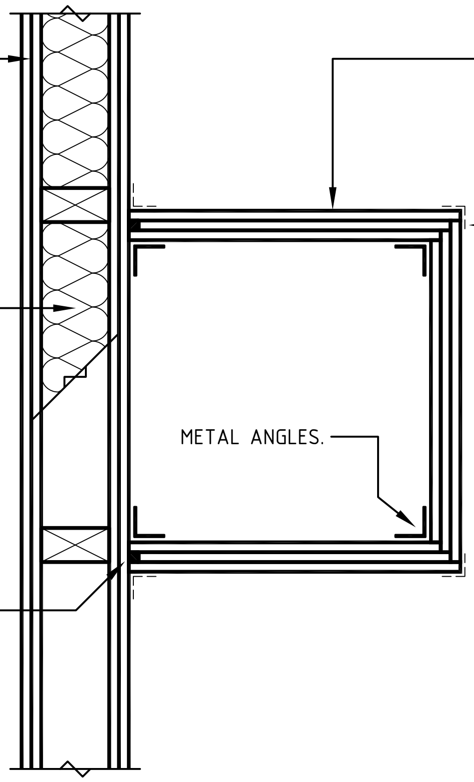

PLAN DETAIL - FIRE RATED SHAFT ON STRAIGHT WALL, BUILT FROM LAMINATED PLASTERBOARD WD0013A

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IMPORTANT NOTICE

DETAIL REFERENCE NO.

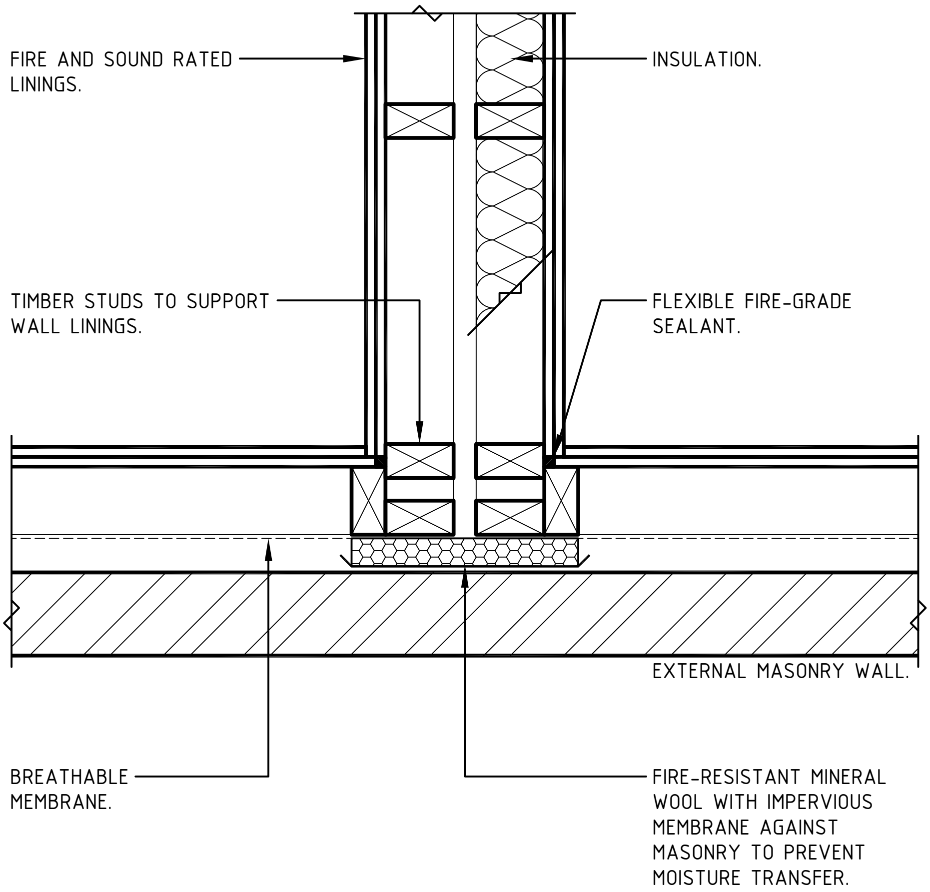
WD0013A

REVISION STATUS

REV A / 01-06-2014 / MS
Original release.

SCALE 1:10 ON A4 SHEET

Researcher:
Timber Development Association (NSW)



PLAN DETAIL - JUNCTION OF FIRE RATED MASONRY VENEER WALL TO DOUBLE STUD WALL WD0021A

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design and build
woodsolutions.com.au

Researcher:
Timber Development Association (NSW)

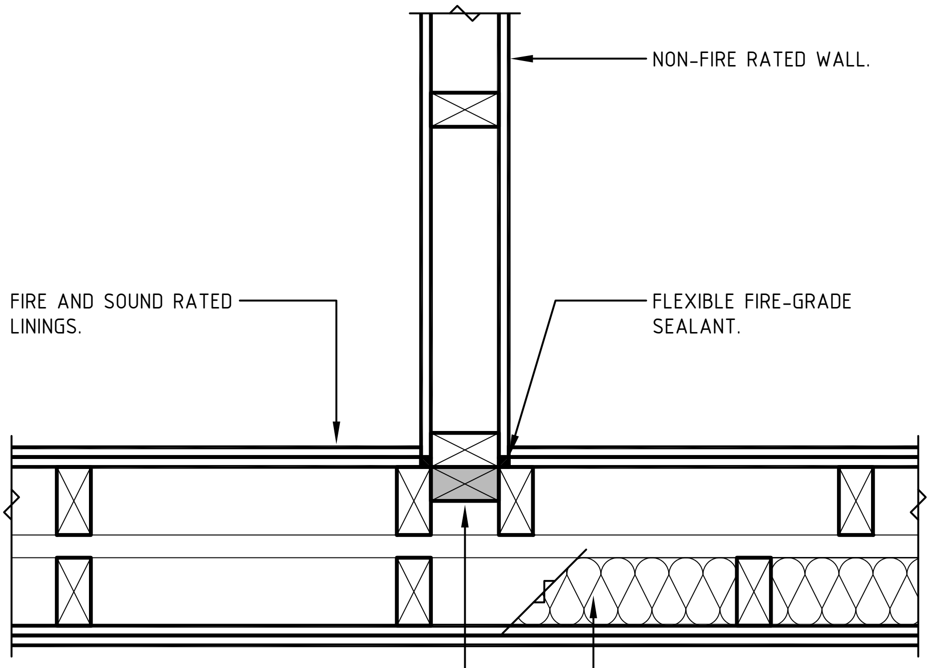
DETAIL REFERENCE NO.

WD0021A

REVISION STATUS

REV A / 01-06-2014 / MS
Original release.

SCALE 1:10 ON A4 SHEET



PLAN DETAIL - JUNCTION OF FIRE RATED DOUBLE STUD WALL TO NON-FIRE RATED WALL, FRL 60/60/60 OR -/60/60 WD0023A

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Researcher:
Timber Development Association (NSW)

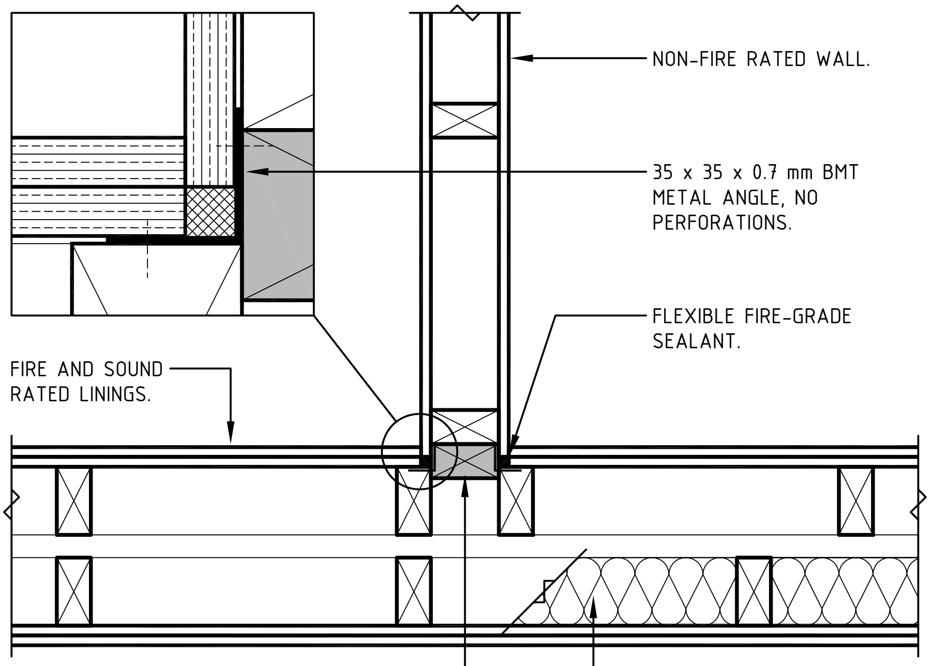
DETAIL REFERENCE NO.

WD0023A

REVISION STATUS

REV A / 01-06-2014 / MS
Original release.

SCALE 1:10 ON A4 SHEET



PLAN DETAIL - JUNCTION OF FIRE RATED DOUBLE STUD WALL TO NON-FIRE RATED WALL, FRL 90/90/90 OR -/90/90 WD0024A

WoodSolutions™
design and build
woodsolutions.com.au

Researcher:
Timber Development Association (NSW)

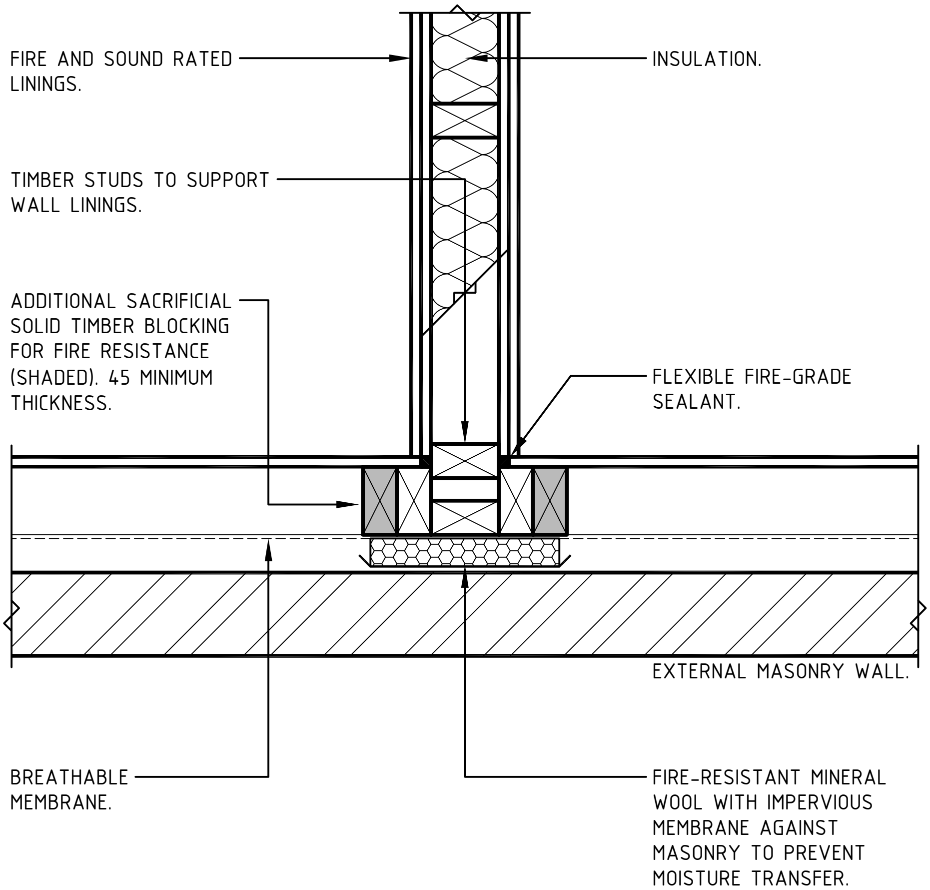
DETAIL REFERENCE NO.

WD0024A

REVISION STATUS

REV A / 01-06-2014 / MS
Original release.

SCALE 1:10 ON A4 SHEET



PLAN DETAIL – JUNCTION OF MASONRY VENEER WALL TO SINGLE STUD WALL WD0030A

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design and build
woodsolutions.com.au

Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

WD0030A

REVISION STATUS

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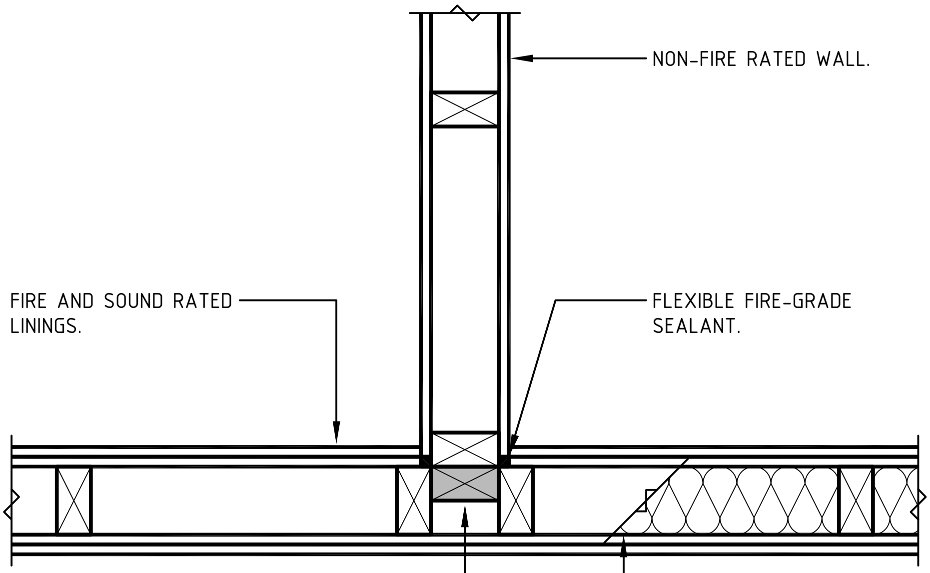
Original release.

SCALE 1:10 ON A4 SHEET



PLAN DETAIL - JUNCTION OF FIRE RATED SINGLE STUD WALL TO NON-FIRE RATED WALL, FRL 60/60/60 OR -/60/60 WD0031A

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design and build
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Researcher:
Timber Development Association (NSW)

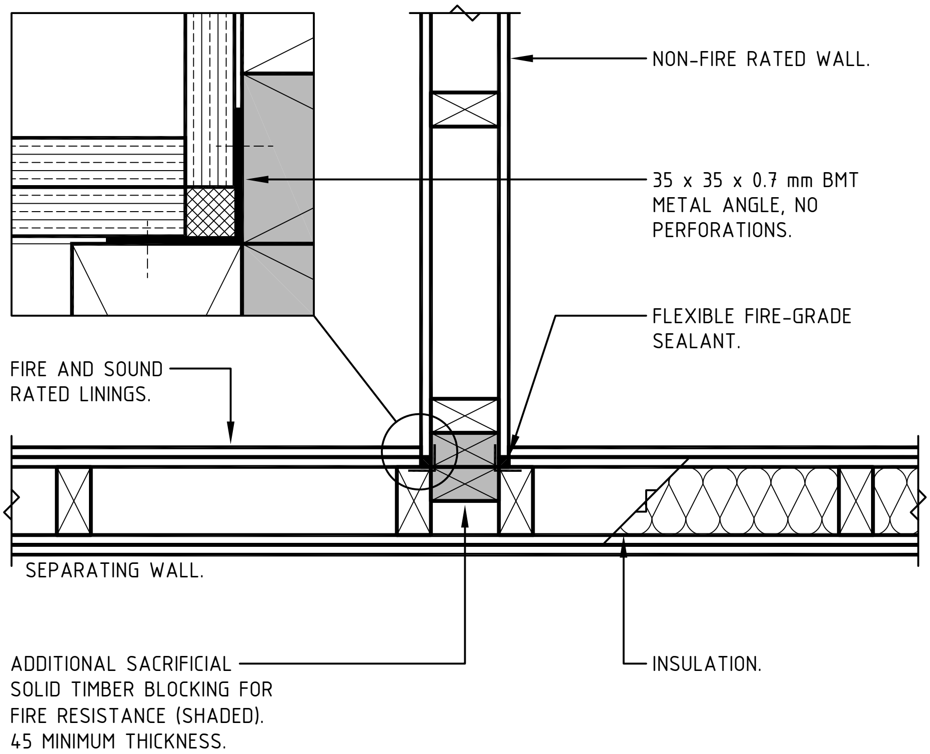
DETAIL REFERENCE NO.

WD0031A

REVISION STATUS

REV A / 01-06-2014 / MS
Original release.

SCALE 1:10 ON A4 SHEET



PLAN DETAIL - JUNCTION OF FIRE RATED SINGLE STUD WALL TO NON-FIRE RATED WALL, FRL 90/90/90 OR -/90/90 WD0032A

WoodSolutions™ design and build
woodsolutions.com.au

Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

WD0032A

REVISION STATUS

REV A / 01-06-2014 / MS
Original release.

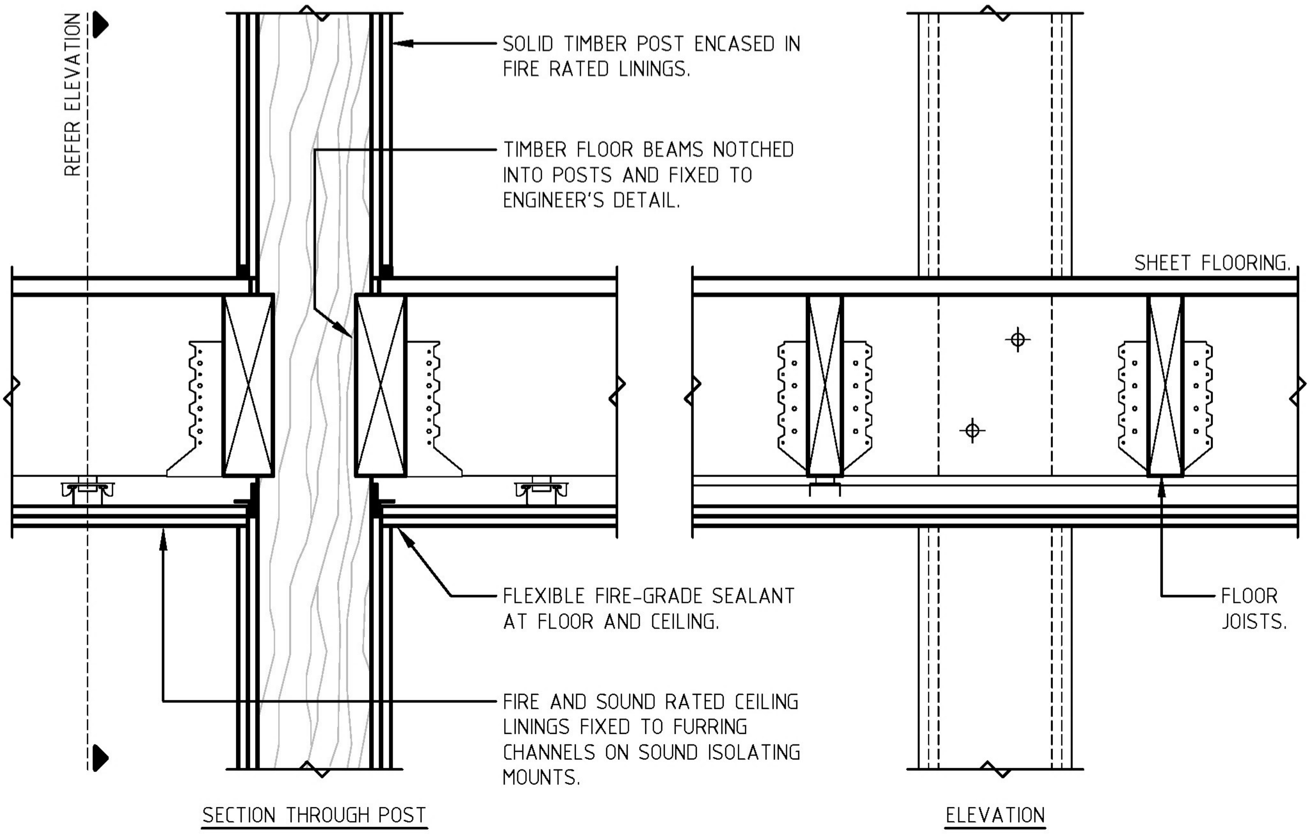
SCALE 1:10 ON A4 SHEET

CROSS REFERENCING BETWEEN WOODSOLUTIONS TECHNICAL DESIGN GUIDES & WOODSOLUTIONS CAD DETAILS

REVISION DATE: 4/09/2014

TDG #	FIGURE #	CAD DETAIL #	REMARK
3	01 -	-	Not provided. TDG detail is diagrammatic.
3	02 -	-	Not provided. TDG detail is diagrammatic.
3	03 -	-	Not provided. TDG detail is diagrammatic.
3	04 -	-	Not provided. TDG detail is diagrammatic.
3	05 -	-	Not provided. TDG detail is diagrammatic.
3	06 -	-	Not provided. TDG detail is diagrammatic.
3	07 -	-	Not provided. TDG detail is diagrammatic.
3	08 -	-	Not provided. TDG detail is diagrammatic.
3	09 -	-	Not provided. TDG detail is diagrammatic.
3	10 -	-	Not provided. TDG detail is diagrammatic.
3	11 -	-	Not provided. TDG detail is diagrammatic.
3	12 -	-	Not provided. TDG detail is diagrammatic.
3	13 -	-	Not provided. Considered that a plan detail of a short section of straight wall is not as useful as a vertical section to
3	14 -	-	Not provided. TDG detail is diagrammatic.
3	15 -	-	Not provided. TDG detail is diagrammatic.
3	16 -	-	Not provided. Considered that a plan detail of a short section of straight wall is not as useful as a vertical section to depict wall construction systems.
3	17 -	-	Not provided. Considered that a plan detail of a short section of straight wall is not as useful as a vertical section to depict wall construction systems.
3	18 -	-	Not provided. Considered that a plan detail of a short section of straight wall is not as useful as a vertical section to depict wall construction systems.
3	19 -	FD0040	-
3	20 -	FD0051	-
3	21 a	FD0080	-
3	21 b	FD0081	-
3	22 a	FD0082	-
3	22 b	FD0083	-
3	23 -	WD0030	-
3	24 -	WD0011	-
3	25 -	WD0031	-
3	26 -	WD0032	-
3	27 -	RD0011	Variation of RD0010 with rafters and ceiling joists instead of trusses.
3	28 -	RD0010	-
3	29 -	RD0012	-
3	30 -	FD0030	Variation of figure FD0032 with joists parallel on both sides.
3	30 -	FD0031	Variation of figure FD0032 with joists perpendicular on both sides.

TDG #	FIGURE #	CAD DETAIL #	REMARK
3	30 -	FD0032	-
3	31 -	FD0033	CAD detail varied to be more realistic by showing floor trusses both sides of the separating wall instead of floor trusses on one side, and timber I-beam sections on the other.
3	31 -	FD0035	Variation of figure FD0033 with floor trusses perpendicular on one side and parallel on the other.
3	32 -	FD0034	CAD detail varied to be more realistic by showing same style of floor truss both sides of separating wall.
3	33 -	FD0054	-
3	34 -	FD0050	CAD detail varied to be more generic by showing a break line over the doorhead.
3	35 -	-	Not provided. TDG detail is diagrammatic.
3	36 -	-	Not provided. TDG detail is diagrammatic.
3	37 -	-	Not provided. TDG detail is diagrammatic.
3	38 -	-	Not provided. TDG detail is diagrammatic.
3	39 -	FD0055	-
3	40 LHS	FD0056	CAD detail drawn with 2 layers of plasterboard instead of 3 (considered to be the more common case).
3	40 RHS	WD0011	-
3	41 -	FD0057	CAD detail drawn as an orthogonal plan and section view to simplify project customisation if necessary.
3	42 -	WD0010	-
3	43 -	FD0058	CAD detail has omitted the perspective view. CAD detail varied to show isolating mounts to the top of the recessed plasterboard.
3	44 -	FD0060	CAD detail varied to be more generic by omitting the stair flight in the background. Furring channels to the underside of the floor joists omitted.
3	44 -	FD0061	Variation of FD0060 with furring channels on sound isolating mounts.
3	45 -	WD0014	-
3	46 -	-	Not provided. TDG detail is diagrammatic.
3	47 -	FD0041	CAD detail varied to depict a different type of upgraded acoustic isolating mount.
3	48 -	FD0043	CAD detail drawn as an orthogonal plan view to simplify project customisation if necessary.
3	49 -	FD0042	CAD detail drawn as an orthogonal plan view to simplify project customisation if necessary.
3	50 -	FD0044	CAD detail drawn as an orthogonal plan view to simplify project customisation if necessary.
3	51 -	FD0045	CAD detail drawn as an orthogonal plan view to simplify project customisation if necessary. CAD detail varied to increase height between underside of ceiling joist and underside of floor joist so that sound insulation doesn't need to be compressed under floor joists.
3	52 -	WD0001	CAD detail varied to be more generic by showing only one side of stair.



SECTION DETAIL - IN-PLANE POST & BEAM CONSTRUCTION WITH ENCASED TIMBER POSTS TO ACHIEVE FIRE RESISTANCE FD0081A

WoodSolutions™ design and build woodsolutions.com.au

Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

FD0081A

REVISION STATUS

REV A / 01-06-2014 / MS
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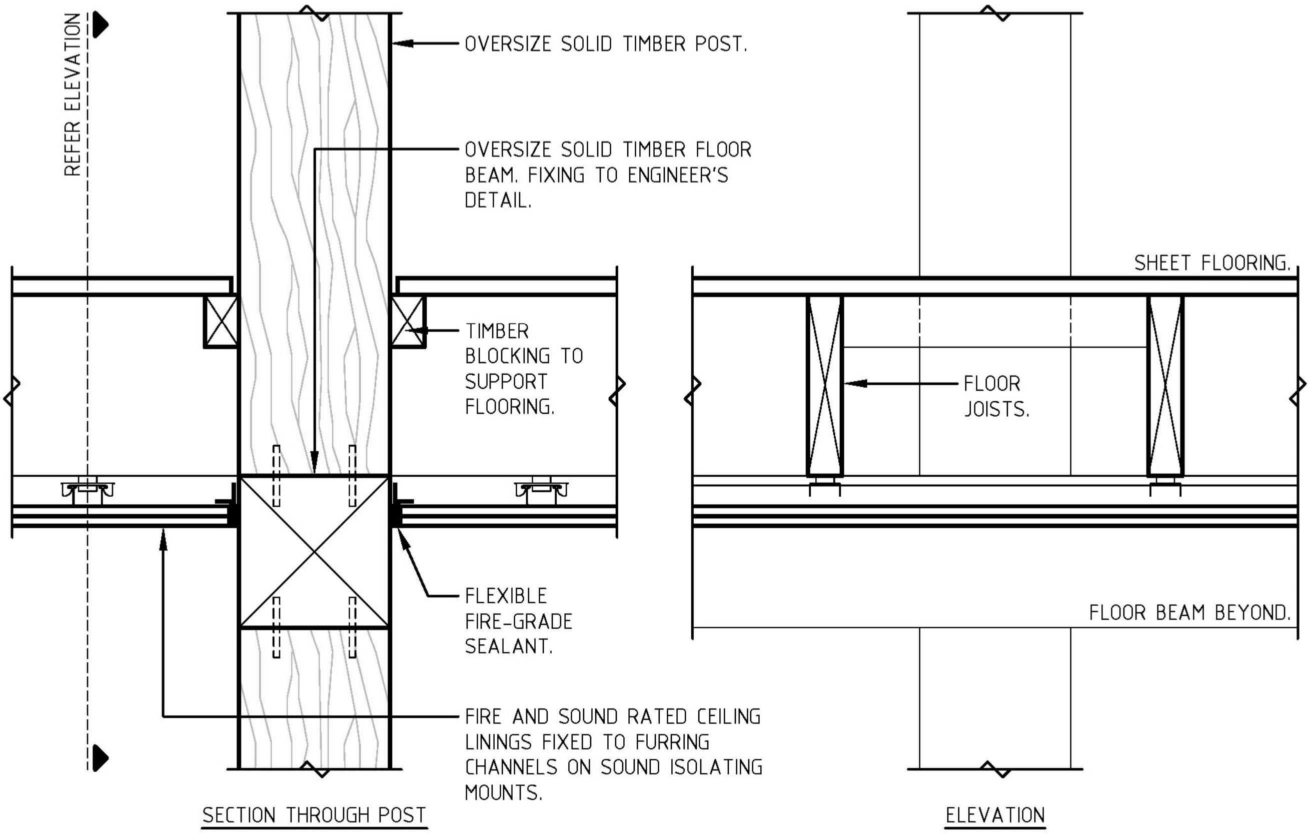

SECTION DETAIL - BULKHEAD POST & BEAM CONSTRUCTION WITH OVERSIZED TIMBER POSTS TO ACHIEVE FIRE RESISTANCE

FD0082A

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design and build
woodsolutions.com.au

Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

FD0082A

REVISION STATUS

REV A / 01-06-2014 / MS
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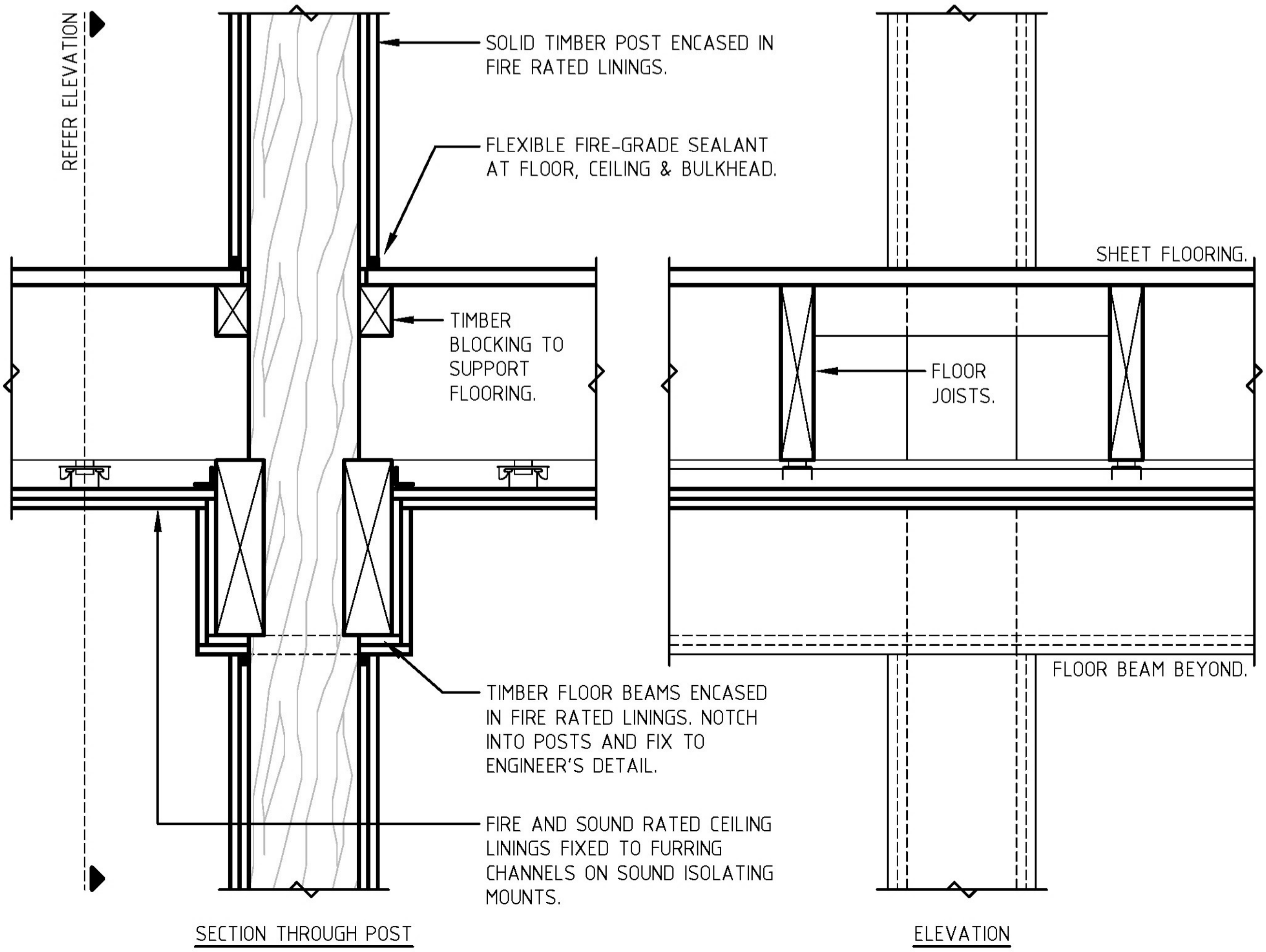
SCALE 1:10 ON A4 SHEET



SECTION DETAIL – BULKHEAD POST & BEAM CONSTRUCTION WITH ENCASED TIMBER POSTS & FLOOR BEAMS TO ACHIEVE FIRE RESISTANCE FD0083A

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IMPORTANT NOTICE

DETAIL REFERENCE NO.

FD0083A

REVISION STATUS

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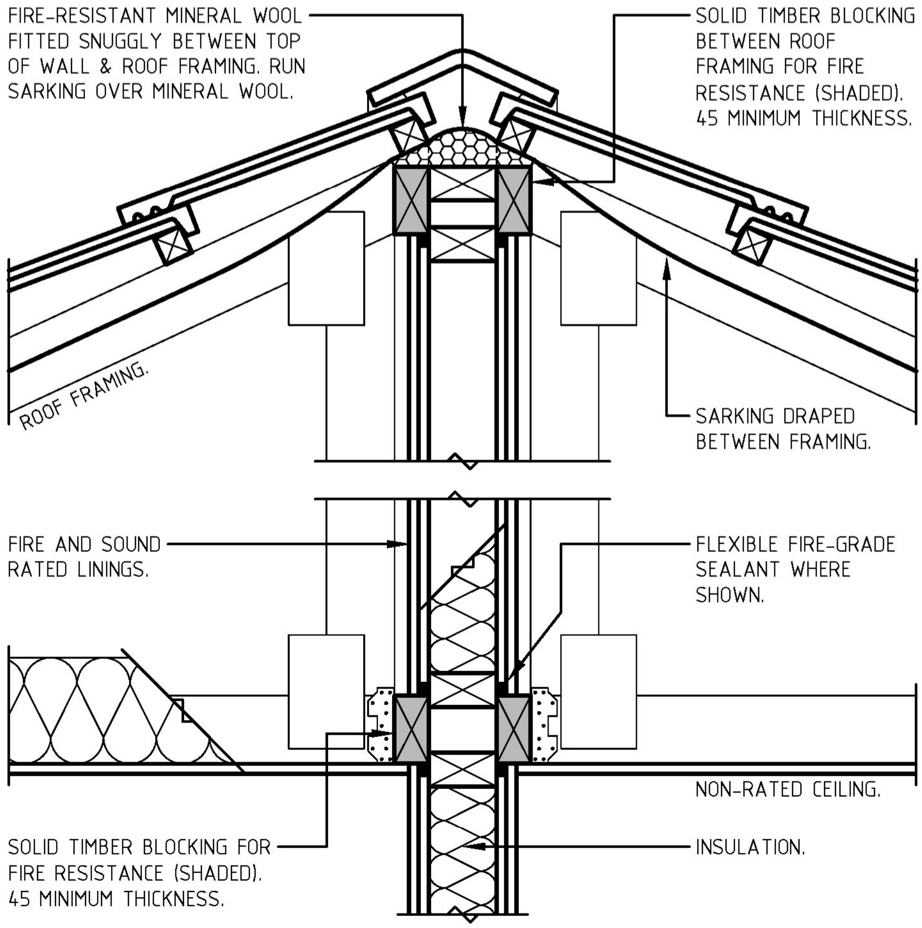
Researcher:
Timber Development Association (NSW)



SECTION DETAIL - ROOF FRAMING TO SINGLE STUD WALL, TRUSSES PERPENDICULAR, FRL 60/60/60 OR -/60/60 RD0010A

WoodSolutions™ design and build woodsolutions.com.au

Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

RD0010A

REVISION STATUS

REV A / 01-06-2014 / MS
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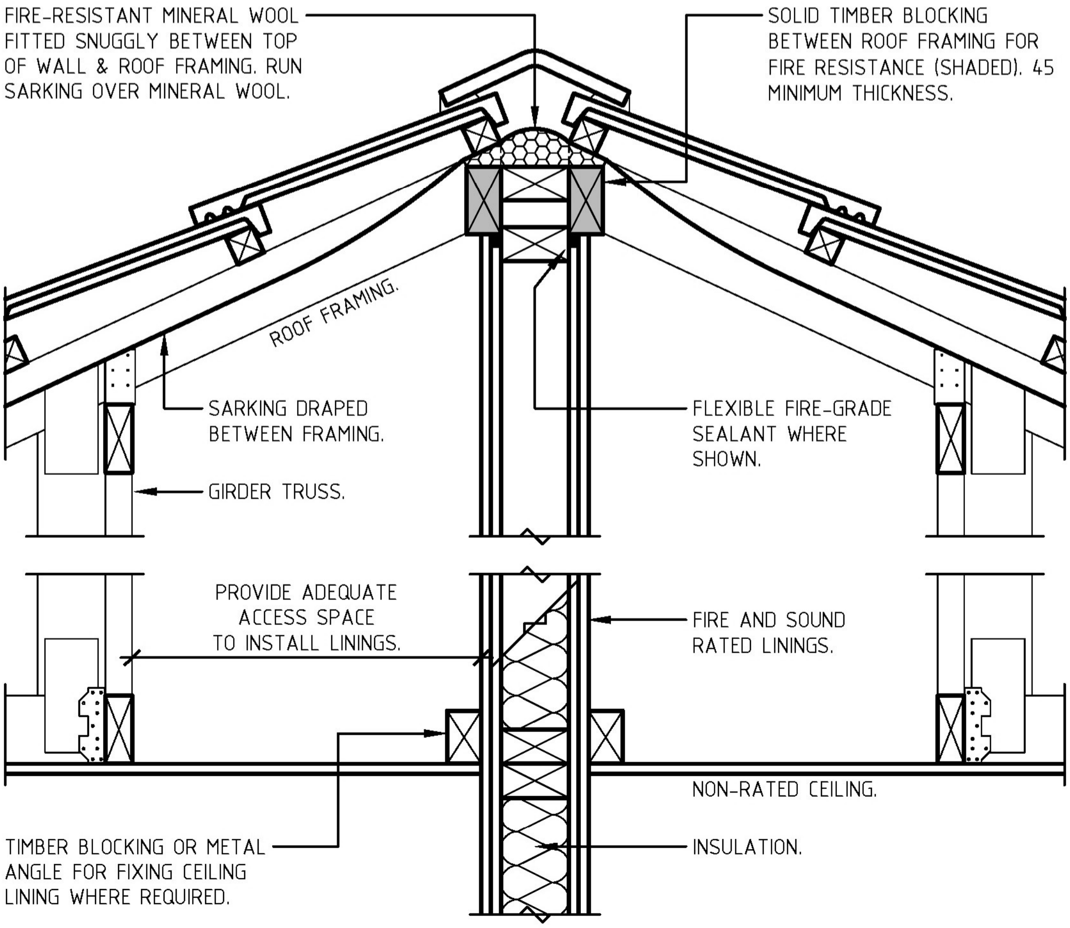
SCALE 1:10 ON A4 SHEET



SECTION DETAIL - ROOF FRAMING TO SINGLE STUD WALL, TRUSSES PERPENDICULAR & PARALLEL GIRDER TRUSS RD0012A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

RD0012A

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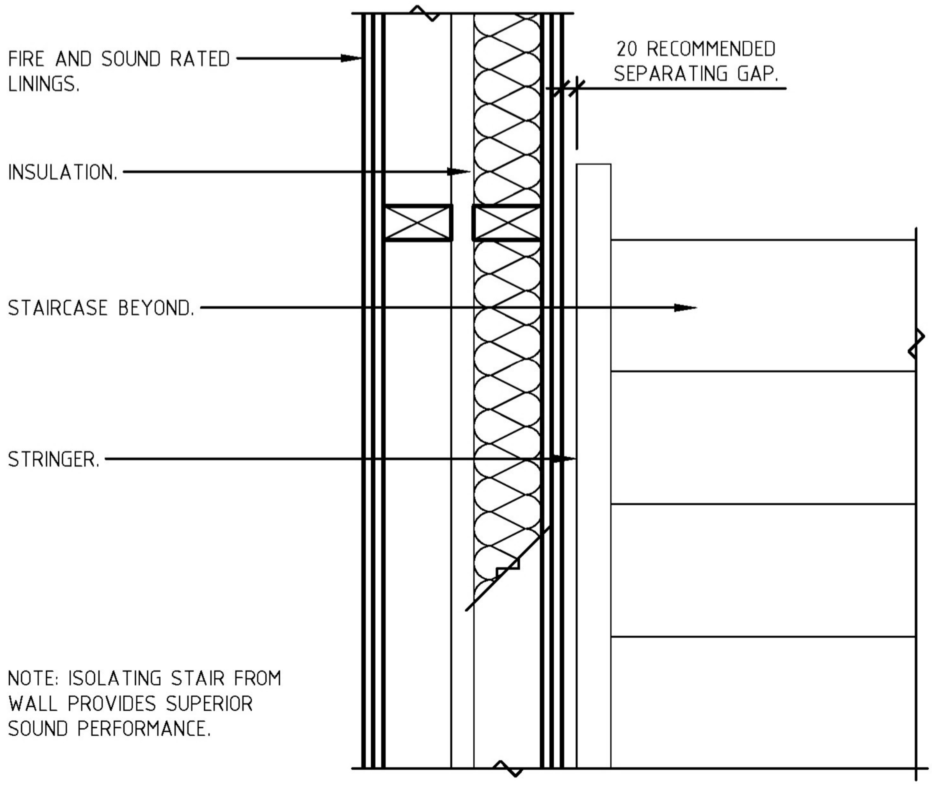
SCALE 1:10 ON A4 SHEET



SECTION DETAIL - STAIR ISOLATED FROM WALL

WD0001A

design and build
woodsolutions.com.au

Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

WD0001A

REVISION STATUS

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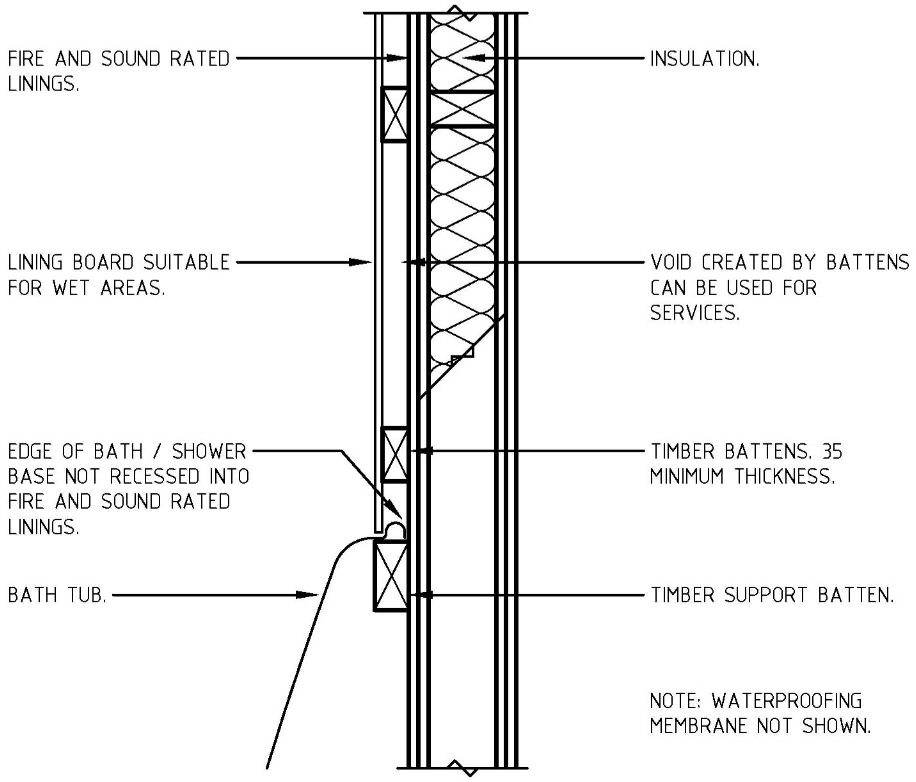

SECTION DETAIL - SINGLE STUD WALL BATTENED TO RECEIVE SERVICES & BATH / SHOWER

WD0010A

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design and build
woodsolutions.com.au

Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

WD0010A

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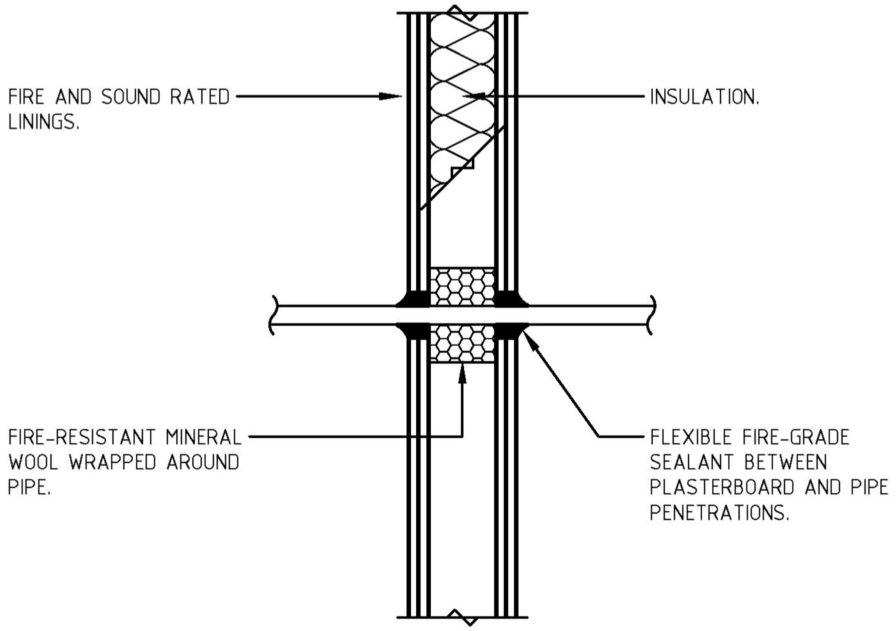

SECTION DETAIL - PIPE PENETRATION THROUGH SINGLE STUD WALL

WD0011A

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Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

WD0011A

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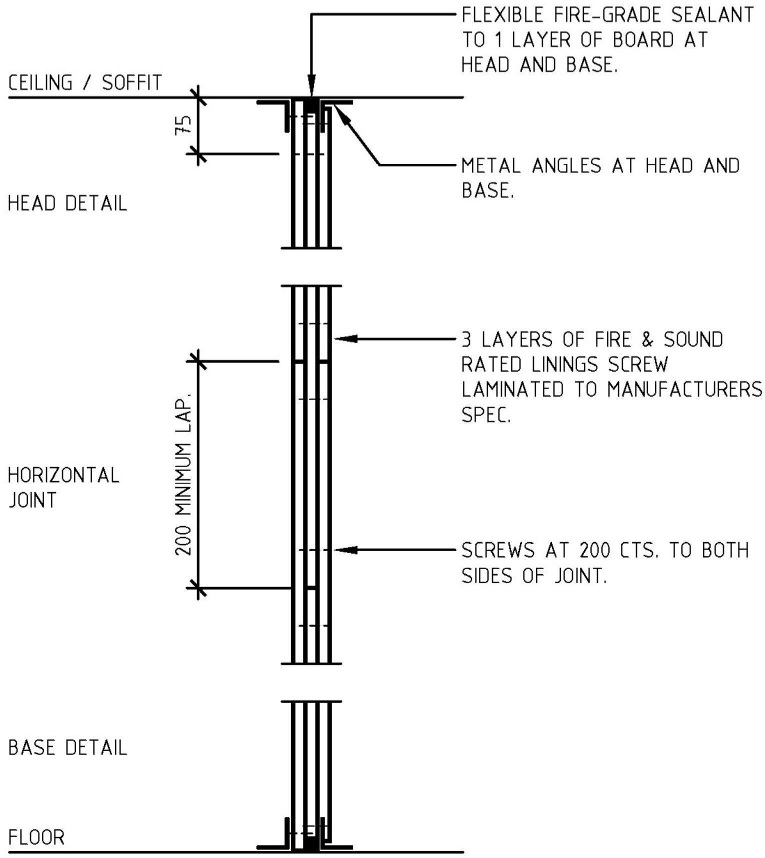

SECTION DETAIL - SMOKE PROOF WALL BUILT FROM LAMINATED PLASTERBOARD, FRL -/90/90 WD0014A

Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

WD0014A

REVISION STATUS

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Original release.

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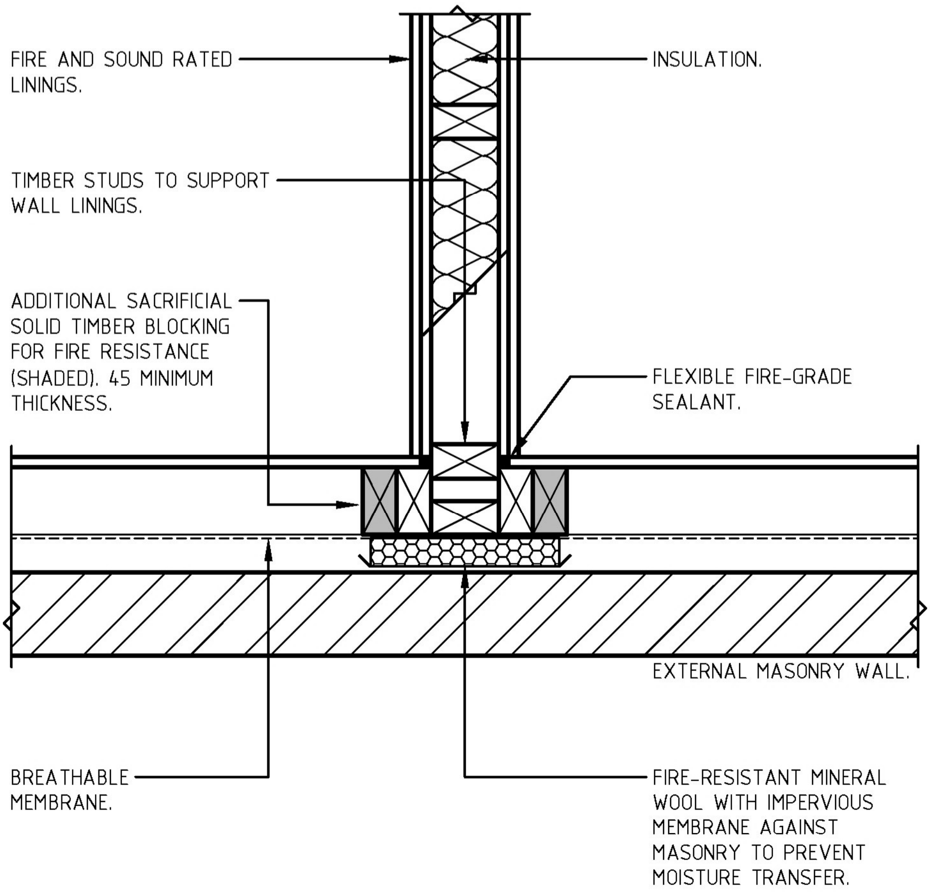

PLAN DETAIL - JUNCTION OF MASONRY VENEER WALL TO SINGLE STUD WALL

WD0030A

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DETAIL REFERENCE NO.

WD0030A

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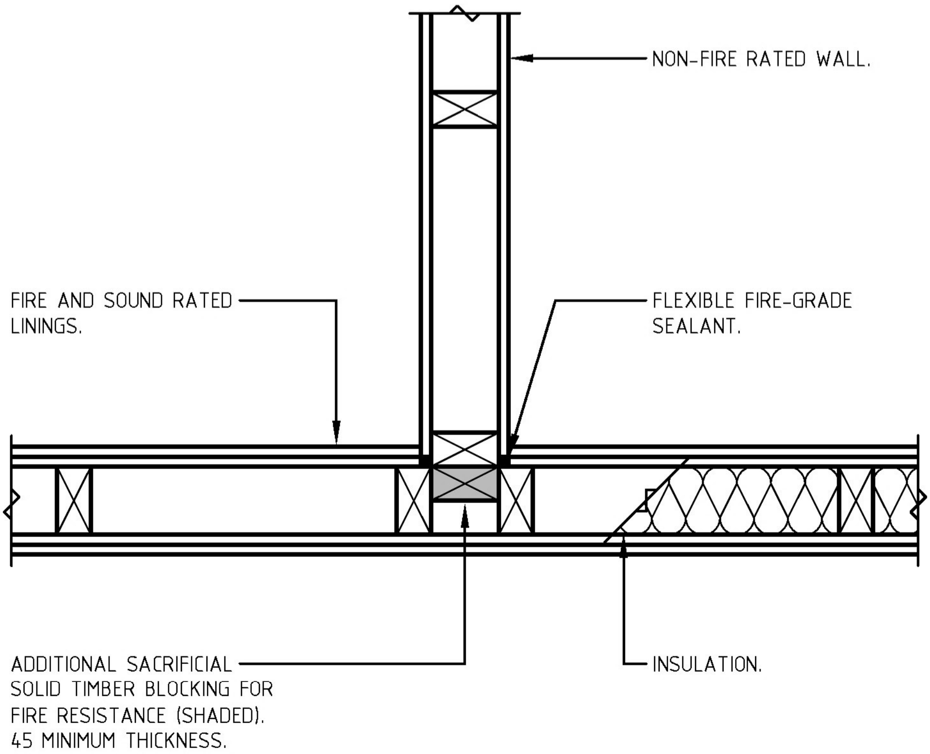

PLAN DETAIL - JUNCTION OF FIRE RATED SINGLE STUD WALL TO NON-FIRE RATED WALL, FRL 60/60/60 OR -/60/60 WD0031A

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Researcher:
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WD0031A

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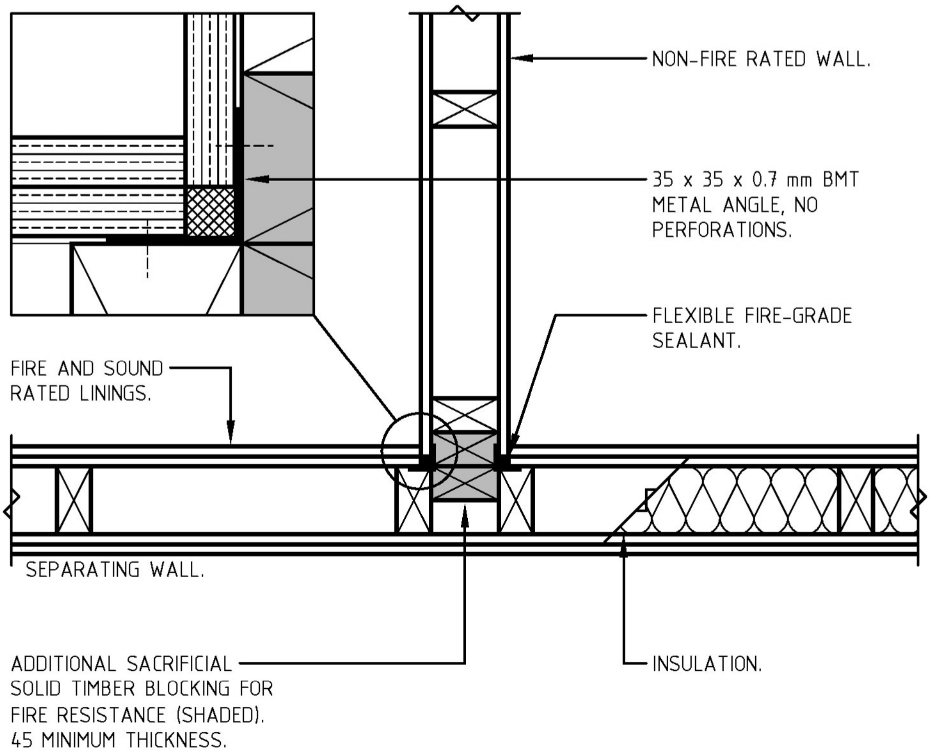

PLAN DETAIL - JUNCTION OF FIRE RATED SINGLE STUD WALL TO NON-FIRE RATED WALL, FRL 90/90/90 OR -/90/90 WD0032A

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Researcher:
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WD0032A

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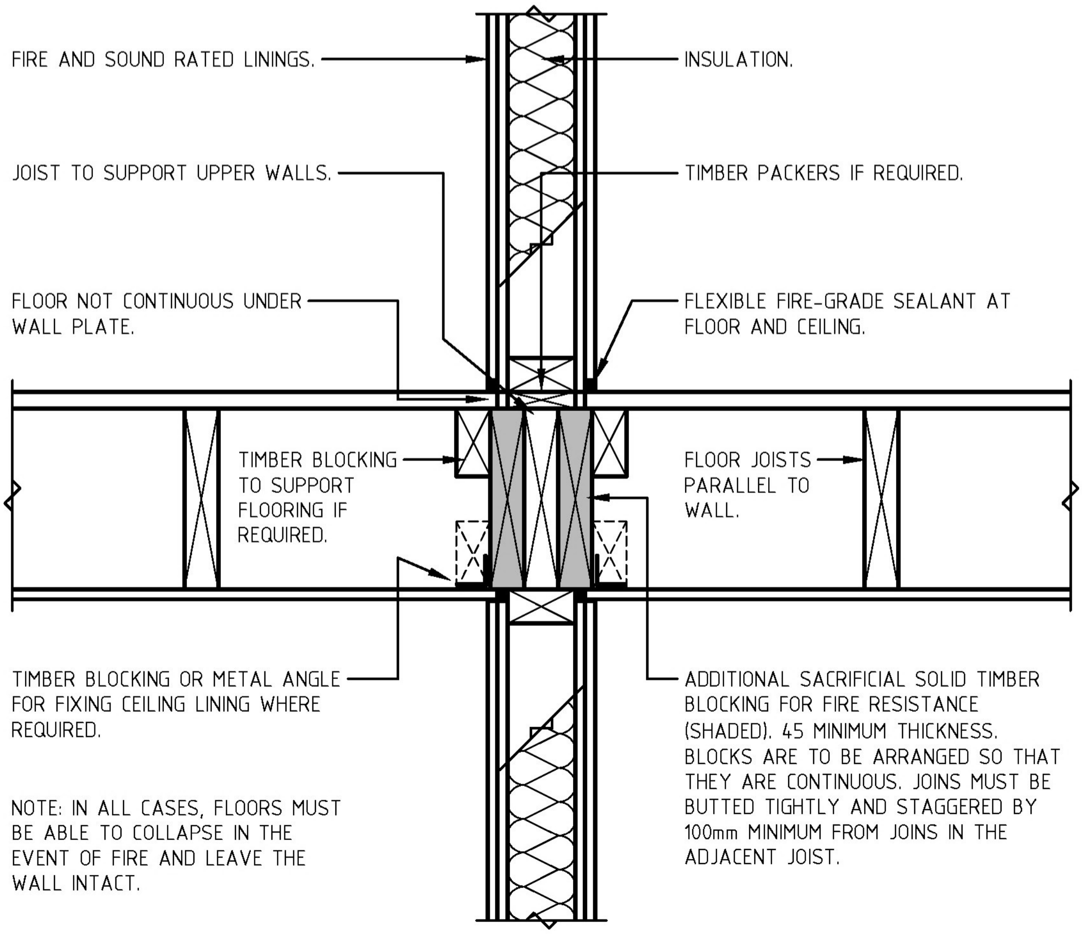

SECTION DETAIL – FLOOR TO SINGLE STUD WALL, JOISTS PARALLEL, FRL 60/60/60 OR –/60/60 FD0030A

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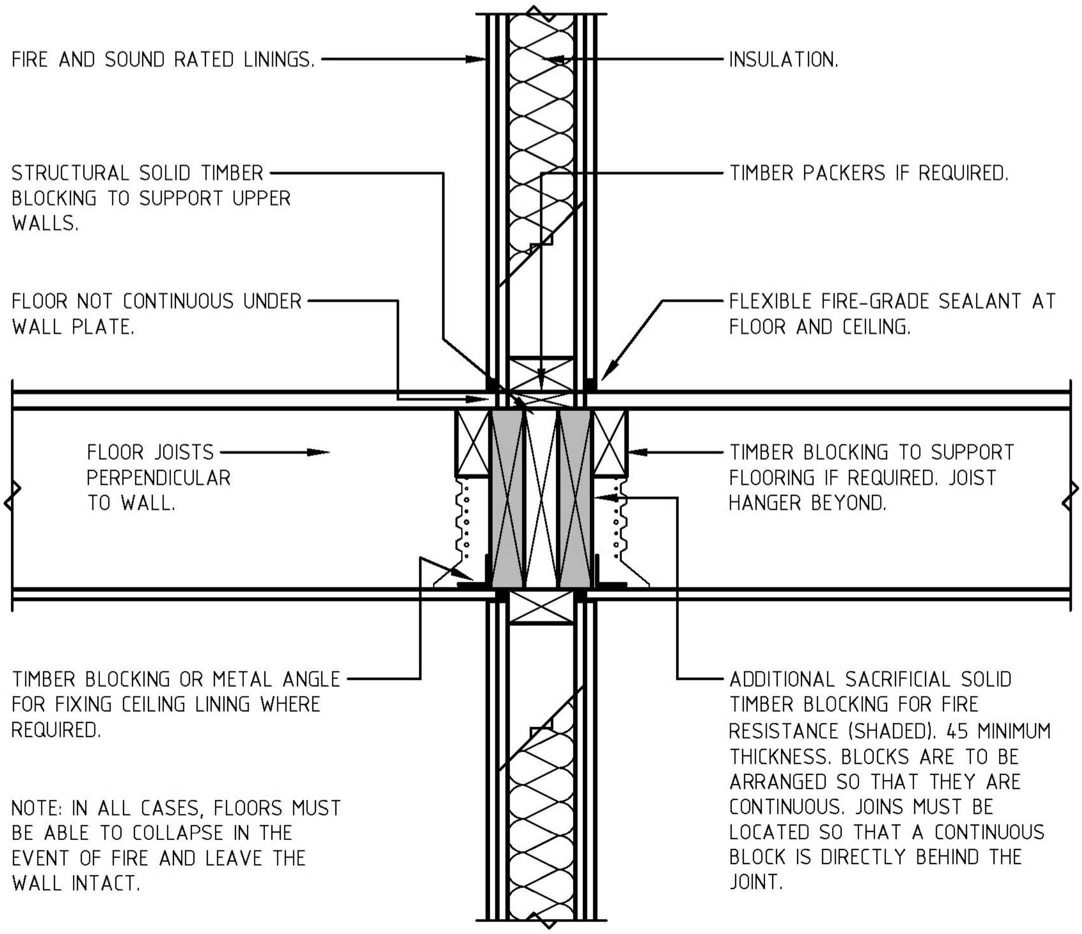

SECTION DETAIL – FLOOR TO SINGLE STUD WALL, JOISTS PERPENDICULAR, FRL 60/60/60 OR –/60/60

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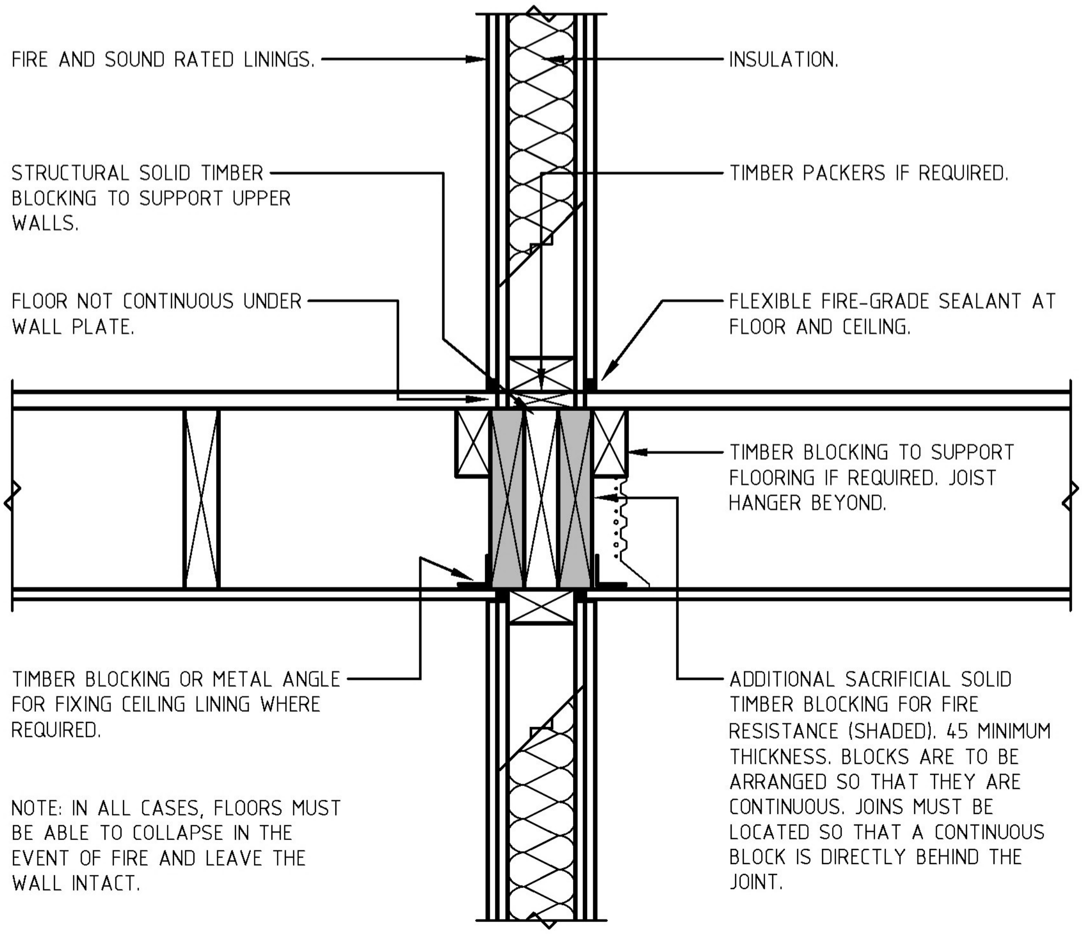

SECTION DETAIL - FLOOR TO SINGLE STUD WALL, JOISTS PERPENDICULAR & PARALLEL, FRL 60/60/60 OR -/60/60

FD0032A

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Researcher:
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DETAIL REFERENCE NO.
FD0032A

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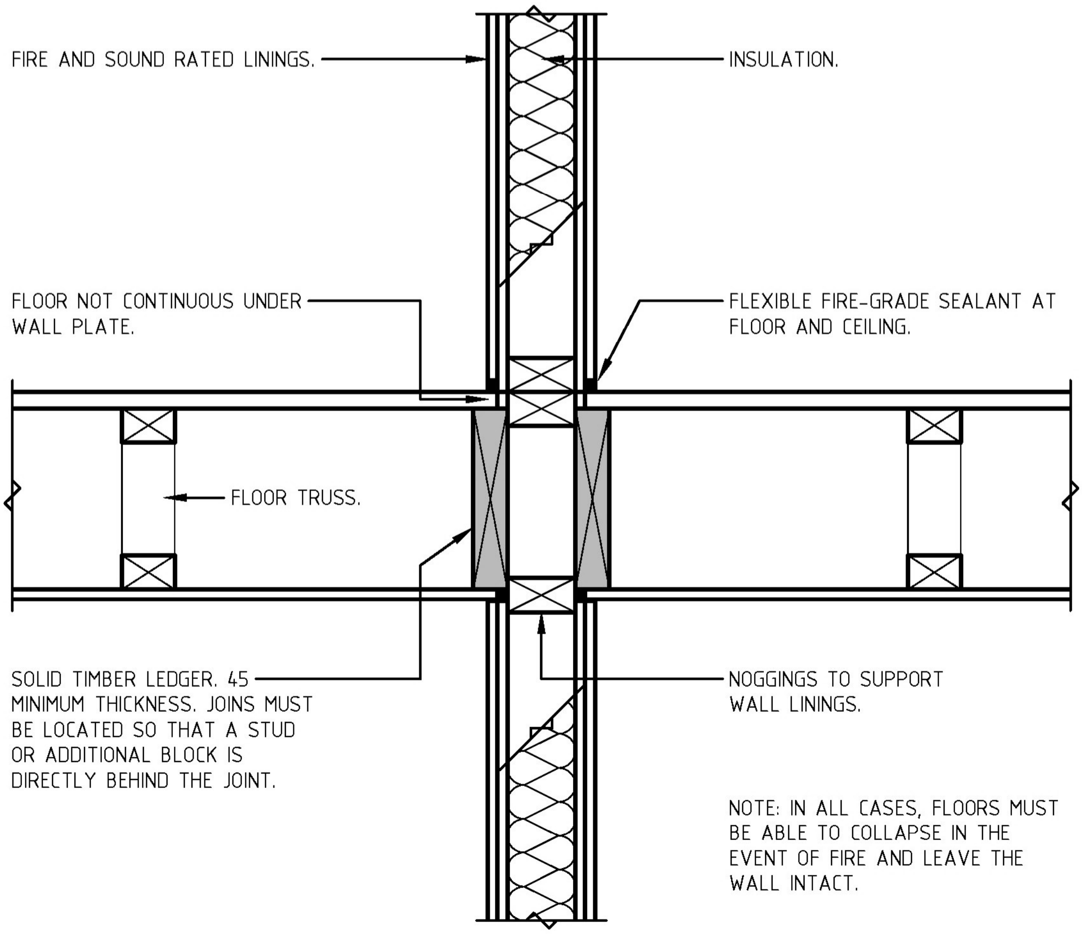

SECTION DETAIL – FLOOR TO CONTINUOUS SINGLE STUD WALL, PARALLEL FLOOR TRUSSES, FRL 60/60/60 OR –/60/60

FD0033A

Researcher:
Timber Development Association (NSW)

DETAIL REFERENCE NO.

FD0033A

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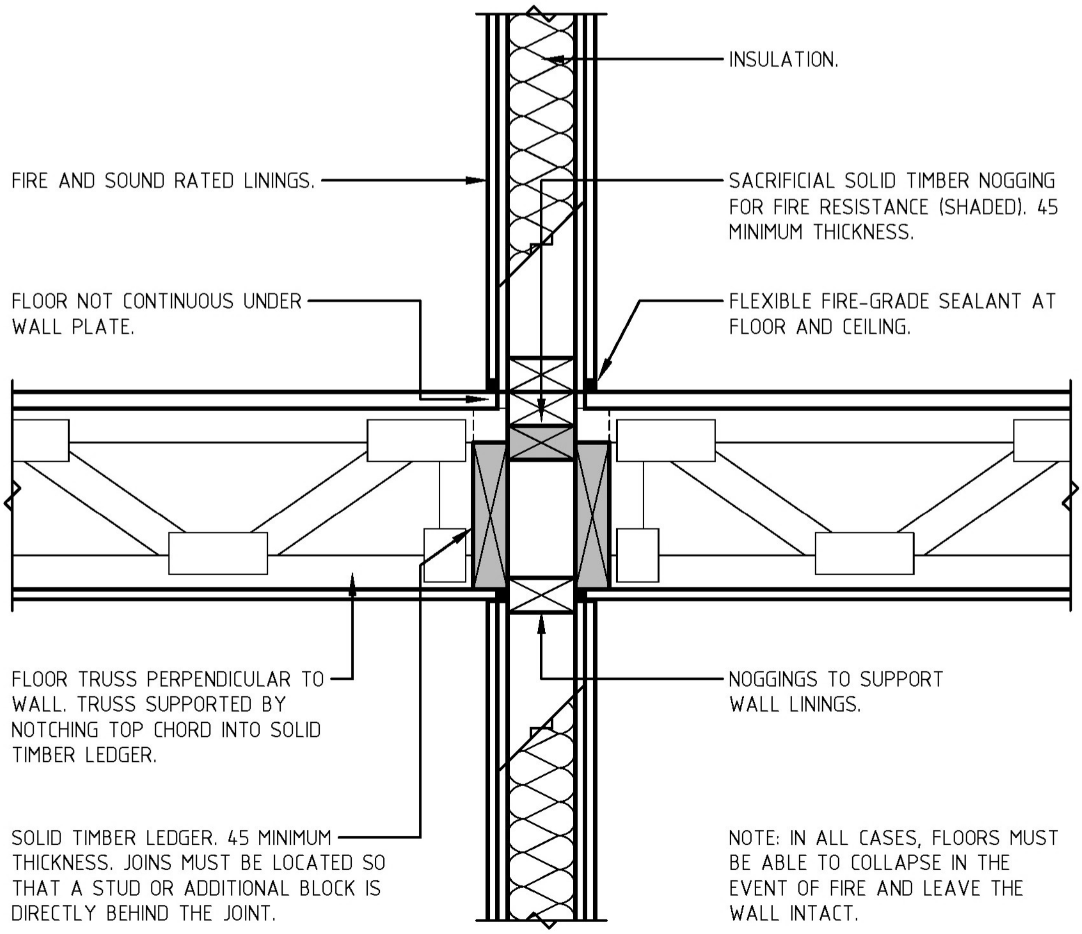

SECTION DETAIL – FLOOR TO CONTINUOUS SINGLE STUD WALL, PERPENDICULAR FLOOR TRUSSES, FRL 60/60/60 OR –/60/60

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Researcher:
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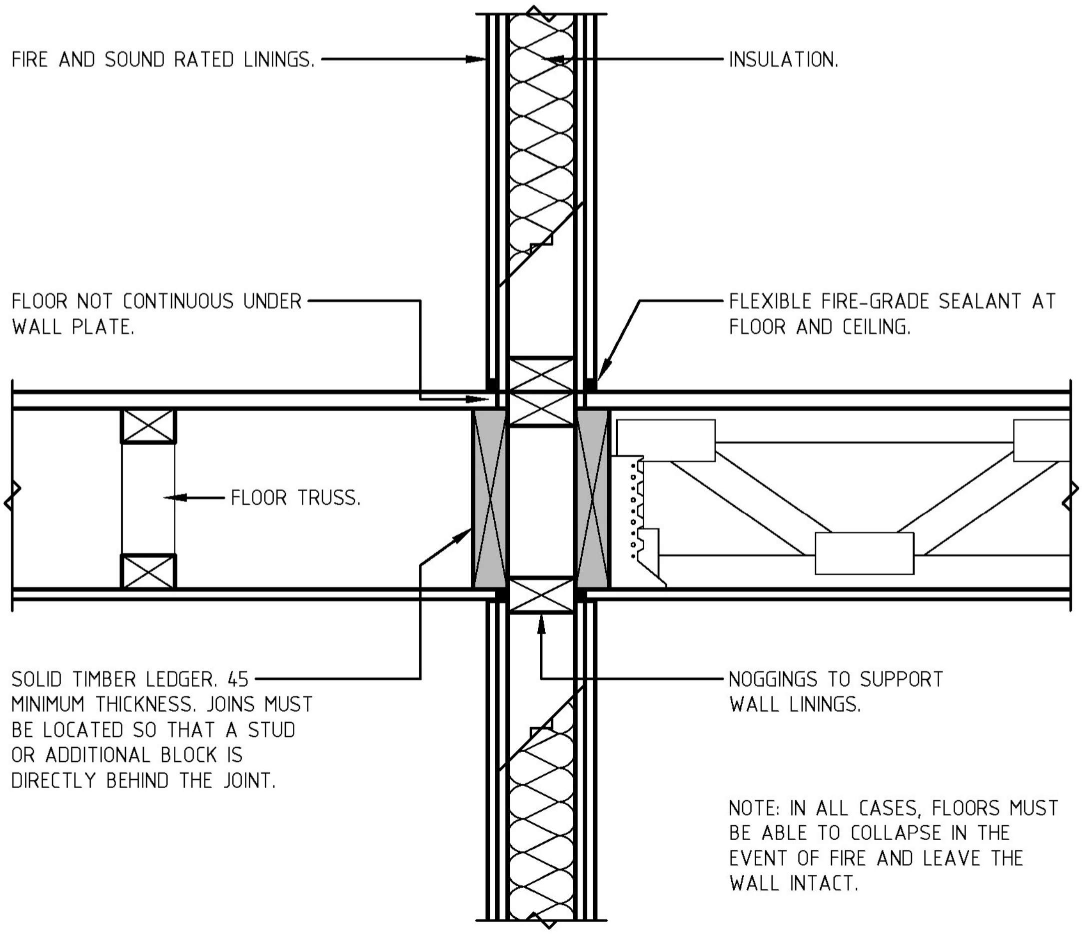

NOTE: IN ALL CASES, FLOORS MUST BE ABLE TO COLLAPSE IN THE EVENT OF FIRE AND LEAVE THE WALL INTACT.

SECTION DETAIL – FLOOR TO CONTINUOUS SINGLE STUD WALL, PERPENDICULAR & PARALLEL FLOOR TRUSSES, FRL 60/60/60 OR –/60/60 FD0035A

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FD0035A

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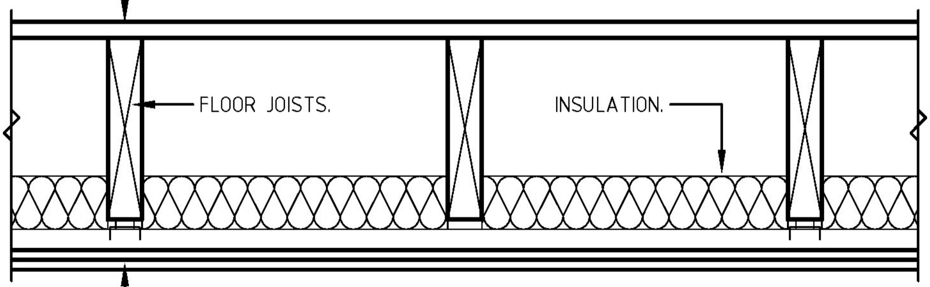
Researcher:
Timber Development Association (NSW)



SECTION DETAIL - SHEET FLOOR WITH ACOUSTIC CEILING

FD0040A

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Researcher:
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DETAIL REFERENCE NO.

FD0040A

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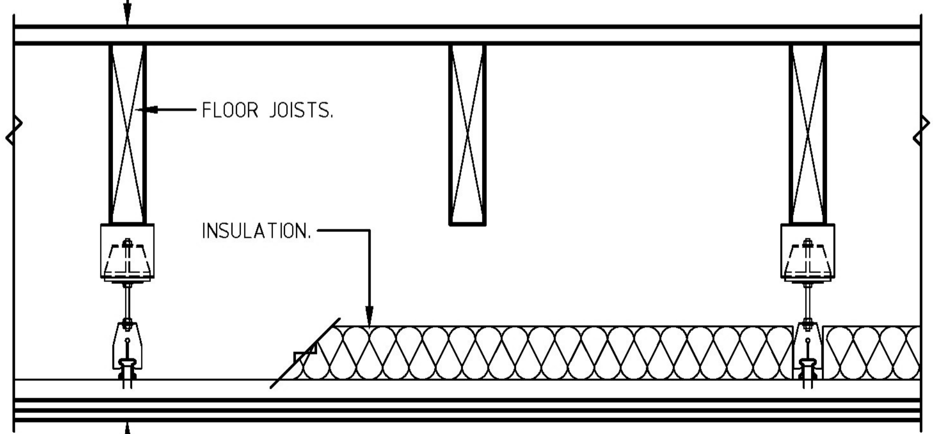

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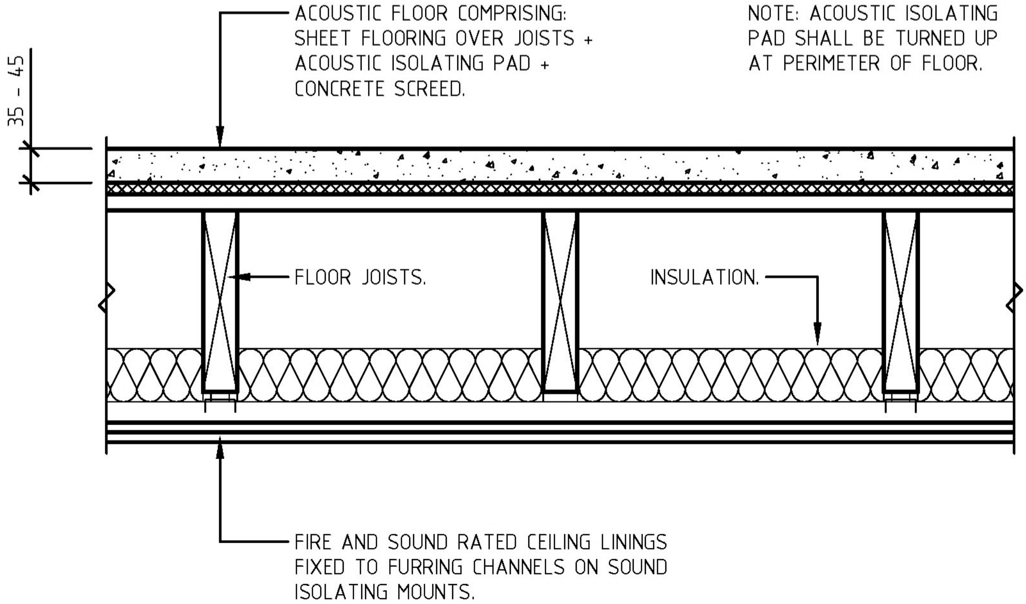

SECTION DETAIL – ACOUSTIC FLOOR WITH CONCRETE SCREED OVER ACOUSTIC MAT, ACOUSTIC CEILING FD0042A

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Researcher:
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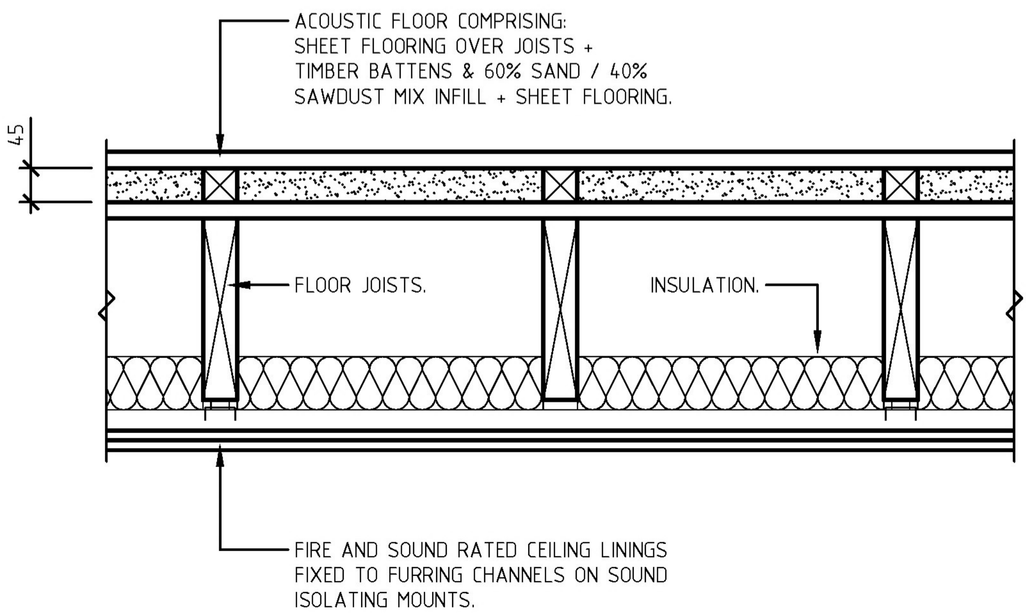

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Researcher:
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DETAIL REFERENCE NO.

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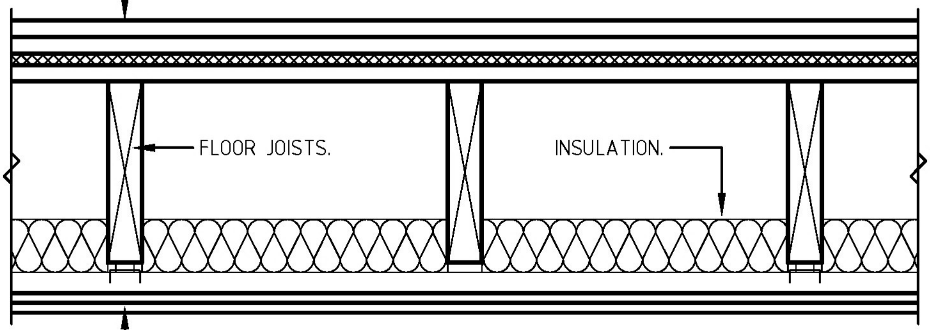

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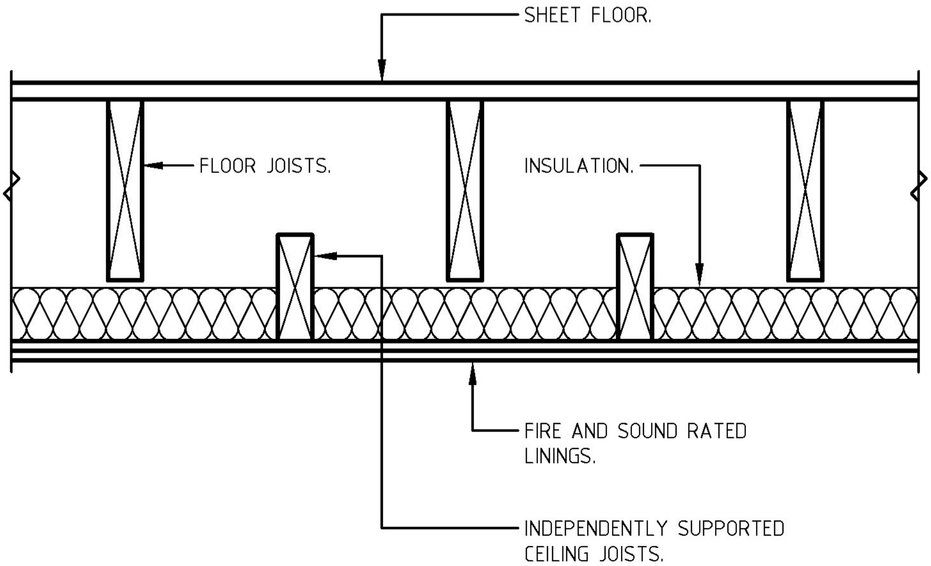

SECTION DETAIL - ACOUSTIC FLOOR WITH SEPARATE FLOOR & CEILING JOISTS FD0045A

Researcher:
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DETAIL REFERENCE NO.

FD0045A

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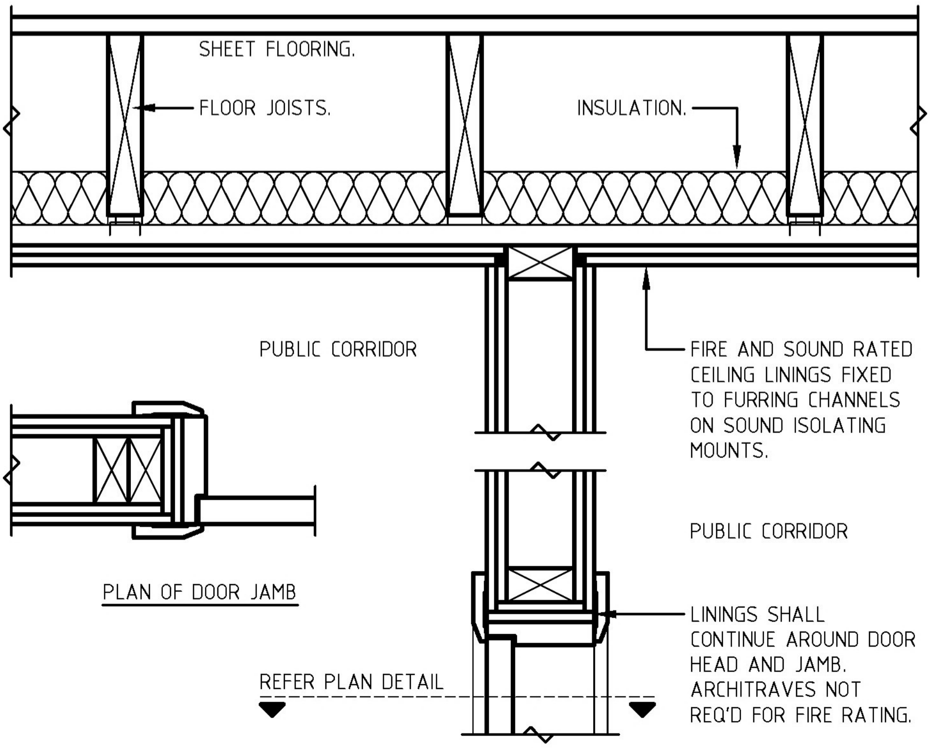

SECTION & PLAN DETAIL - NON-RATED OPENING IN FIRE RATED WALL
FD0050A

Researcher:
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DETAIL REFERENCE NO.

FD0050A

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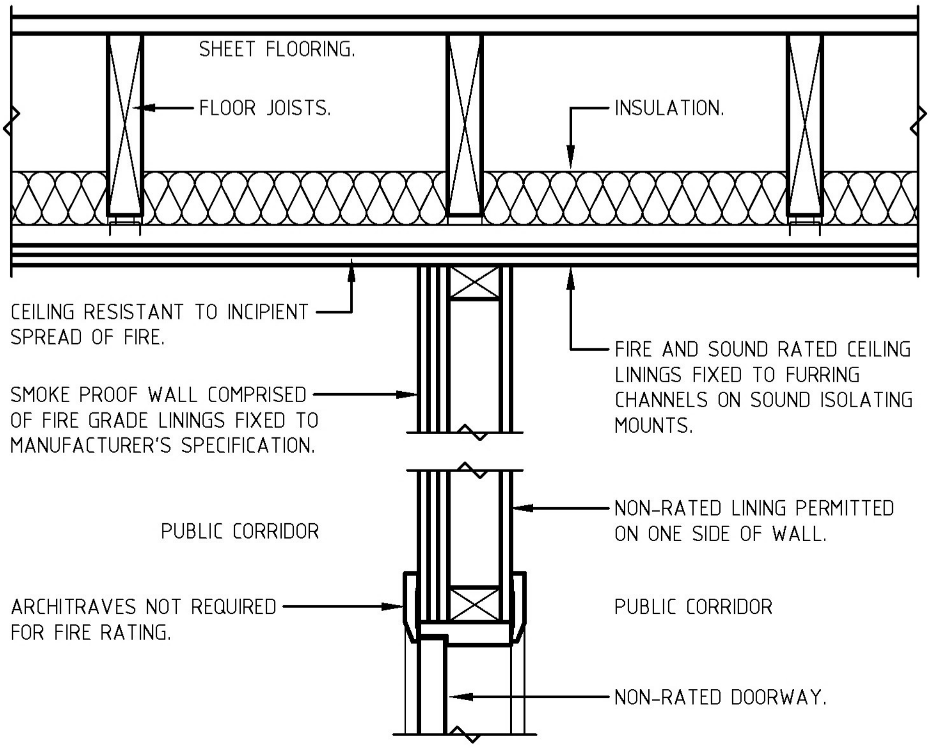

SECTION DETAIL – SMOKE PROOF WALL TO FLOOR ABOVE AT DOORWAY, BUILT FROM LAMINATED PLASTERBOARD

FD0051A

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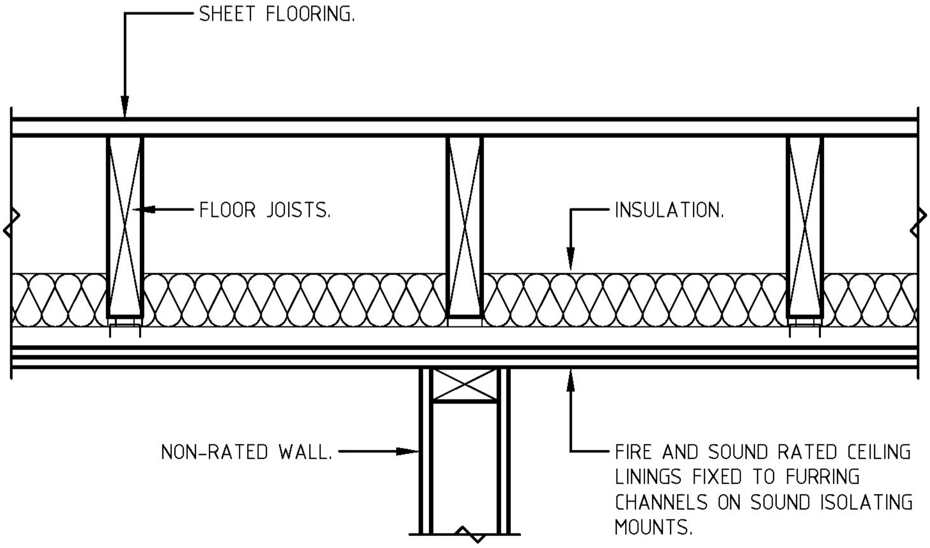

SECTION DETAIL - INTERNAL NON-RATED WALL TO RATED FLOOR ABOVE FD0054A

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DETAIL REFERENCE NO.

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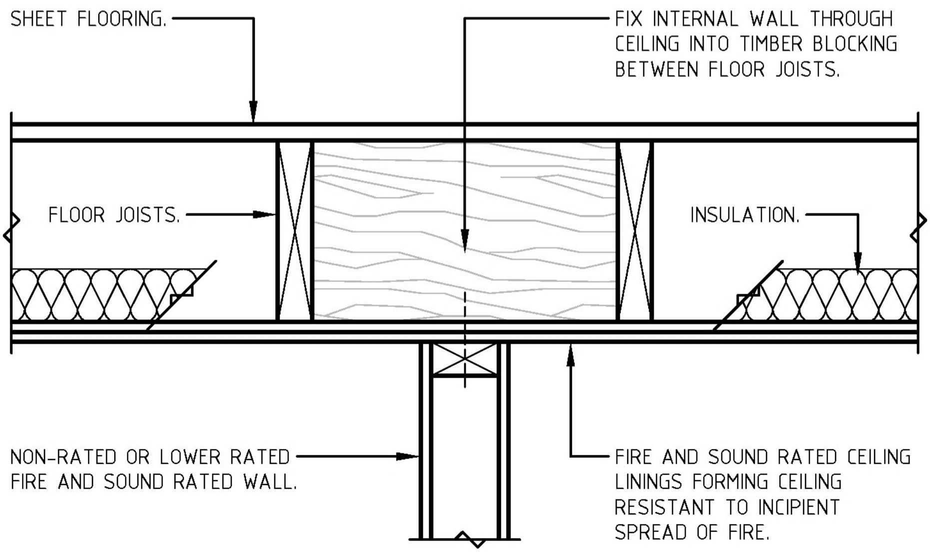

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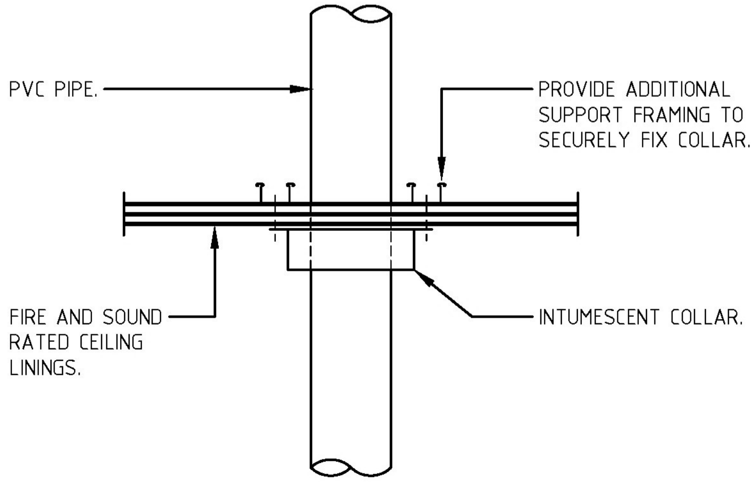

ELEVATION DETAIL - VERTICAL PIPE PENETRATION WITH FIRE COLLAR

FD0056A

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FD0056A

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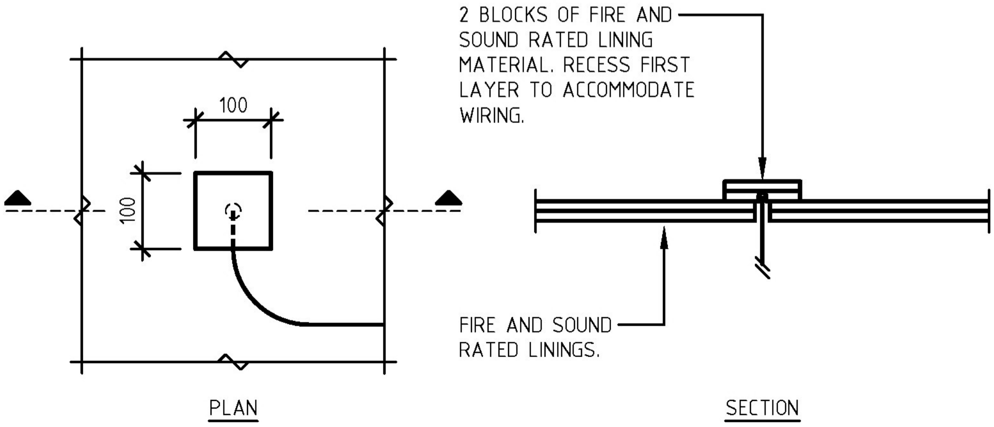

PLAN & SECTION DETAIL - ELECTRICAL WIRING PENETRATION IN RATED PLASTERBOARD LINING FD0057A

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DETAIL REFERENCE NO.

FD0057A

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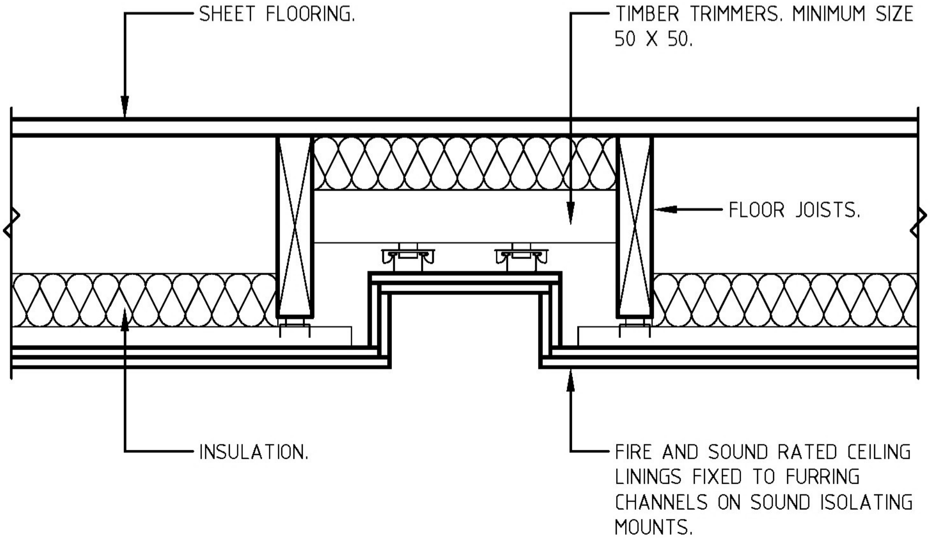

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FD0058A

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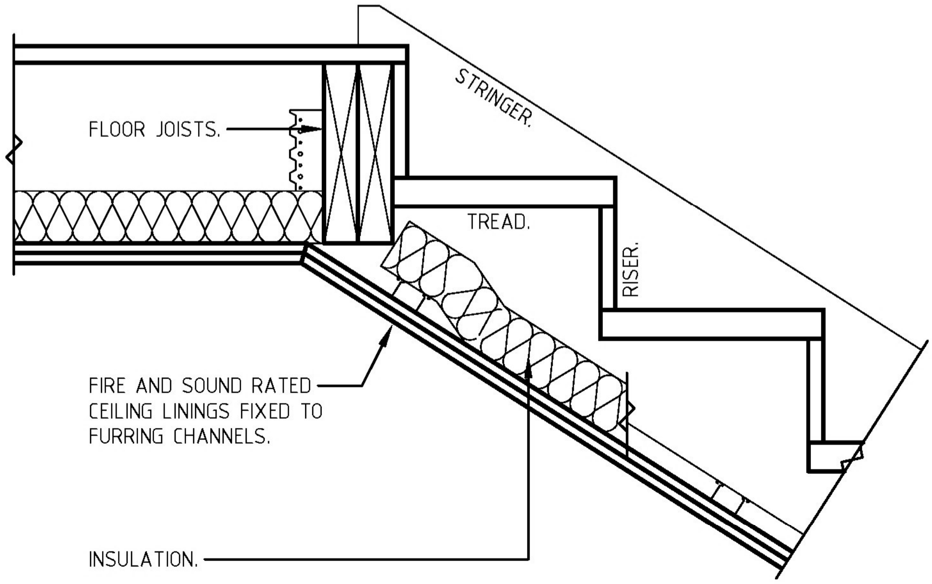

SECTION DETAIL – FIRE RATED LINING TO STAIR SOFFIT

FD0060A

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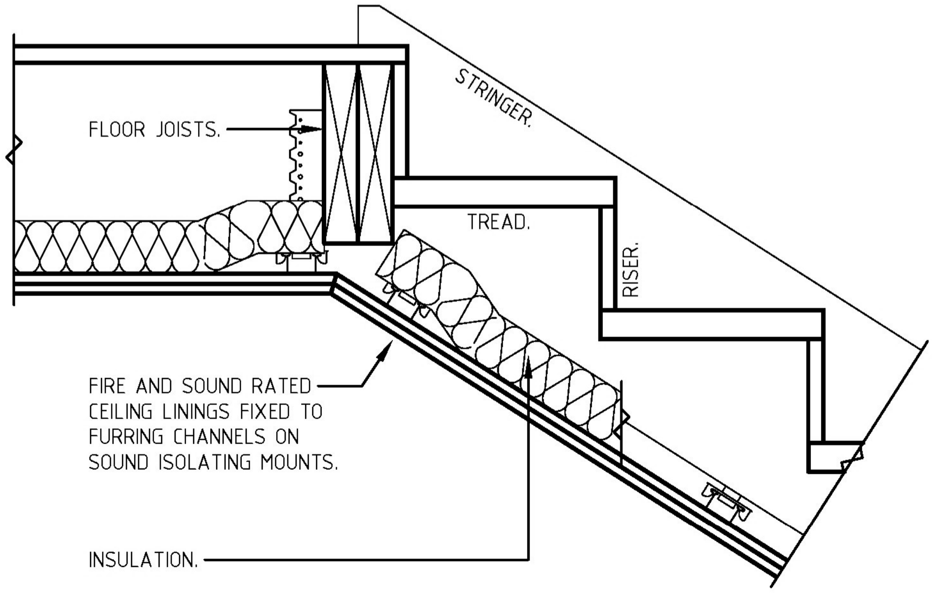

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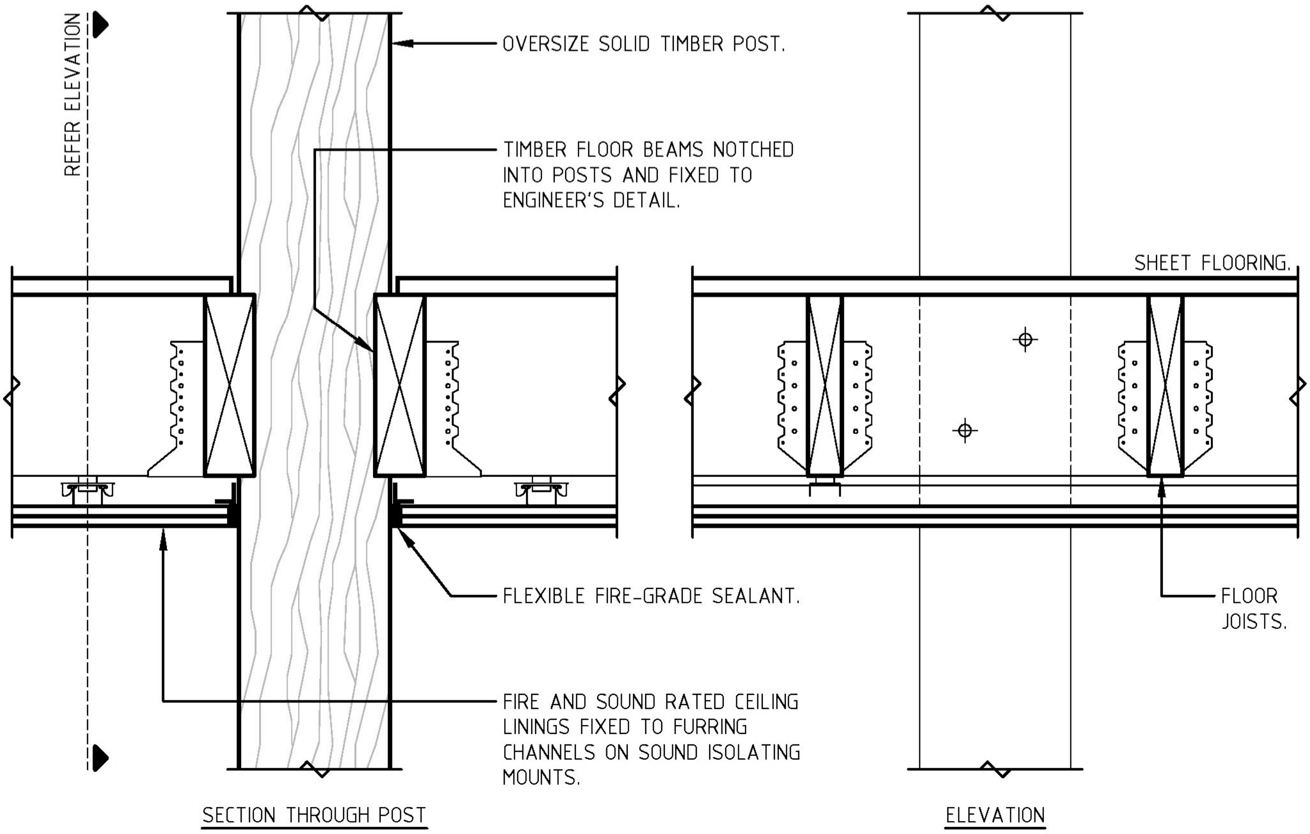

SECTION DETAIL - IN-PLANE POST & BEAM CONSTRUCTION WITH OVERSIZED TIMBER POSTS TO ACHIEVE FIRE RESISTANCE

FD0080A

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04

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This guide was revised in Feb 2020 incorporating AS 3959-2018

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Building with Timber in Bushfire-prone Areas

NCC Compliant Design and Construction Guide

Technical Design Guide issued by Forest and Wood Products Australia

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WoodSolutions is an industry initiative designed to provide independent, non-proprietary information about timber and wood products to professionals and companies involved in building design and construction.

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Contents

Introduction

Designing to 'build out' bushfires requires minimising the risk from ember, radiant heat and even flame damage. With appropriate design decisions you can create an attractive timber home, using sustainably sourced timber, both inside and out.

Bushfires are becoming more frequent around the world and, as a consequence of global warming and changes in weather patterns, they are increasingly severe. The destruction from uncontrolled fires, some lasting for months, disrupts families, businesses and communities. The question of how and where to build or rebuild to minimise risk is being asked in many countries.

In Australia, the updated *Standard AS 3959–2018 Construction of buildings in bushfire-prone areas* has the benefit of many years of scientific development and provides an extensive guide to building homes to minimise risk for different levels of bushfire vulnerability.

AS 3959–2018 provides construction details to:

improve the ability of a building to better withstand attack from bushfire; provide the building with a level of protection while the front passes; and give occupants a level of protection while a fire front passes.

However, because bushfires are naturally unpredictable and extreme weather conditions can present more difficulties, these measures cannot guarantee a building will survive.

This Guide has been written to help architects, designers, builders and owners to understand the Standard and what is required for each of the Bushfire Attack Level (BAL) areas. It focuses on traditional building methods using timber.

Where applicable, the contents explain alternative ways of compliance. For instance, there are several ways to comply with the Standard with respect to windows. One is the permanent fitting of bushfire shutters or screens. Another is to lift windows higher than 400 mm off the nearest external 'horizontal' surface – this saves on the extra glazing and joinery requirements needed to protect a lower window.

Building safely means building bushfires out – it does not necessarily mean abandoning timber. In fact, the first roof system tested to comply with the most demanding BAL–FZ (Flame Zone) requirements uses seasoned plywood as a roof membrane to provide additional 'insulation' and to support other components. This roof system has now been incorporated into AS 3959 as a deemed-to-satisfy solution.

Updates

New information about building with timber in bushfire-prone areas will be available at www.woodsolutions.com.au.

Related Publications

'Timber Housing in Bushfire-prone Areas': An overview of the issues involved in designing and building with timber while complying with the Standard.

Information and updates will be available at www.woodsolutions.com.au

Adoption of AS 3959–2018 by the various Australian States and Territories.

AS3959 – 2018 Construction of buildings in bushfire-prone areas was formally referenced in the National Construction Code 2019 (NCC) on 1 May 2019. Although referenced, the NCC does allow State variations or deletions of some of its provisions. The following summarises the adoption of AS 3959 by the various Australian States and Territories.

Reference should also be made to relevant State and Territory Planning requirements (e.g. the Guidelines for Planning in Bushfire Prone Areas (WAPC) for supporting information. published by the Western Australian Planning Commission and the Fire and Emergency Services Authority; Planning for Bush Fire Protection published by the NSW Rural Fire Service; Minister's Code - Undertaking Development in Bushfire Protection Areas which modifies construction requirements in relation to bushfire risk areas.

Queensland, Northern Territory, Australian Capital Territory, South Australia
Adopted without change.

New South Wales
Refer to Appendix A (this Guide) regarding the modified BAL construction requirements as detailed in *Planning for Bush Fire Protection* – Addendum: Appendix 3 - NSW Rural Fire Service.

Tasmania
Plus specific fire fighting vehicular access and water supply requirements as detailed in the NCC.

South Australia
Refer to Minister's Code - Undertaking Development in Bushfire Protection Areas.

Victoria
Minimum construction standard of BAL–12.5 in designated bushfire–prone areas. Refer *Building Amendment (Bushfire Construction) Regulations 2011*.

Western Australia
Refer to the *Guidelines for Planning in Bushfire Prone Areas* (WAPC) for supporting information.

1 Standard Maintains the Use of Timber Frames and Construction Materials

This Guide shows how you can design and build with timber and meet the requirements of the Australian Standard *AS 3959–2018 Construction of buildings in bushfire-prone areas* to build out bushfires.

Written for those designing or building new homes requiring bushfire protection, this Guide will help you continue many traditional building practices and learn new ones needed to meet the requirements of AS 3959 in each of the six Bushfire Attack Levels (BAL).

Visit www.woodsolutions.com.au for the most up-to-date data sheets and information on building out bushfires.

The emphasis is on keeping out embers and protecting against radiant heat and even flame contact. As part of revising the Standard, scientific testing confirmed that these are the key aspects of building out bushfires.

Most importantly, AS 3959 makes no additional requirement for internal framing. Wherever you are building, you can still use cost-effective and sustainable timber framing. As the Standard does not limit you to a concrete slab, you can still benefit from the advantages of building off the ground, which include the embodied carbon of the material and the cost advantages in construction on sloping sites.

This Guide clarifies how, where and what types of timber can be used in home construction in keeping with the Standard. Normal building practices and materials apply for the lowest bushfire-attack level (BAL–LOW) – typically applied to homes in suburbs and built-up areas. The other five levels require increasingly stringent protection of the building envelope. These are outlined in this Guide and will be updated by data sheets as new complying building and materials systems are tested and approved.

AS 3959 makes no demands on framing material, allows suspended timber-floor construction and includes options for weatherboard and other lightweight external cladding materials. These can even be used at the highest bushfire attack levels – with appropriate building techniques. For instance, the moisture-resistant fire-grade plasterboard and timber system *(see pages 32 & 33)* which has been tested to perform beyond the Standard's requirements.

The Standard also specifies which timbers can be used and in what ways. The Standard identifies seven bushfire-resisting timbers and two categories for other timbers suitable for a range of applications across the bushfire attack levels *(see page 9)*. Suitable timbers include many hardwoods already used, for instance, for decking and window frames. In the lower BALs the Standard provides for the use of timber in combination with other products.

Use this Guide in conjunction with the Standard for more complex details. Our simple approach and practical instructions will help you establish what is required when building or specifying to comply with AS 3959. To this end, we have also included some design tips – based on the science behind the Standard and research from previous bushfire experiences.

2 Understanding Key Requirements

What is an external horizontal surface?

A number of the Bushfire Attack Levels (BALs) specify extra requirements for building components, such as some cladding, doors and windows, that are 400 mm or closer to "an external surface which may collect smouldering embers or burning debris". Such surfaces include the ground, a deck, balcony, carport roof, awning, etc, having an angle less than 18° to the horizontal and extending more than 110 mm in width from the door or window. (See Appendix D of *AS 3959*).

Complying shutters

AS 3959 Clause 3.7 specifies that shutters must be non-removable (but operable) and, when closed, there should be no gap more than 2 mm between the shutter and wall, the sill or the head. Check the shutters comply with the Standard's construction requirements or have been tested for the particular BAL.

Before investing in bushfire shutters, homeowners should ensure that they comply with their site's Bushfire Attack Level and get this in writing. They should also check that the bushfire shutters or screens can be closed and secured quickly and safely by everyone in the family.

Complying screens for windows and doors

Where fitted, screens for windows and doors need to be made of materials specified for the relevant BAL and have a mesh (or perforated sheet) with a maximum aperture of 2 mm. Gaps between the perimeter of screen assembly and the building element to which it is fitted should not exceed 2 mm. The frame supporting the mesh or perforated sheet needs be made from materials specified for the relevant BAL.

Building Materials

AS 3959 makes reference to requirements in two parts of AS 1530 to establish the suitability of certain materials or building systems at higher bushfire attack levels.

AS 1530 Part 8 Building Materials in Bushfire-prone Areas

For bushfire-prone areas, AS 1530 offers a verification method to an approved standard for the testing and certification of building systems. AS 3959 references Part 8.1 and Part 8.2.

The test methods for building elements of construction exposed to simulated bushfire attack are:

- AS1530 Part 8.1 – Radiant heat and small flaming sources
- AS1530 Part 8.2 – Large flaming sources.

Building designers, those specifying building materials and building surveyors need to ensure that they use test reports, issued by Accredited Testing Laboratories, as quantifiable evidence of suitability for their performance-based bushfire designs and construction when required by AS 3959.

AS 1530 Part 4 Fire Resistance Level (FRL)

The National Construction Code (NCC) defines a Fire Resistance Level (FRL) as the grading when under fire attack, in minutes, for three criteria: structural adequacy, integrity and insulation.

- Structural adequacy is the ability of a structure to maintain its stability and load-bearing capacity
- Integrity is the ability of a structure to resist the passage of flames and hot gases
- Insulation is the ability of a structure to maintain a temperature below specified limits on the surface *not exposed* to fire.

For example, a FRL requirement for glazing FRL -/30/- means there is a requirement that the glass can resist the passage of flame and hot gases for at least 30 minutes.

The relevant standard is *AS 1530 Methods for fire tests on building materials, components and structures – Fire-resistance tests of elements of construction*.

What is decking?

The term, as used in the Standard, includes decking, stair treads and the trafficable surfaces of ramps and landings. Depending on the requirements of the relevant BAL, materials include treated and untreated timber decking boards, sheet products, concrete and ceramic tiles.

Vents and Weepholes

When located in an external wall of a sub-floor space, screen with a mesh with a maximum 2 mm aperture made up of corrosion–resistant steel, bronze or aluminium depending on the BAL classification.

3 Understanding the Bushfire Attack Level

Assessing the Bushfire Attack Level (BAL) of the home site is the first step towards building. Slope, surrounding vegetation type and proximity are part of the assessment.

This requirement applies to any new home construction – on new sites, infill and rebuilding and some renovations, repairs and additions in areas subject to the Standard. Local councils and shires may have other matters to be considered. Check before preparing planning applications.

A BAL, as defined in AS 3959, considers the type of the surrounding vegetation, the distance of the vegetation from the site and the effective slope of the land under the classified vegetation. Once a site has been assessed for its BAL, plans, building methods and materials need to take the requirements of that BAL into account.

'Slope' refers to the slope under the classified vegetation in relation to the building – not the slope between the vegetation and the building.

BAL–LOW	Standard construction materials and methods, including timber framing and cladding materials can be used. These sites have no special requirements as there is such a low risk of bushfire attack.

Building wisely to the Standard includes using specific timbers for doors and frames, windows, cladding and decks.

BAL–12.5	Some possibility of ember attack has been identified from looking at the closeness of vegetation, the site itself and local conditions with construction elements expected to be exposed to a radiant heat flux not greater than 12.5 kilowatts per square metre (kW/m^2).
BAL–19	Sites identified as having an increasing level of predicted ember attack and burning debris ignited by wind-borne embers together with an increasing radiant heat flux, not greater than 19 kW/m^2.
BAL–29	Increasing level of chance of ember attack and burning debris ignited by wind-borne embers, together with an increasing radiant heat flux not greater than 29 kW/m^2.

Additionally, at these next BALs, fire resistant lining materials, thicker or treated glass, special shutters and building systems increase protection.

BAL–40	Further possibility of ember attack and burning debris ignited by wind-borne embers; together with an increasing radiant heat flux, not greater than 40 kW/m^2, and an increased likelihood of exposure to bushfire flames.
BAL–FZ	Extremely bushfire-prone, probably in a picturesque bushland setting, a home with this BAL has a predicted direct exposure risk to flames from a fire front, ember attack and a radiant heat flux greater than 40 kW/m^2. Reduce the potential for bushfire attack and damage by following the Standard's guidelines for building systems and materials and special timber choices. Following the Standard, ensuring commonsense maintenance, as well as complying with Wildfire Management Overlays (WMO) and fire authority rules and instructions, are all important.

This information is based on Appendix G of AS 3959.

4 What Timbers Can We Use?

There is no restriction on what structural timber products are used for house framing. Use engineered, softwood or hardwood products as usual.

For internal joinery applications again there are no limitations on materials. Continue with normal use of timber products for doors, wall linings, ceiling linings, floorboards, staircases, etc.

In a range of external situations, appropriately treated timber products and many high density Australian hardwoods are suitable for use in meeting the requirements of higher Bushfire Attack Levels (BAL).

For external applications, the material used depends on the designated BAL. As well as the timbers indicated in the following tables, suitably treated timbers are often an option. Your manufacturer or supplier will be able to advise you in regard to the compliance of particular treated timber products and their external application for each BAL.

Australia has a number of high density timbers that provide an inherent natural bushfire resistance. Seven of these are defined by AS 3959 (Appendix F) as bushfire-resisting timbers (BRTs). They are solid, dense hardwoods that performed well in extensive fire testing.

Both fire-retardant (FR) treated timbers and specific species can be used in many external applications. These are specified in AS 3959 and summarised in this publication. Lists of timber species with specified densities are given in Appendix E of *AS 3959 Construction of buildings in bushfire-prone areas*. The most common construction timbers from these lists are:

Bushfire – resisting timbers* (BRTs)

Blackbutt, Kwila (Merbau), Red Ironbark, River Red Gum, Silvertop Ash, Spotted Gum, Turpentine

Timber* species from E1: density 750 kg/m^3 or greater include:

All BRTs (above) plus:

Brownbarrel, Grey Box, Grey Gum, Grey Ironbark, Jarrah, Manna Gum, Messmate, Mountain Grey Gum, Stringybark/s Sugar Gum, Sydney Blue Gum

Timber* species from E2: density 650 kg/m^3 or greater include:

All species from E1 (above, including BRTs), also:

Alpine Ash, Slash Pine, Mountain Ash (Victorian Ash), Shining Gum, Cypress

*in solid, laminated or reconstituted form.

To ensure a ready supply of suitable species for your requirements it is a good idea to check with your usual or local timber supplier before specifying timber types.

Timber log walls (guage planed, species density of 680 kg/m^3 or greater at 12% moisture content) can also be used with a minimum nominal overall thickness of 90 mm and a minimum thickness of 70 mm (at the interface of two logs) and comply up to BAL–29.

Homeowners need to understand what is being used and why. Some examples of external timber applications:

- Bushfire shutters made from bushfire-resisting timber comply up to BAL–29.
- Window frames made from E2 timber such as Victorian (Mountain/Alpine) Ash comply up to BAL–19 (at any height within a wall).
- Treated pine external wall cladding that is 400 mm or more above the ground complies up to BAL–19. Such cladding can also be installed as part of a system which complies with BAL–FZ requirements that can be used at lower BALs as well *(see pages 32 and 33)*.

5 Building with Timber – Construction Requirements for Bushfire Attack Levels

The National Construction Code (NCC) applies bushfire provisions to:

- Class 1 buildings
- Class 2 & 3 buildings
- Class 10a buildings
- or deck associated with one of the above classes of buildings.

Australian states, territories or local government authorities may require construction to AS 3959 for other classes of buildings - confirm with the authority having jurisdiction prior to commencing building design and specification work.

The National Construction Code Volume Two Performance Requirement P2.7.5 (similar wording for Class 2 and 3 buildings) says: "Buildings in bushfire prone areas: A Class 1 building or a Class 10a building or deck associated with a Class 1 building...(must) be designed and constructed to reduce the risk of ignition from a bushfire while the fire front passes."

A Bushfire Attack Level (BAL), as defined in AS 3959, considers the type of the surrounding vegetation, the distance of the vegetation from the site and the effective slope of the land under the classified vegetation.

BAL–LOW

Most metropolitan and suburban blocks are defined as BAL–LOW. These sites have no special requirements as there is a very low risk of bushfire attack.

Build as usual once BAL–LOW is confirmed by the site's local government, building surveyor or planning authority.

All traditional timber framing products and systems can be used, along with the usual timber species and treated pine for decks, balustrades, handrails, finials, pergolas, etc.

We recommend building with a timber sub-floor, rather than a concrete slab, for less environmental damage to the site and all the convenience and comfort of building off the ground.

The production of wood products uses less energy (usually sourced from finite fossil fuels) compared with some other building materials.

A timber frame also reduces your carbon footprint. Growing trees absorb carbon dioxide from the atmosphere and store the carbon so efficiently that about half the dry weight of a tree is carbon. This carbon remains locked up in the wood even when we use it for building products or furniture.

Individual state and territory requirements may exist for this Bushfire Attack Level. Please refer to Adoption AS 3959 by the various Australian states and territories (page 5) for guidance.

BAL–12.5

At BAL–12.5, some possibility of ember attack has been identified, from looking at the closeness of vegetation, the site itself and local conditions. The '12.5' means that external construction elements are not expected to be exposed to radiant heat greater than 12.5 kilowatts per square metre (kW/m^2).

For a bushfire resisting building at this BAL, the Standard allows roofs to be fully sarked as a simple means of compliance. There are requirements for windows – the most vulnerable part of the building envelope. The easiest window solution is simply to lift the bottom of the window to above 400mm from any adjacent 'horizontal' surface – such as decking, porch or garden, roof section or balcony – then extra requirements are minimal.

All traditional timber framing products and systems can be used, along with the usual timber species and treated pine for enclosed and raised decks (bearers and joists), balustrades, handrails, finials, pergolas etc.

It should also be noted that you can still build with a timber sub-floor, rather than a concrete slab, for less damage to the site, a smaller carbon footprint and all the convenience and comfort of building off the ground. **Note: When building with an unenclosed sub-floor, storage of combustible materials in the sub-floor space should be avoided.*

The simplest solution for decking at BAL–12.5 is to use a bushfire-resisting timber such as Merbau or an E1 timber *(see page 9)*, or suitably fire-retardant (FR) treated timber, at least close to the house. After the first 300 mm, traditional decking such as treated pine may be used.

Individual state and territory requirements may exist for this Bushfire Attack Level. Please refer to Adoption AS 3959 by the various Australian states and territories (page 5) for guidance.

BAL–12.5 requirements summary

Subfloor spaces	
Enclosed • posts, stumps, supports, etc • floor bearers, joists & flooring	 All durable timber species and suitably preservative-treated timbers as usual. All timber species and engineered timber products as usual
Unenclosed • posts, stumps, supports, etc	 Bushfire-resisting timber.
Less than 400 mm above finished ground level • floor bearers, joists & flooring	Bushfire-resisting timber – Flooring may be any timber flooring product where the underside is lined with sarking type material or mineral wool insulation.
400 mm or more above finished ground level • floor bearers, joists & flooring	All timber species and engineered timber products as usual.
Internal framing	All timber species and engineered timber products as usual.
Internal joinery	Including doors, wall lining, ceiling linings, flooring over concrete slabs, staircases, etc – all timber as usual.
Fascia and bargeboards	Timber as usual.
Eaves lining	Fibre-cement or timber as usual.
Tiled roof	Framing – all timber species and engineered timber framing members as usual.
Fully sarked	With a sarking with a flammability index of not more than 5 • install sarking directly below the tile battens • ensure that the sarking covers the entire roof area, including ridges, and is extended into gutters and valleys, with no gaps greater than 2 mm where the sarking meets fascias, gutters, valleys, etc.
Sheet roof	Framing – all timber species and engineered timber framing members as usual.
Fully sarked	With a sarking with a flammability index of not more than 5. Install as for a tiled roof (above), except that foil-backed insulation blankets may be installed over battens; and any gaps greater than 2 mm are to be sealed with one or a combination of: • mesh made of corrosion-resistant steel, bronze or aluminium with a maximum 2 mm aperture, ***or*** • mineral wool, ***or*** • other non-combustible material

BAL–12.5 requirements summary

Windows, shutters and screens	The full cover option gives you timber frames and glazing as usual for all windows: • completely protect all windows with compliant bushfire shutters or compliant screens
Windows finishing 400 mm or more above an external horizontal surface *(see page 7 for definition)*	Windows need: • timber frames as usual • annealed glass • screens (internal or external) to openable parts
Windows finishing closer than 400 mm to an external surface *(see page 7 for definition)*	Windows need: • Frames – bushfire-resisting timber ***or*** timber species from E2 list *(see page 9)* • Glazing – 4 mm Grade A safety glass • Screens – openable parts screened (internally or externally) with a mesh or perforated sheet (internally or externally) made of corrosion-resistant steel, bronze or aluminium with a maximum 2 mm aperture

The simplest solution is to lift windows to 400 mm or more above any external surface which may collect smouldering embers or burning debris (ground, deck or balcony, carport roof, etc).

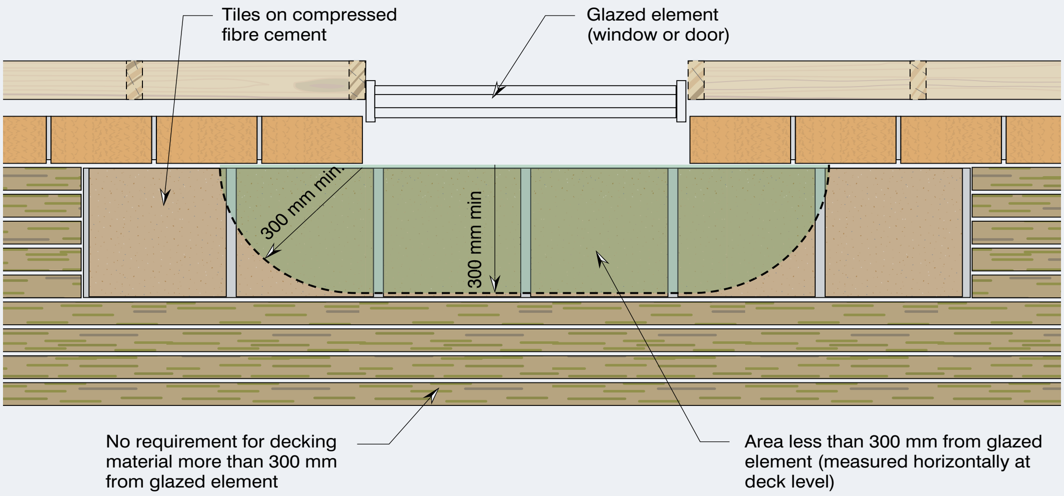
External walls, lightweight cladding	Framing members – all structural timber as usual.
Cladding materials	Weatherboards, ply sheeting, fibre-cement treatments etc.
Lower 400 mm of a wall near an external horizontal surface *(see page 7 for definition)*	Use cladding that is: • a bushfire-resisting timber ***or*** • a timber species from E1 ***or*** • a timber log wall *(see page 9)* ***or*** • made from a non-combustible material ***or*** • fibre-cement at least 6 mm thick ***or*** • any combination of the above materials
400 mm and above an external horizontal surface *(see page 7 for definition)*	Timber and timber products as usual.
External walls, heavyweight cladding	Framing members – all structural timber as usual.
Cladding materials	Brick veneer, blockwork, stone, stone cladding, etc – no special requirements.
External side-hung doors	
Protected doors	The full cover option gives you timber doors and joinery as usual for external side-hung doors: • completely protect doors and door frames with compliant bushfire shutters ***or*** compliant screens
Unprotected doors, unglazed	The main concern is protecting the lower 400 mm section of the door. The alternatives are: • using solid, laminated or reconstituted timber having a minimum thickness of 35 mm for the lower 400 mm ***or*** • attaching a non-combustible external kick-plate for the lower 400 mm to a solid, laminated or reconstituted timber having or hollow-core ***or*** • installing a door constructed of non-combustible materials

Unprotected doors, glazed	Install a fully-framed glazed door where the framing is: • bushfire-resisting timber ***or*** • a timber species from E2 (e.g. Victorian Ash, or a suitably fire-retardant treated timber) Glazing in unprotected doors needs to be • 4 mm Grade A safety glass
Unprotected door frames – lower 400 mm	At least the lower 400 mm of the door frame needs to be either a bushfire-resisting timber ***or*** a timber species from E2 (e.g.Victorian Ash or a suitably fire-retardant (FR) treated timber)
External sliding doors	
Protected doors glazing as usual	The full cover option gives you timber frames and standard • completely protect all external sliding doors with compliant bushfire shutters ***or*** compliant screens
Unprotected doors – glazing	• 4 mm Grade A safety glass
Unprotected doors – joinery	• Ensure the sliding door is tight-fitting in its frame • Use either a bushfire-resisting timber ***or*** a timber species from E2 (eg. Victorian Ash or a suitably fire-retardant (FR) treated timber)
Unprotected doors – screening	In this case there is no requirement to screen the openable part of the sliding door. It is assumed it will be closed during a bushfire event. If you do screen it, use a mesh or perforated sheet made of corrosion-resistant steel, bronze or aluminium with a maximum 2 mm aperture.
Enclosed or unenclosed *subfloor spaces* of verandas, decks, steps, ramps and landings	
Supports	Timber and timber products as usual.
Framing	Timber and timber products as usual.
Lightweight cladding wall enclosing the sub-floor space	For the first 400 mm above a 'horizontal' surface you have the same options as for external walls. Use cladding that is: • a bushfire-resisting timber ***or*** • a timber species from E1 ***or*** • made from a non-combustible material ***or*** • fibre-cement at least 6 mm thick ***or*** • any combination of the above materials
Decking with enclosed, or unenclosed, sub-floor*	
Decking 300 mm or more from a glazed element	Use timber as usual, e.g. treated pine.
Decking less than 300 mm (measured horizontally) from a glazed element	The decking closest to a window that is less than 400 mm above the deck or glazed door needs to be of the following materials: • a bushfire-resisting timber (e.g. Merbau) ***or*** • a timber species from E1 (e.g. Grey Ironbark) ***or*** • a non-combustible material (e.g. slate or ceramic tiles) This first 300 mm (measured horizontally) can be achieved with a few planks of bushfire-resisting or E1 timbers, or a row of 300 mm wide tiles laid on top of, or as an inset with, your normal treated pine decking. *(see BAL–12.5 Diagrams 1 and 2 on page 14).*

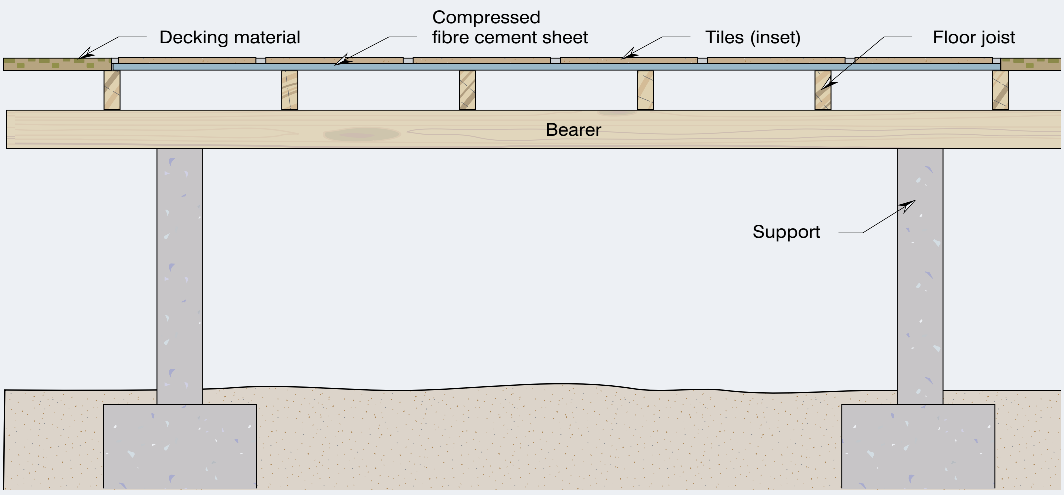
For the simplest solution decking can be a bushfire-resisting timber such as Merbau or an E1 timber.

BAL–12.5 diagrams 1 and 2 show a mixed material decking solution using a tile or slate insert for the first 300 mm of decking near a glazed door or window. A simpler solution is to use a fire- retardant treated, E1 or bushfire-resisting timber species for the first 300 mm close to the house. 'Decking' includes steps, porches, etc (see page 7)

BAL–12.5 Diagram 1: Plan View
Mixed material decking solution



BAL- 12.5 Diagram 2: Elevation View.
Mixed material decking solution



Balustrades and handrails	Timber as usual.
Veranda posts	All durable timber species mounted on galvanised shoes or stirrups at least 75 mm above the 'horizontal' surface
Less than 400 mm above finished ground level	• Bushfire-resisting timber ***or*** • a timber species from E1 ***or*** • a non-combustible material
Garages, carports, verandas and similar roofed structures	The Standard looks to the roof elements of these attached an adjacent structures, any separation from the main building's roof cavity and the fire resistance of the house wall to which they will abut or be near.
When an adjacent (closer than 6 metres) or attached roofed structure is separated from the main building by a fire-rated *(see page 32)* wall that extends to the underside of a non-combustible roof covering	All structural timber products as usual.
When the roof of an attached structure is separated from the roof space of the main building by a complying external wall	• All structural timber products as usual • Roof covering must be non-combustible
The separation between the house and adjacent building is 6 metres or more.	All structural timber products as usual.
Pergolas and similar unroofed structures (attached and adjacent)	The Standard makes no specific mention of these, therefore specify timber as usual - refer **Fire-grade plasterboard** (page 19).

Building designers and builders have a duty to inform building owners of the design, materials and building system obligations of the BAL of their site under AS 3959 and how this will affect future repairs, replacements, extension or renovation.

BAL–19

BAL–19 sites have been identified as having an increasing level of predicted ember attack and burning debris ignited by wind-borne embers. The '19' refers to an increasing radiant heat, not greater than 19 kW/m^2.

All traditional timber framing products and systems can be used, along with the usual timber species and treated pine for enclosed and raised decks (bearers and joists), balustrades, handrails, finials, pergolas, etc.

It should be noted that you can still build with a timber sub-floor, rather than a concrete slab, for less damage to the site, a smaller carbon footprint and all the convenience and comfort of building off the ground. **Note: when building with an unenclosed sub-floor, storage of combustible materials in the sub-floor space should be avoided.*

The simplest solution for decking at BAL–19 is to use a bushfire-resisting timber such as Merbau or an E1 timber (see page 9), or suitably fire-retardant (FR) treated timber, at least close to the house. After the first 300mm, traditional decking such as treated pine may be used.

This is the last BAL at which E2 timbers can be used for windows and doors.

Stronger, thicker glass is required for unprotected glazed doors and windows.

Individual state and territory requirements may exist for this Bushfire Attack Level. Please refer to Adoption AS 3959 by the various Australian states and territories (page 5) for guidance.

BAL–19 requirements summary

Subfloor spaces	
Enclosed • posts, stumps, columns, etc	All durable timber species and suitably preservative treated timbers as usual.
• floor bearers, joists & flooring	All timber species and engineered timber products as usual.
*Unenclosed** • posts, stumps, columns, etc	Bushfire-resisting timber.
Less than 400 mm above finished ground level • floor bearers & joists & flooring	Bushfire-resisting timber – Flooring may be any timber flooring product where the underside is lined with sarking type material or mineral wool insulation.
400 mm or more above finished ground level • floor bearers & joists & flooring	All timber species and engineered timber products as usual.

The simplest solution on many sites will be to build well off the ground (400 mm or more). This disturbs the natural drainage as little as possible and keeps your top soil on your block. When homeowners use an unenclosed subfloor space for storage they should consider possible combustibility e.g. stacks of old newspapers, cardboard packing materials, etc. This area should also be kept free of litter and combustible materials, especially in bushfire season.

Internal framing	All timber species and engineered timber products as usual.
Internal joinery	Including doors, wall lining, ceiling linings, flooring over concrete slabs, staircases, etc – all timber as usual.
Fascia and bargeboards	Timber as usual.
Eaves lining	Fibre-cement ***or*** timber as usual.
Tiled roof	Framing – all timber species and engineered timber framing members as usual.
Fully sarked	With a sarking with a flammability index of not more than 5. Install sarking directly below the tile battens: • ensure that the sarking covers the *entire roof area*, including ridges, and is extended into gutters and valleys, with no gaps greater than 2 mm where the sarking meets fascias, gutters, valleys, etc

BAL–19 requirements summary (continued)

Sheet roof	Framing – all timber species and engineered timber framing members as usual.
Fully sarked	With a sarking with a flammability index of not more than 5. Install as for a tiled roof (above), except that foil-backed insulation blankets may be installed over battens; and any gaps greater than 2 mm are to be sealed with one or a combination of: • mesh made of corrosion resistant steel, bronze or aluminium with a maximum 2 mm aperture ***or*** • mineral wool ***or*** • other non-combustible material
Windows, shutters and screens	The full cover option gives you timber frames and glazing as usual for all windows: • completely protect all windows with compliant bushfire shutters ***or*** compliant screens
Windows finishing 400 mm or more above an external horizontal surface *(see page 7 for definition)*	Windows need: • timber frames as usual • annealed glass • screens to all parts of window
Windows finishing closer than 400 mm to an external horizontal surface *(see page 7 for definition)*	Windows need: • Frames – bushfire-resisting timber ***or*** timber species from E2 • Glazing – 5 mm toughened glass • Screens (internal or external) to openable parts
Screens	Mesh made of corrosion resistant steel, bronze or aluminium with a maximum 2mm aperture
External walls, lightweight cladding	Framing members – all structural timber as usual.
Cladding materials	Weatherboards, ply sheeting, fibre-cement treatments etc.
Lower 400 mm of a wall near an external horizontal surface *(see page 7 for definition)*	Use cladding that is: • a bushfire-resisting timber ***or*** • a timber species from E1 ***or*** • a timber log wall *(see page 9)* ***or*** • made from a non-combustible material ***or*** • fibre cement at least 6mm thick ***or*** • any combination of the above materials.
400 mm and above an external surface *(see page 7 for definition)*	Timber and timber products as usual.
External walls, heavyweight cladding	Framing members – all structural timber as usual.
Cladding materials	Brick veneer, blockwork, stone, stone cladding, etc – no special requirements.
External side-hung doors	
Protected doors	The full cover option gives you timber doors and joinery as usual for external side-hung doors: • completely protect doors & door frames with compliant bushfire shutters ***or*** compliant screens
Unprotected doors, unglazed	The main concern is protecting the lower 400 mm section of the door. The alternatives are: • using solid, laminated or reconstituted timber, having a minimum thickness of 35 mm, for the lower 400 mm ***or*** • attaching a non-combustible external kick-plate for the lower 400 mm to a solid, laminated or reconstituted or hollow-core door ***or*** • a door constructed of non-combustible materials
Unprotected doors, glazed	Install a fully-framed glazed door where the framing is bushfire-resisting timber ***or*** a timber species from E2 (e.g. Victorian Ash, or a suitably fire-retardant (FR) treated timber.) • Glazing in unprotected doors needs to be 5mm toughened glass.
Unprotected door frames – lower 400 mm	At least the lower 400 mm of the door frame needs to be either a bushfire-resisting timber ***or*** a timber species from E2 (e.g. Victorian Ash or a suitably fire-retardant (FR) treated timber.)

BAL–19 requirements summary (continued)

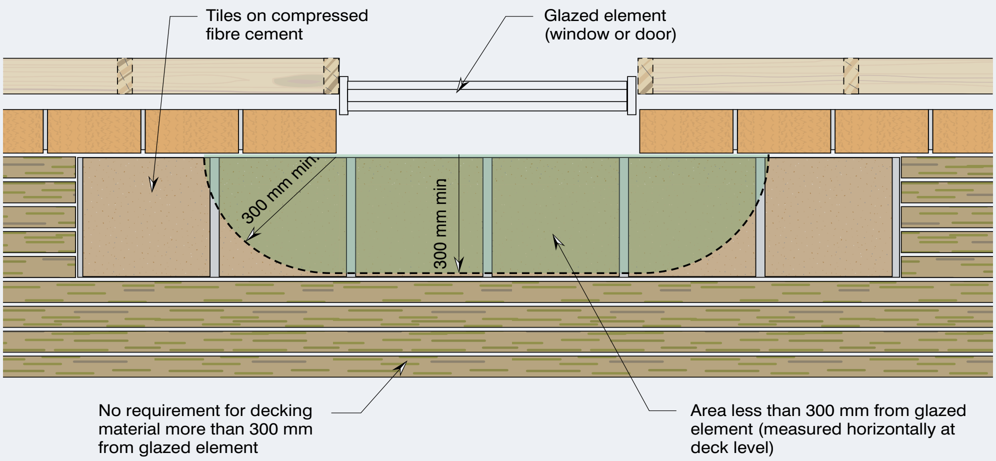
Owners should be supplied with copies of all documentation relating to compliance to the Standard of particular materials and building systems. These should be passed on to new the owners when the property is sold.

External sliding doors	
Protected doors	The full cover option gives you timber frames and standard glazing as usual: • completely protect all external sliding doors with compliant bushfire shutters ***or*** compliant screens.
Unprotected doors – glazing	• 5 mm toughened glass.
Unprotected doors – joinery	• Ensure the sliding door is tight-fitting in its frame. • Use either a bushfire-resisting timber ***or*** timber species from E2 (e.g. Victorian Ash or a suitably fire-retardant (FR) treated timber.
Unprotected doors – screening	In this case there is no requirement to screen the openable part of the sliding door. It is assumed it will be closed during a bushfire event. If you do screen it, use a mesh or perforated sheet made of corrosion-resistant steel, bronze or aluminium with a maximum 2mm aperture.
Enclosed and Unenclosed* *subfloor spaces* of verandas, decks, steps, ramps & landings	
Supports	Timber and timber products as usual.
Framing	Timber and timber products as usual.
Lightweight cladding wall enclosing a sub-floor space	For the first 400 mm above a horizontal surface you have the same options as for external walls. Use cladding that is: • a bushfire-resisting timber ***or*** • a timber species from E1 ***or*** • made from a non-combustible material ***or*** • fibre-cement at least 6 mm thick ***or*** • any combination of the above materials.
Decking with enclosed or unenclosed sub-floor	
Decking 300 mm or more from a glazed element	Use timber as usual, e.g. treated pine.
Decking less than 300 mm (measured horizontally) from a glazed element	The decking closest to a window that is less than 400 mm above the deck or glazed door needs to be of the following materials: • a bushfire-resisting timber (e.g. Merbau) ***or*** • a timber species from E1 (e.g. Grey Ironbark) ***or*** • a non-combustible material (e.g. slate or ceramic tiles) This first 300 mm (measured horizontally) can be achieved with a few planks of bushfire-resisting or E1 timbers, or a row of 300 mm wide tiles laid on top of, or as an inset with, your normal treated pine decking. *(see BAL–19 Diagrams 1 & 2, page 19)*.
Garages, carports, verandas and similar roofed structures	The Standard looks to the roof elements of these attached and adjacent structures, any separation from the main building's roof cavity and the fire resistance of the house wall to which they will abut or be near.
When an adjacent (closer than 6 metres) or attached roofed structure is separated from the main building by a fire rated *(see p32)* wall that extends to the underside of a non-combustible roof covering	All structural timber products as usual.

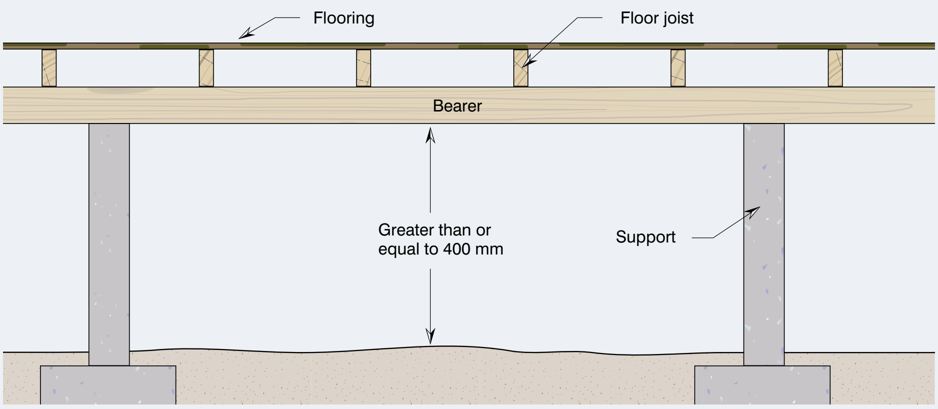
BAL–19 requirements summary (continued)

When the roof of an attached structure is separated from the roof space of the main building by a complying external wall	• All structural timber products as usual. • Roof covering must be non-combustible.
The separation between the house and adjacent building is 6 metres or more.	All structural timber products as usual.
Pergolas and similar unroofed structures (attached and adjacent)	The Standard makes no specific mention of these, therefore specify timber as. usual - refer fire-grade plasterboard below.
Balustrades and handrails	Timber as usual.
Veranda posts	All durable timber species mounted on galvanised shoes or stirrups at least 75 mm above the 'horizontal' surface
Less than 400 mm above finished ground level	• Bushfire-resisting timber ***or*** • a timber species from E1 ***or*** • a non-combustible material

BAL–19 Diagram 1: Plan View. Mixed material decking solution.



BAL–19 Diagram 2: Elevation View. Mixed material decking solution.



BAL–19 diagrams 1 and 2 show a mixed material decking solution using a tile or slate insert for the first 300 mm of decking near a glazed door or window. A simpler solution is to use a fire- retardant treated, E1 or bushfire-resisting timber species for the first 300 mm close to the house. 'Decking' includes steps, porches, etc (see page 7)

Fire-grade plasterboard

Where a carport or similar roofed structure, such as a veranda, is attached or closer than 6 metres, BAL–19 walls need to be built as a complying external wall (meeting the construction requirements of the designated BAL) that extends to the underside of a non-combustible roof covering or a fire-rated wall (see BAL–FZ).

BAL–29

At BAL–29 there is an increasing level of chance of ember attack and burning debris ignited by wind-borne embers. The '29' refers to the chance of an increasing radiant heat not greater than 29 kW/m².

Bushfire-resisting timbers *(see page 9)* and fire-retardant (FR) treated timbers are the only timbers to be used for exposed applications. For full window and glazed door protection, timber shutters (e.g. red ironbark) suitable to BAL–29 are available.

Always check external building materials and systems have been tested and comply with Standard requirements.

Individual state and territory requirements may exist for this Bushfire Attack Level. Please refer to Adoption AS 3959 by the various Australian states and territories (page 5) for guidance.

BAL-29 requirements summary

Enclosed subfloor spaces	
• posts, stumps, columns, etc	All durable timber species and suitably preservative treated timbers as usual.
•floor bearers, joists & flooring	All timber species and engineered timber products as usual.
Unenclosed subfloor spaces	
• posts, stumps, columns etc	Bushfire-resisting timber ***or*** non-combustible material.
• floor bearers and joists	
400 mm or more above the ground	All timber species and engineered timber products as usual. *(see BAL–29 Diagram 1, page 23)*
less than 400 mm from the ground	Materials need to be: • a bushfire-resisting timber ***or*** • timber, particleboard or plywood flooring with the underside lined with either mineral wool insulation or sarking ***or*** • a non-combustible material (e.g. fibre-cement flooring sheets).

The simplest solution on many sites will be to build well off the ground (400 mm or more). This disturbs the natural drainage as little as possible and keeps your top soil on your block. When homeowners use an unenclosed subfloor space for storage they should consider possible combustibility e.g. stacks of old newspapers, cardboard packing materials, etc. This area should also be kept free of litter, especially in bushfire season.

Internal framing	All timber species and engineered timber products as usual.
Internal joinery	Including doors, wall lining, ceiling linings, flooring over concrete slabs, staircases, etc. – all timber as usual.
Fascia and bargeboards	• a bushfire-resisting timber ***or*** • metal fixed at 450 mm centres
Eaves lining	• a bushfire-resisting timber ***or*** • 4.5 mm fibre-cement
Tiled roof	Framing – all timber species and engineered timber framing members as usual.
Fully sarked	With a sarking with a flammability index of not more than 5. Install sarking directly below the tile battens • ensure that the sarking covers the *entire roof area*, including ridges, and is extended into gutters and valleys, with no gaps where the sarking meets fascias, gutters, valleys, etc.

BAL–29 requirements summary (continued)

Sheet roof	Framing – all timber species and engineered timber framing members as usual.
Fully sarked	With a sarking with a flammability index of not more than 5. Install as for a tiled roof (above), except that foil-backed insulation blankets may be installed over battens; and any gaps greater than 2 mm are to be sealed with one or a combination of: • mesh made of corrosion-resistant steel, bronze or aluminium with a maximum 2 mm aperture ***or*** • mineral wool ***or*** • other non-combustible material.
Windows, shutters and screens	The full cover option gives you timber frames and glazing as usual for all windows: • completely protect all windows with compliant bushfire shutters.
Windows finishing 400 mm or more above an external horizontal surface *(see page 7 for definition)*	• Window frames and joinery are to be made from a bushfire-resisting timber • Glazing is to be 5 mm toughened glass • Screen (internally or externally) openable parts with a mesh made of corrosion-resistant steel, bronze or aluminium with a maximum 2 mm aperture.
Windows finishing closer than 400 mm to an external horizontal surface *(see page 7 for definition)*	• Window frames and joinery are to be made from a bushfire resisting timber- • Glazing is to be 5 mm toughened glass • External screens to all parts of window
Screens	Mesh made of corrosion resistant steel, bronze or aluminium with a maximum 2 mm aperture

Timber shutters tested as suitable to BAL–29 are available. Always check the materials and system have been tested and comply with the Australian Standard requirements.

External walls, lightweight cladding	Framing members – timber as usual.
Cladding materials	• a bushfire-resisting timber, with a vapour-permeable sarking attached to the *outside* of the frame ***or*** • a timber log wall *(see page 9)* ***or*** • fibre-cement that is at least 6 mm thick
External walls, heavyweight cladding	Framing members – all structural timber as usual.
Cladding materials	Brick veneer, blockwork, stone, stone cladding, etc – no special requirements.
External side-hung doors	
Protected doors	The full cover option gives you timber doors and joinery as usual for external side-hung doors: • completely protect doors and door frames with compliant bushfire shutters ***or*** compliant screens.
Unprotected doors, unglazed	The main concern is protecting the lower 400 mm section of the door. The alternatives are: • using solid, laminated or reconstituted timber, having a minimum thickness of 35 mm, for the lower 400 mm ***or*** • attaching a non-combustible external kick-plate for the lower 400 mm to a solid, laminated or reconstituted timber or hollow-core door ***or*** • a door constructed of non-combustible materials
Unprotected doors, glazed	Install a fully-framed glazed door where: • the framing is a bushfire-resisting timber • glazing is 6 mm toughened glass
Unprotected door frames	The door frame material needs to be a bushfire-resisting timber.

BAL–29 requirements summary (continued)

External sliding doors	The full cover option gives you timber frames and standard glazing as usual • completely protect all external sliding doors with compliant bushfire shutters ***or*** compliant screens
Unprotected doors – glazing	• 6 mm toughened glass
Unprotected doors – joinery	• Ensure the sliding door is tight-fitting in its frame • Use a bushfire-resisting timber
Unprotected doors – screening	In this case there is no requirement to screen the openable part of the sliding door. It is assumed it will be closed during a bushfire event. If you do screen it, use a mesh or perforated sheet made of corrosion-resistant steel, bronze or aluminium with a maximum 2 mm aperture.
Enclosed *subfloor spaces* of verandas, decks, steps, ramps and landings	
Supports	Timber and timber products as usual.
Framing	Timber and timber products as usual.
Lightweight cladding wall enclosing a sub-floor space	For the first 400 mm above a horizontal surface use cladding that is: • a bushfire-resisting timber ***or*** • made from a non-combustible material ***or*** • fibre-cement at least 6 mm thick ***or*** • a mesh made of corrosion-resistant steel, bronze ***or*** • aluminium with a maximum 2 mm aperture ***or*** • any combination of the above materials
Unenclosed *subfloor spaces* of verandas, decks, steps, ramps and landings	
Supports	• a bushfire-resisting timber ***or*** • a non-combustible material
Framing	• a bushfire-resisting timber ***or*** • a non-combustible material
Decking with enclosed or unenclosed sub-floor	Use either a bushfire-resisting timber (such as Merbau, Silvertop Ash) ***or*** a non-combustible material (such as slate, tiles).
Garages, carports, verandas and similar roofed structures	The Standard looks to the roof elements of these attached and adjacent structures, any separation from the main building's roof cavity and the fire resistance of the house wall to which they will abut or be near.
When an adjacent (closer than 6 metres) or attached roofed structure is separated from the main building by a fire-rated (see p32) wall that extends to the underside of a non-combustible roof covering	All structural timber products as usual.
When the roof of an attached structure is separated from the roof space of the main building by a complying external wall	• Build roof frame with bushfire-resisting timber ***or*** use all structural timber roof framing products as usual lined on the underside of the rafters with 6 mm fibre-cement sheeting • Roof covering must be a non-combustible material • The standard currently makes no direct reference to exposed beams and supporting posts. We recommend the use of bushfire-resisting timber
The separation between the house and adjacent building is 6 metres or more.	All structural timber products as usual.

BAL-29 requirements summary (continued)

Pergolas and similar unroofed structures (attached and adjacent)	The Standard makes no specific mention of these, therefore specify timber as usual - refer **Fire-grade plasterboard** below.
Balustrades and handrails	
125 mm or more from glazing or a combustible wall, ***or*** against a non-combustible wall	Use timber as usual.
Less than 125 mm from glazing ***or*** a combustible wall	Use either a bushfire-resisting timber ***or*** a non-combustible material, such as steel.
Veranda posts	• Bushfire-resisting timber ***or*** • a non-combustible material

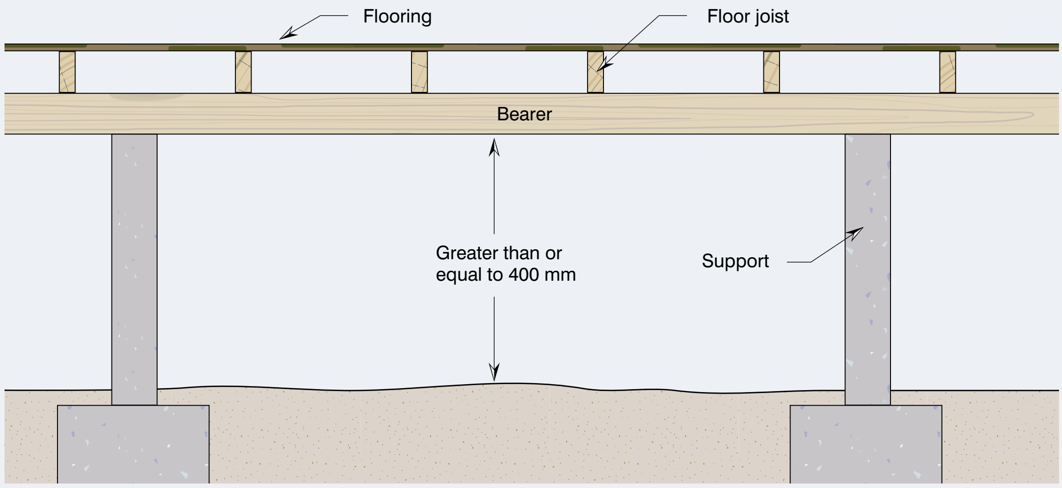
Evolution of the Standard AS 3959 – Prescriptive bushfire standard

Edition One 1991 – Ember attack only, no assessment.

Edition Two 1999 – Four construction levels and an assessment method; Ember and flame attack.

Edition Three 2009 – Six construction levels; two assessment methods; includes ember and flame attack with measurable criteria and test methods.

BAL–29 Diagram 1: Elevation View.
Standard subfloor construction when building above the ground by 400 mm or more.
Use traditional and engineered wood products as usual



Fire-grade plasterboard

Where a carport or similar roofed structure, such as a veranda, is attached or closer than 6 metres, BAL–29 walls need to be built as a complying external wall (meeting the construction requirements of the designated BAL) that extends to the underside of a non-combustible roof covering or a fire-rated wall (see BAL–FZ).

BAL–40

The second-highest Bushfire Attack Level, BAL–40 has a possibility of ember attack and burning debris ignited by wind-borne embers and an increased likelihood of exposure to bushfire flames. The '40' comes from an increasing radiant heat not greater than 40 kW/m².

The use of fire-resistant lining materials, thicker or treated glass, special shutters and building systems increase protection. At BAL–40 a number of building materials and systems used for the building envelope (external components) need to have met the specific test methods for building elements of construction exposed to simulated bushfire attack, as indicated in *AS 1530 Part 8.1 – Radiant heat and small flaming sources.*

There is no guarantee that a house will survive a bushfire event on all occasions. Consider installing a complying private bushfire shelter (bunker) for the safety of occupants in the event they cannot evacuate. Houses can be rebuilt... but lives cannot!

Individual state and territory requirements may also exist for this Bushfire Attack Level. Refer to Adoption AS 3959 by the various Australian states and territories (page 5) for guidance.

BAL–40 requirements summary

Enclosed subfloor spaces	
• posts, stumps, columns, etc	All durable timber species and suitably preservative treated timbers as usual.
• floor bearers, joists and flooring	All timber species and engineered timber products as usual.
For this extreme BAL we recommend that all subfloors are enclosed.	
Unenclosed subfloor spaces	
• posts, stumps, columns etc	• non-combustible material ***or*** • a system or material which complies with AS1530.8.1.
• floor bearers, joists and flooring	• timber members must have the underside lined with a non-combustible material (e.g. fibre-cement sheet, *see BAL–40 Diagram 1, page 28*) ***or*** • a non-combustible material or system ***or*** • material or system which complies with AS1530.8.1
Internal framing	All timber species and engineered timber products as usual.
Internal joinery	Including doors, wall lining, ceiling linings, flooring over concrete slabs, staircases, etc – all timber as usual.
Fascia and bargeboards	• material or system which complies with AS1530.8.1. *(see BAL–40 Diagram 1, page 28)*
Eaves lining	• 6 mm fibre-cement ***or*** • 6 mm calcium silicate.
Tiled roof	Framing – all timber species and engineered timber framing members as usual.
Fully sarked	With a sarking with a flammability index of not more than 5. Install sarking directly below the tile battens: • ensure that the sarking covers the *entire roof area*, including ridges, and is extended into gutters and valleys, with no gaps where the sarking meets fascias, gutters, valleys, etc.

BAL–40 requirements summary (continued)

Sheet roof	Framing – all timber species and engineered timber framing members as usual.
Fully sarked	Fully sarked with a sarking with a flammability index of not more than 5. Install as for a tiled roof (above), except that foil-backed insulation blankets may be installed over battens; and any gaps greater than 2 mm are to be sealed with one or a combination of: • mesh made of corrosion resistant steel or bronze with a maximum 2 mm aperture ***or*** • mineral wool ***or*** • other non-combustible material
Windows, shutters and screens	The full cover option gives you timber frames and glazing as usual for all windows: • completely protect all windows with compliant bushfire shutters
Windows without compliant shutters	• Window frames – metal • Glazing – 6 mm toughened glass • Screens – to all parts of window with a compliant material • Seals – materials with a flammability index no greater than 5 or silicone
External walls, lightweight cladding	Framing members – timber as usual.
Cladding materials	• a system complying with AS 1530.8.1. The moisture-resistant fire-grade plasterboard and timber system we recommend exceeds the requirement for the next BAL (BAL–FZ) and still enables the attractive appearance of timber *(see page 32)* ***or*** • steel sheet (sarking required) ***or*** • fibre cement cladding, with a minimum thickness of 9 mm (sarking required)
External walls, heavyweight cladding	Framing members – all structural timber as usual.
Cladding materials	Brick veneer, blockwork, stone, stone cladding, etc – no special requirements.
External side-hung doors	
Protected doors	The full cover option gives you timber doors, glazing and joinery as usual for external side-hung doors: • completely protect doors and door frames with compliant bushfire shutters
Unprotected doors, unglazed	The main concern is protecting the lower 400 mm section of the door. The alternatives are: • using solid timber, having a minimum thickness of 35 mm and the lower 400 mm protected behind a metal framed screen door with a mesh or perforated sheet made of corrosion resistant steel or bronze, with a maximum 2 mm aperture ***or*** • use a non-combustible material, such as steel
Unprotected doors, glazed	Install a fully-framed glazed door where: • the framing is metal • glazing is 6 mm toughened glass with the lower 400 mm fitted with a compliant external screen
Unprotected door frames	The door frame material needs to be a metal.
Seals	Materials with a flammability index no greater than 5 or silicone.

BAL–40 requirements summary (continued)

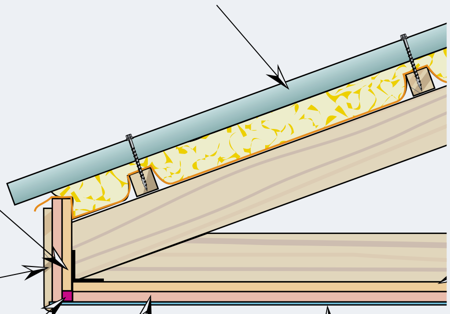
External sliding doors	
Protected doors	The full cover option gives you timber frames and standard glazing as usual: • completely protect all external sliding doors with compliant bushfire shutters.
Unprotected doors – glazing	• FRL – /30/ – *(see page 7 for definition)* ***or*** • 6 mm toughened glass behind screens to openable and fixed doors
Unprotected doors – joinery	• Ensure the sliding door is tight-fitting in its frame. • Use a metal material
Unprotected doors – screening	In this case there is no requirement to screen the openable part of the sliding door. It is assumed it will be closed during a bushfire event. If you do screen it, use a mesh or perforated sheet made of corrosion-resistant steel or bronze with a maximum 2 mm aperture.
Seals	Materials with a flammability index no greater than 5 or silicone.
Enclosed *subfloor spaces* of verandas, decks, steps, ramps and landings	
Supports	Timber and timber products as usual.
Framing	Timber and timber products as usual.
Lightweight cladding wall enclosing a sub-floor space	For the first 400 mm above a horizontal surface use cladding that is: • a system complying with AS 1530.8.1. The moisture resistant fire grade plasterboard and timber system we recommend exceeds even the requirement for the next BAL (BAL- FZ) and still enables the attractive appearance of timber. *(see page 32)* ***or*** • steel sheet (sarking required) ***or*** • fibre-cement cladding, with a minimum thickness of 9 mm (sarking required) Screen all openings greater than 2 mm with a corrosion-resistant steel or bronze mesh or perforated sheet with a maximum aperture of 2 mm.
Unenclosed *subfloor spaces* of verandas, decks, steps, ramps and landings	*(see BAL–40 Diagram 2 on page 28)*
Supports	• a system complying with AS 1530.8.1 ***or*** • a non-combustible material, e.g. concrete.
Framing	• a system complying with AS 1530.8.1 ***or*** • a non-combustible material, e.g. concrete.
Decking with enclosed or unenclosed sub-floor	Decking to have no gaps and be • a system complying with AS 1530.8.1 ***or*** • non-combustible material, e.g. slate or tiles

BAL–40 requirements summary (continued)

Building owners should be supplied with copies of all documentation relating to compliance to the Standard of particular materials and building systems. These should be passed on to new the owners when the property is sold.

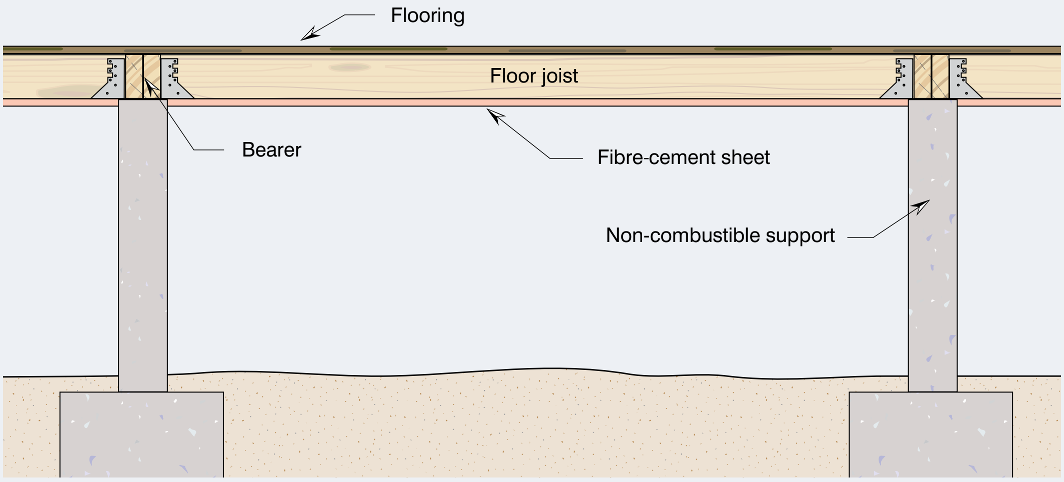
Garages, carports, verandas and similar roofed structures	The Standard looks to the roof elements of these attached and adjacent structures, any separation from the main building's roof cavity and the fire resistance of the house wall to which they will abut or be near.
When an adjacent (closer than 6 metres) or attached roofed structure is separated from the main building by a fire rated *(see p32)* wall that extends to the underside of a non-combustible roof covering	All structural timber products as usual.
When the roof of an attached structure is separated from the roof space of the main building by a complying external wall beams and supporting posts.	• Use all structural timber roof framing products as usual lined on the underside of the rafters with 6 mm fibre-cement sheeting • Roof covering must be a non-combustible material • The Standard currently makes no direct reference to exposed We recommend the use of bushfire-resisting timber
The separation between the house and adjacent building is 6 metres or more.	All structural timber products as usual.
Pergolas and similar unroofed structures (attached and adjacent)	The Standard makes no specific mention of these, therefore specify timber as usual.
Balustrades and handrails 125 mm or more from glazing or a combustible wall, or against a non-combustible wall	Use timber as usual.
Less than 125 mm from glazing or a combustible wall	Use a non-combustible material, such as steel.
Veranda posts	• a non-combustible material

BAL–40 Diagram 1: Fascia solution for BAL–40 using the flame zone (FZ) tested solution for roof systems.



This fascia and eaves system provides a solution for lightweight cladding walls and can be used with other wall systems, such as brick veneer, for improved protection in this vulnerable area.

BAL–40 Diagram 2: Elevation View. Unenclosed, lined sub-floor system



The solution in BAL–40 Diagram 2 uses a subfloor 'ceiling' of fibre-cement sheet and non-combustible posts, columns and stumps. A more practical solution is to enclose the subfloor using a complying wall system and normal timber subfloor construction.

Fire grade plasterboard

For BAL–40 the Standard, AS 3959 stipulates a lightweight cladding wall should comply to AS 1530.8.1. At time of printing we are unaware of any system that has been tested to comply with this requirement. There are, however, building systems that have been tested to the more rigorous requirements of BAL–FZ. Our system is easily constructed utilising a membrane of fire grade plasterboard with the external timber cladding. Just one layer of 16 mm moisture-resistant fire-grade plasterboard in this system achieves twice the required FRL of 30/30/30. Even higher FRLs can be achieved with more layers of suitable plasterboard, if desired.

For more information refer to pages 32 and 33.

BAL–FZ

This is the highest Bushfire Attack Level (BAL) in AS 3959. Very bushfire-prone, probably in a picturesque bushland setting, a home designated BAL–FZ has a predicted direct exposure risk to flames from a fire front, ember attack and radiant heat greater than 40 kW/m².

Following the Standard, ensuring commonsense maintenance, as well as complying with Bushfire Management Overlays (BMO) and fire authority rules and instructions, are all important. Reduce the potential for bushfire attack and damage by following the Standard's guidelines for building systems and materials and special timber choices.

In areas identified as BAL–FZ (Flame Zone) the building envelope needs extra reinforcement, especially in the most vulnerable places – such as the leading edges of roofs, glazed areas and decks where flames, embers and hot air can penetrate.

For this extreme BAL we recommend that all subfloors are enclosed, with complaint mesh on sub-floor external wall vents.

By ensuring no gaps of more than 2 mm, tight door seals and the most fire-resistant materials it is still possible to have a nice home, using lightweight cladding such as weatherboards, on the exterior. A system using a membrane of moisture-resistant, fire-grade plasterboard gives you a normal choice of exterior cladding looks *(see pages 32 and 33)*.

The relevant BAL–FZ test methods for building elements of construction exposed to simulated bushfire attack are available in *AS 1530 Part 8.2 – Large flaming sources*.

There is no guarantee that a house will survive a bushfire event on all occasions. Consider installing a complying private bushfire shelter (bunker) for the safety of occupants in the event they cannot evacuate. Houses can be rebuilt... but lives cannot!

The BAL–FZ roofing system needs to comply with AS 1530.8.2 when tested from the outside. AS 3959 provides a deemed-to-satisfy sheet metal roofing system, utilising structural plywood, that is illustrated on pages 36-40. As new timber systems are developed and tested, further data sheets will be available at www.woodsolutions.com.au.

Building designers, those ordering building materials and building surveyors need to ensure they use test reports, issued by Accredited Testing Laboratories, as quantifiable evidence of the suitability of their performance-based bushfire designs and construction.

Individual state and territory requirements may exist for this Bushfire Attack Level. Please refer to Adoption AS 3959 by the various Australian states and territories (page 5) for guidance.

BAL–FZ requirements summary

Building owners should be supplied with copies of all documentation relating to compliance to the Standard of particular materials and building systems. These should be passed on to new the owners when the property is sold.

Enclosed subfloor spaces	
• posts, stumps, columns, etc	All durable timber species and suitably preservative treated timbers as usual.
•floor bearers & joists & flooring	All timber species and engineered timber products as usual.
Unenclosed subfloor spaces	
• posts, stumps, columns, etc	• a system with FRL of at least 30/-/- and non-combustible ***or*** • a system complying with AS 1530.8.2.
• floor bearers, joists and flooring	• a system with FRL of at least 30/30/30 and non-combustible surface material ***or*** • protect the underside of combustible floor elements with a 30 minute resistance to incipient spread of fire system ***or*** • a system complying with AS 1530.8.2, when tested from the outside.
Internal framing	All timber species and engineered timber products as usual.
Internal joinery	Including doors, wall lining, ceiling linings, flooring over concrete slabs, staircases, etc all timber as usual.
Fascia and bargeboards	A system complying with AS 1530.8.2. Refer to the first tested system to comply (Ply membrane) *(see page 38)*

BAL–FZ requirements summary (continued)

Eaves lining	• a system with FRL – /30/30 ***or*** • a system complying with AS 1530.8.2. Refer to the first tested system to comply *(see page 38)*
Tiled roof	Framing – all timber species and engineered timber framing members as usual. The roofing system needs to comply with AS 1530.8.2 when tested from the outside.
Sheet roof	Framing – all timber species and engineered timber framing members as usual. The roofing system needs to comply with AS 1530.8.2 when tested from the outside *(see pages 35-39)*
Windows, shutters and screens	The full cover option gives you timber frames and glazing as usual for all windows: • completely protect all windows with bushfire shutters that comply with AS 1530.8.2, when tested from the outside.
Windows without compliant shutters	The openable parts of the window screened with a metal-framed screen with mesh made of corrosion resistant steel or bronze with a maximum 2 mm aperture ***and*** be either: • a window system having FRL of – /30/ – ***or*** • a window system complying with AS 1530.8.2, when tested from the outside

Vents in exterior walls need to be protected with a corrosion-resistant steel or bronze mesh with a maximum aperture of 2 mm.

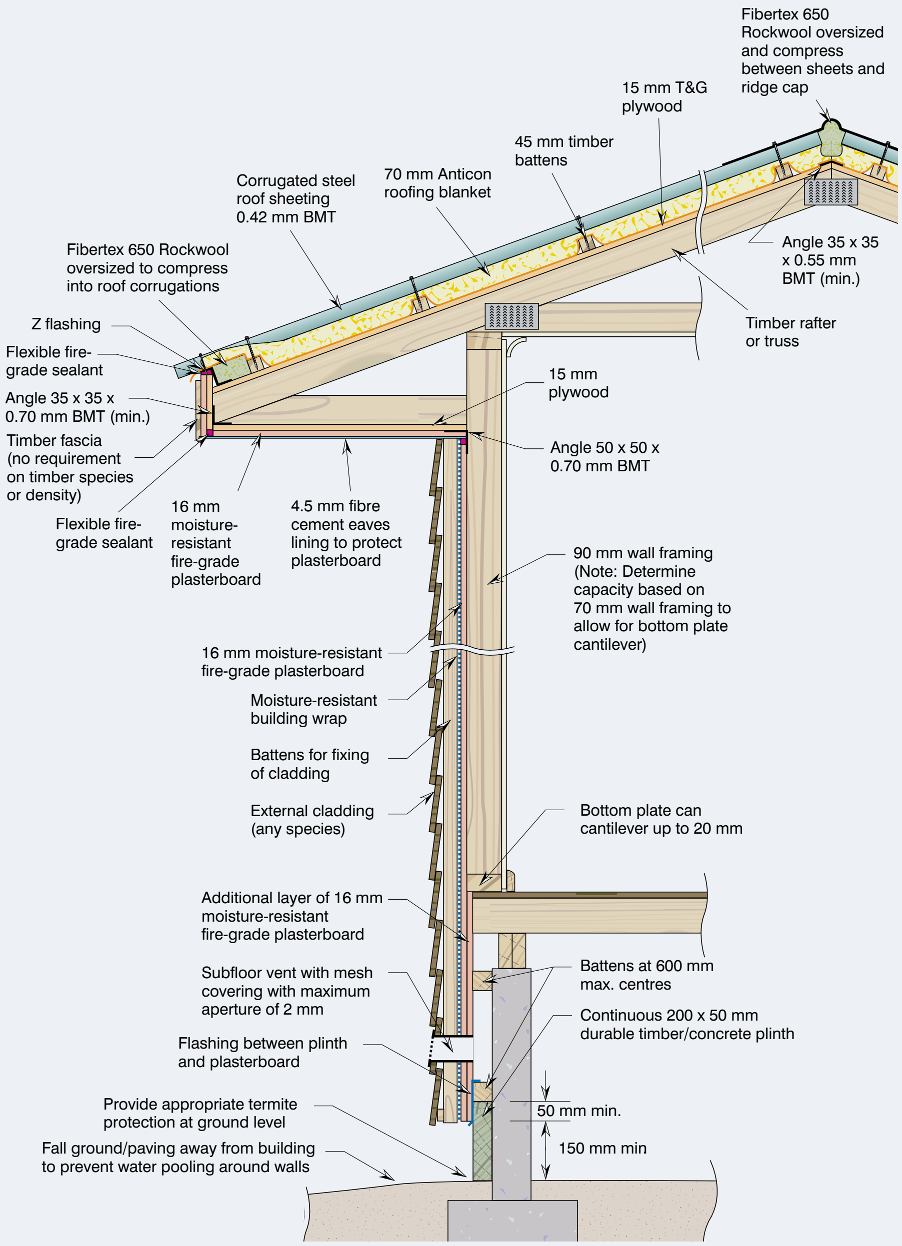
External walls, lightweight cladding	Framing members – timber as usual.
Cladding materials	• a system complying with AS 1530.8.2. when tested from the outside ***or*** • a system having an FRL of 30/30/30 or -/30/30 when tested from the outside The moisture resistant fire-grade plasterboard and timber system we recommend exceeds this requirement and still enables the attractive appearance of timber *(see pages 32 & 33)*.
External walls, heavyweight cladding	Framing members – all structural timber as usual.
Cladding materials	Brick veneer, blockwork, stone, stone cladding, etc – no special requirements.
External side-hung doors	
Protected doors	The full cover option gives you timber doors, glazing and joinery as usual for external side-hung doors • completely protect doors and door frames with bushfire shutters that comply with AS 1530.8.2, when tested from the outside
Unprotected doors glazed and unglazed	The door system can comply for this BAL by: • having FRL of – /30/ – ***or*** • complying with AS 1530.8.2 when tested from the outside
Seals	Materials with a flammability index no greater than 5 or silicone.
External sliding doors	
Protected doors	The full cover option gives you timber frames and standard glazing • completely protect all external sliding doors with bushfire shutters that comply with AS 1530.8.2 when tested from the outside
Unprotected doors	The door system can comply for this BAL by: • having FRL of – /30/ – ***or*** • complying with AS 1530.8.2 Ensure the sliding door is tight-fitting in the frames.
Seals	Materials with a flammability index no greater than 5 or silicone.

BAL–FZ requirements summary (continued)

Enclosed *subfloor spaces* of verandas, decks, steps, ramps and landings	
Supports	Timber and timber products as usual.
Framing	Timber and timber products as usual.
Lightweight cladding wall enclosing a sub-floor space	• a system complying with AS 1530.8.2. when tested from the outside ***or*** • a system having an FRL of 30/30/30 or –/30/30 when tested from the outside. The moisture-resistant fire-grade plasterboard and timber system we recommend exceeds this requirement and still enables the attractive appearance of timber *(see pages 32 and 33)*. Screen all openings greater than 2 mm with a corrosion resistant steel or bronze mesh or perforated sheet with a maximum 2 mm aperture.
Unenclosed *subfloor spaces* of verandas, decks, steps, ramps and landings	
Supports	• a system complying with AS 1530.8.2 ***or*** • a non-combustible material, e.g. concrete
Framing	• a system complying with AS 1530.8.2 ***or*** • a non-combustible material, e.g. concrete
Decking with enclosed sub-floor	Decking to have *no gaps* and be • a non-combustible material, such as slate or ceramic tiles, on a compressed fibre cement substrate ***or*** • a system which complies with AS 1530.8.2
Decking with unenclosed sub-floor	Decking to be • a non-combustible material ***or*** • fibre-cement sheets ***or*** • a system complying with AS 1530.8.2
Garages, carports, verandas and similar roofed structures	The Standard looks to the roof elements of these attached and adjacent structures, any separation from the main building's roof cavity and the fire resistance of the house wall to which they will abut or be near.
When an adjacent (closer than 6 metres) or attached roofed structure is separated from the main building by a fire rated (see p15) wall that extends to the underside of a non-combustible roof covering	All structural timber products as usual.
When the roof of an attached structure is separated from the roof space of the main building by a complying external wall	• Use structural timber roof framing products as usual lined on the underside of the rafters with 6 mm fibre-cement sheeting • Roof covering must be a non-combustible material • The Standard currently makes no direct reference to exposed beams and supporting posts. We recommend the use of bushfire-resisting timber
The separation between the house and adjacent building is 6 metres or more.	All structural timber products as usual.
Pergolas and similar unroofed structures (attached and adjacent)	The Standard makes no specific mention of these, therefore any usual timber can be specified. At this BAL we recommend a bushfire-resisting timber.

Balustrades and handrails	
125 mm or more from glazing or a combustible wall, or against a non-combustible wall	Use timber as usual.
Less than 125 mm from glazing or a combustible wall	Use a non-combustible material, such as steel.

BA-FZ Diagram 1: Sectional view.
Deemed-to-satisfy sheet metal roof and FRL 60/60/60 wall system.
Note: AS 3959 simply requires a wall FRL of 30/30/30



At this BAL an unenclosed subfloor 'ceiling' requires a system which will give at least a 30 minute resistance to incipient spread of fire.

Fire-grade plasterboard

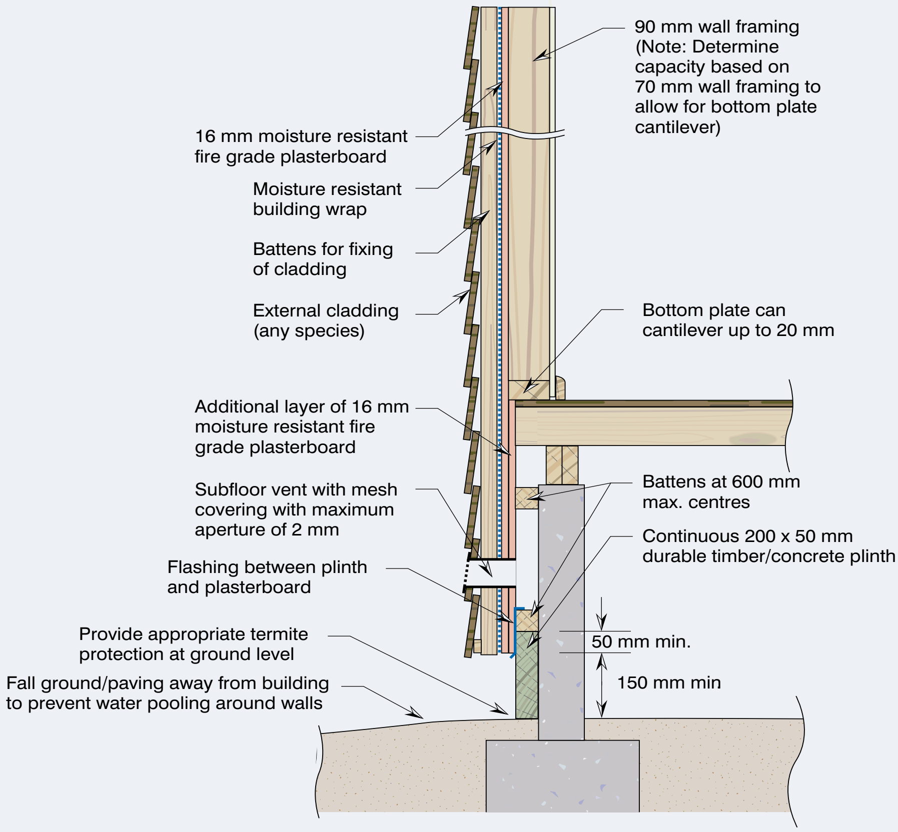
For BAL–FZ the Standard, AS 3959 stipulates requirements for external walls. You can use a non-combustible material such as bricks, rock, concrete blocks etc or you can continue to use attractive, space-saving lightweight cladding such as weatherboards and sheeting products such as external grade ply with *"A system with an FRL (Fire Resistance Level:) of 30/30/30 or –/30/30 when tested from the outside."* (See Section 9 of the Standard).

The Fire Resistance Level (FRL) is the "structural adequacy / integrity / insulation" of the system each measured in minutes.

- Structural adequacy means the ability of a structure to maintain its stability and load-bearing capacity
- Integrity is the ability of a structure to resist the passage of flames and hot gases
- Insulation means the ability of a structure to maintain a temperature below specified limits on the surface *not exposed* to fire.

For example, a FRL requirement for glazing of –/30/– means there is a requirement that the glass can resist the passage of flame and hot gases for at least 30 minutes. The relevant standard is *AS 1530.4 Methods for fire tests on building materials, components and structures – Fire-resistance tests of elements of construction.*

BAL–FZ Diagram 2: Sectional View
Timber and other lightweight cladding Fire-Rated External Wall System using fire-grade plasterboard FRL 60/60/60 *(Typical detail - refer plasterboard manufacturer's installation details)*



BAL–FZ Diagram 2 shows a typical sectional view of the timber and other lightweight cladding Fire-Rated External Wall System using fire-grade plasterboard which achieves double the protection stipulated by the Standard. Key design elements of the system are:

1. Design the wall as a 70 mm timber frame (studs and plates) but utilise 90 mm timber framing.
   This allows the wall to be cantilevered up to 20 mm at floor level to allow for the additional layer of 16 mm moisture-resistant, fire-grade plasterboard required to enclose the subfloor space.
2. The floor joists supporting the external load-bearing walls are cantilevered to enable the installation of elements within the subfloor space.

3. Install a continuous 200 x 50 mm durable timber (e.g. H4 treated pine) or concrete plinth around the base of the system. This 50 mm thick durable timber is designed to resist burn through for up to 60 minutes and will provide the durability needed at ground level.
4. Install sheets of 16 mm moisture-resistant fire-grade plasterboard to the outside of the wall frame in accordance with the plasterboard manufacturer's requirements for fixings, spacings and joint detailing. Keep the plasterboard at least 150 mm above the ground to minimise possible water penetration.
5. Batten out the wall frame and install your timber cladding of choice over the plasterboard system.
6. Install subfloor vents to provide adequate air movement as required by your local building authority. Screen vents with a mesh made of corrosion resistant steel or bronze that has a maximum aperture of 2 mm.

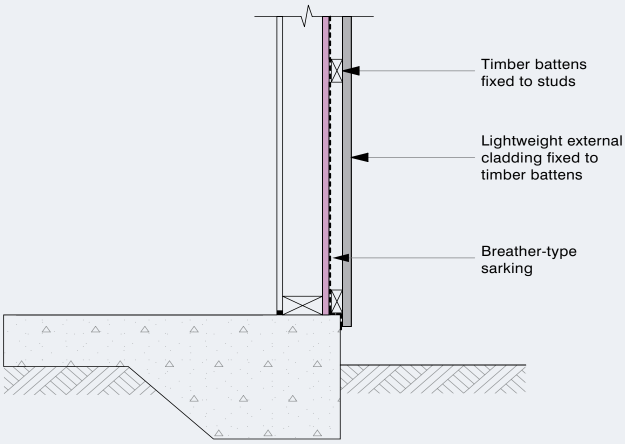
The preceding assumes a subfloor with concrete or similar piers. This system can also be used in combination with a concrete slab (BAL–FZ Diagram 3) or on base brick work (BAL–FZ Diagram 4).

When used with a concrete slab, leave a gap of 75 mm between the bottom of the cladding and exterior ground surface to minimise possible water penetration.

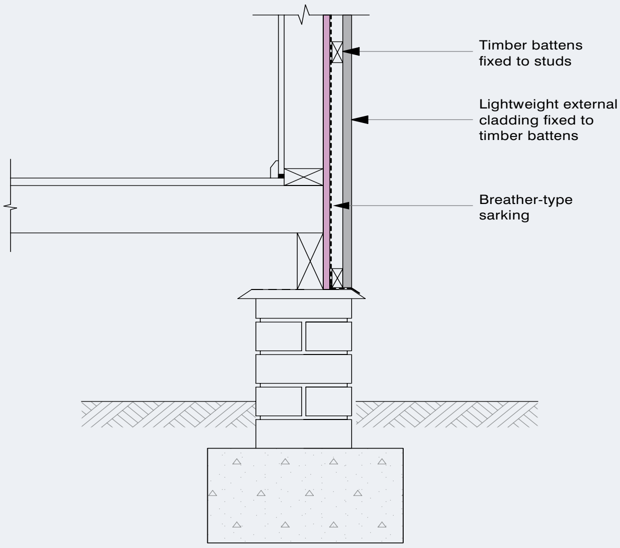
With base brick work, install required screened subfloor vents and moisture/termite barriers.

As with all buildings, keep garden beds and soil away from the house to enable regular pest or fungal inspections.

BAL–FZ Diagram 3: Sectional view.
Timber and other lightweight cladding Fire-Rated External Wall System using fire grade plasterboard on a concrete slab.



BAL-FZ Diagram 4: Sectional view.
Timber and other lightweight cladding Fire-Rated External Wall System using fire-grade plasterboard with base brick work.



6 Bushfire Flame Zone Resistant Sheet Metal Roofs

The Australian Standard *AS 3959 Construction of buildings in bushfire-prone areas* (2009) is referenced in the National Construction Code Series Building Code of Australia.

Under the Standard, sites that have been assessed at the highest Bushfire Attack Level, Flame Zone (BAL–FZ) must have roof and eaves systems that comply by meeting the requirements of ***AS1530.8.2 Test on Elements of Construction for buildings exposed to simulated bushfire attack – large flame source.*** This section details the first system for sheet metal roofs to comply and can be found in Appendix H3 of AS 3959. This plywood membrane roof system can be used in combination with any wall cladding system that complies with AS3959 to BAL–FZ, this includes systems utilising wall sheeting and weatherboard.

The roof system uses a membrane of 15 mm plywood over the rafters/trusses with 70 mm Anticon™ Roofing Blanket (glasswool). The eaves system combines 15 mm plywood and 16 mm moisture-resistant fire grade plasterboard.

As additional roof solutions are tested and certified for compliance with BAL–FZ, up-to-date information can be found at www.woodsolutions.com.au as it becomes available.

The AS1530.8.2 test method is quite severe. The resultant building systems resemble the fire-rated requirements commonly used for wall or floor construction. Roofing installers must ensure the same level of care and supervision applies when building bushfire resisting roofs and eaves systems.

The prevention of embers, radiant heat and flames through the roof system is critical. The following details are important for the points that are known to be most vulnerable, e.g. the leading edge of roofing (at fascias, ridge, hips and valleys). Obviously, by simplifying the roof design you can reduce the opportunity for the fire to breach the roof system and gathering points for embers. You will also save on construction and material costs.

Plywood Membrane Roof System for BAL-FZ

Plywood sheeting between the roof cavity and insulation system provides a rigid base for the mineral wool and is a material that will smoulder rather than melt and collapse in extreme conditions.

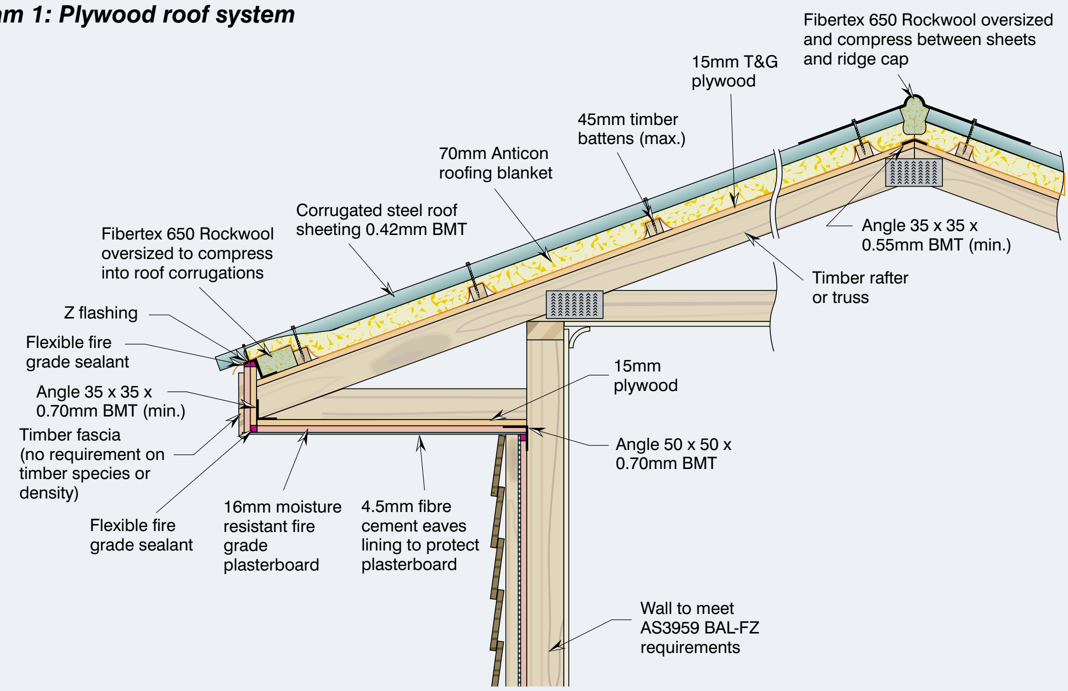
To meet the test Standard:

- 15 mm tongue and grooved (T&G) plywood is placed directly over the rafters/trusses, with the face veneer at right angles to the rafter direction.
- The end joints must be made over rafter edges.
- Where a free end is unavoidable, use a nogging (not less than 70 mm x 35 mm) running between the rafters and set flush to the top of the rafters.
- Each plywood panel must be continuous over more than one span.

Readily available plywood stress grades are F11 and F14.

Diagram 1 shows the AS3959 BAL–FZ compliant roof system using a plywood membrane.

Diagram 1: Plywood roof system



Fixing Plywood

To fix the plywood to the rafters/trusses, use the same method as for fixing plywood flooring, (detailed in AS1684 *Residential timber-framed construction* standards).

Space nails and/or screws at 150 mm centres at panel ends and at 300 mm centres at intermediate rafters/trusses and noggings. Do not fix the plywood at less than 10 mm from edges.

Hand driven nails	2.8 mm minimum diameter, flathead or bullet head nail, minimum length of 40 mm (this length is 2.5 times plywood thickness)
Gun driven nails	2.5 mm minimum diameter gun nails, minimum length of 40 mm (this length is 2.5 times the plywood thickness)
Screws to timber joists	No. 8 x 30 self-drilled countersunk wood screws.

At the ridge and valley position, the plywood joint must be covered by a 35 x 35 mm x 0.55BMT (BMT = base metal thickness) angle or flashing.

Battens

Use timber battens with a maximum size of 45 mm x 90 mm. Traditional timber battens are 35-38 mm thick and therefore comply. They are also easy to handle and fix.

When fixing battens to rafters/trusses roofing installers need to comply with the specific tie-down as required for the site's location.

Insulation

Roof systems for BAL-FZ require additional steps and materials compared to traditional steel roofs. The steps described below detail how to provide protection to the points known to be most vulnerable. e.g. the leading edge of roofing (at fascias, ridge, hips and valleys). These steps are vital to ensure that the roofing system performs as tested, to limit the possibility of entry of embers, radiant heat and flames.

Roof area

To comply with the tested system, lay 70 mm Anticon™ Roofing Blanket over the roof filling the void between the plywood deck and the underside of the metal sheet.

Note: The original tested system used a 75 mm Anticon roofing blanket which is now no longer manufactured. Bradford Insulation have confirmed that the performance of the (new) 70 mm blanket is equivalent to the 75 mm blanket tested.

Interface with fascia

At the interface of the metal roof sheet and the fascia, use an oversized Fibretex 650 Rockwool strip to seal between the plywood and the roof sheet. The Rockwool strip is to be 75 mm thick by 90 mm high, fitted snugly between the Z flashing and the first lower roof batten and placed continuously along the roof's edge (see Diagram 2). The Anticon™ Roofing Blanket (foil facing down) is laid over the battens and the Rockwool strip and under the roof sheeting. Compress the blanket, along with the Rockwool, to assist in sealing off the leading edge of the roof sheeting.

Roof ridge and hips

At the ridge and hips, install a 90 mm high by 75 mm thick strip of Fibretex 650 Rockwool fitted between the ends of the roof sheets so that the Rockwool is compressed to 50 per cent of its thickness and placed above the Anticon™ Roofing Blanket.

Valleys

On both sides of the valley, install two layers of 15 mm plywood 'strips' on top of the plywood membrane cut to neatly fit under the valley gutter.

At the interface of the metal roof sheet and the valley, use an oversized Fibretex 650 Rockwool strip to seal between the plywood and the roof sheet. The Rockwool strip is to be 75 mm thick by 90 mm high, fitted snuggly between the Z flashing and the first lower roof batten and placed continuously along both valley edges – detail similar to Diagram 2. Between the Z flashing and the double plywood strips, apply fire grade sealant along each side of the valley.

The Anticon™ Roofing Blanket (foil facing down) will cover the Rockwool strip but needs to be trimmed back to the Z flashing to avoid moisture problems. Compress the blanket, along with the Rockwool, to assist in sealing off the leading edge of the roof sheeting.

Roof Sheeting

To reach *AS1530.8.2 Test on Elements of Construction for buildings exposed to simulated bushfire attack – large flame source*, use 0.42 mm BMT corrugated roof sheets that comply with AS1445. Fix the roof sheets normally, except you need to apply double fixings along the leading edge of the roof into the Z flashing (see detail plan view, Diagram 3).

Eaves, Fascia And Barge Boards

Testing revealed that eaves and fascia construction does not benefit from the inclusion of insulation, so the system requires a different approach.

The BAL–FZ sheet metal roof system solution for fascia and eaves takes advantage of the strength of plywood in both the eaves soffit and fascia to achieve fire resistance. It combines 15 mm plywood and 16 mm fire-grade moisture-resistant plasterboard to effectively seal the building envelope at these points.

First fix the plywood sheet to the framing (using the same methods described for the roof).

Over the plywood, fix 16 mm fire grade moisture-resistant plasterboard to the timber framing using 38 mm x 6 g needlepoint screws at 150 mm centres – plasterboard oriented so that butt joins do not fall on joins in plywood.

Diagram 2: Eaves, Fascia and Bargeboard details for compliant sheet metal roof systems.

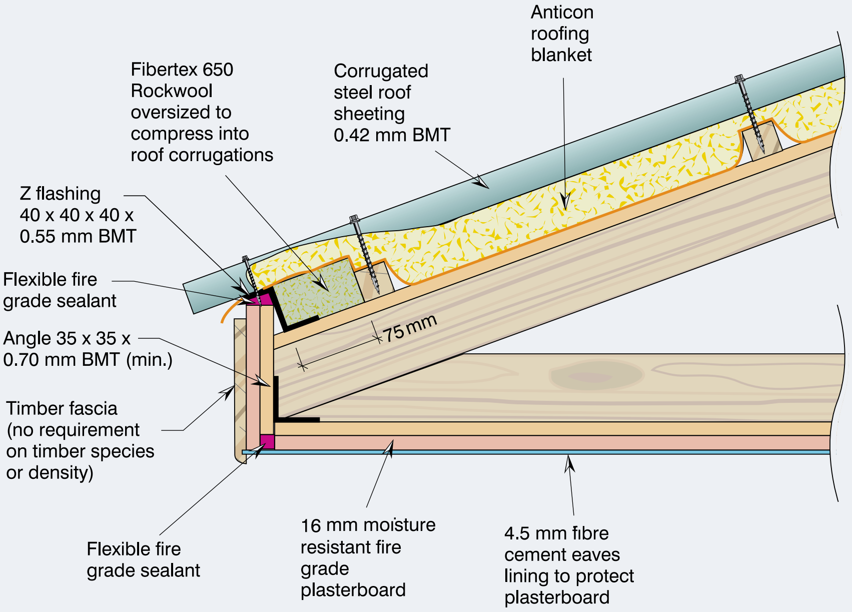
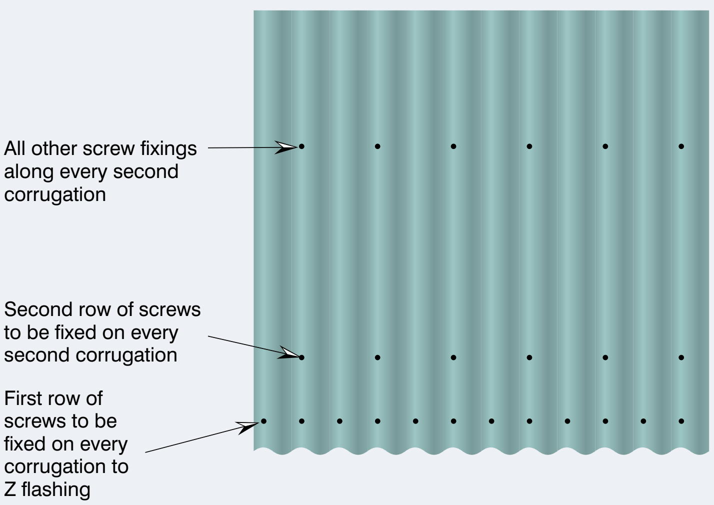


Diagram 3: Detail, Roof fixing requirements



Joints, corners and abutting sections

Use flexible fire-grade mastic to seal joints in the 16 mm fire-grade moisture-resistant plasterboard, corners or where the plasterboard abuts another element.

Support the plasterboard by using 35 x 35 x 0.70 mm angles, timber noggings or follow the plasterboard manufacturer's requirements.

Weather protection

Cover the 16 mm fire-grade moisture-resistant plasterboard with a weather protector. For the:

- Eaves soffit – 4.5 mm (minimum) fibre cement eaves lining.
- Fascias or bargeboards – standard 19 mm timber fascia.

These elements are an integral part of the roof system.

Other issues

This data sheet details the roof system requirements to meet the fire resistance mandated by the test method.

This data sheet does not address other issues, such as durability, ventilation, structural adequacy, bracing, fixing (unless required by the fire test) or tie-down that may affect the roof. Designers and/or roofing installers should seek information on these matters from relevant technical sources.

Using materials of other thicknesses or densities

Information contained in this data sheet represents the minimum to meet the tested system. Products that are thicker or denser maybe used, unless otherwise indicated herein.

Proprietary products

Products that are described by manufacturer's name (eg Anticon™) cannot be substituted for similar products.

Compliance information

This section outlines how to comply with BAL–FZ with a sheet metal roof. It outlines the requirements as described in AS3959 *Construction of buildings in bushfire-prone areas* Standard. The system described above complies with AS1530.8.2 *Methods for fire tests on building materials, components and structures*. The report on which this is based is:

> Exova Warringtonfire Report No: 23626A-07 – An assessment of the bushfire attack level (BAL) performance of various sheet metal roof systems if tested in accordance with AS1530.8.2-2007 Section 16 (Flame Zone).

Wall cladding systems and other exterior construction elements

The roof system can be used in combination with any wall cladding system that complies with AS3959 to the relevant bushfire attack level. A system combining traditional light-weight cladding materials (including weatherboard and fibre cement sheeting) and a moisture-resistant, fire-grade plasterboard can achieve a Fire Resistance Level (FRL) in excess of the Standard requirements at BAL–FZ (FRL 30/30/30). Find out more from your specialist plasterboard supplier.

Ensure that alternative exterior wall sections used in combination with, or to replace, brick veneer comply with the relevant requirements in the Standard.

A Appendix A - NSW variations to building requirements

Simplified Bushfire Standard Complying Timber Construction in NSW

The NSW building regulations vary the requirements in the Acceptable Construction Manual within the Building Code of Australia (BCA) for construction in Bushfire-prone Areas.

To help understand the differences between construction to the AS3959 *Construction of buildings in bushfire-prone areas* standard, as spelt out in WoodSolutions Technical Design Guide 04 *Building with Timber in Bushfire prone Areas* and Planning for Bushfire Protection - Addendum: Appendix 3, NSW Rural Fire Service - Planning for Bush Fire 'Protection' the following table incorporates the requirements of both guides.

Although every effort has been taken to reflect the requirements contained in the NSW Rural Fire Service - Planning for Bush Fire Protection and AS 3959 *Construction of buildings in bushfire-prone areas* standard, it is recommended that this Appendix be used in conjunction with these two documents, especially where in doubt.

Reading the Tables

Information provided within the following table relates to the minimum allowable construction requirements for timber and wood products. There are many other non-timber systems that can be used and are described in this Guide or AS3959. Solutions described in a higher BAL level can also used in lower BAL levels. For simplicity the higher performing solutions are not repeated in the lower BAL levels.

For construction solutions in BAL-40 and FZ the NSW Rural Fire Service also considers flaming materials will increase the exposure and *"...can contribute to the risk of loss of life and compromise the ability of residents to defend their property and egress from the building once the bush fire front has passes."*

Comment: This is the view of the NSW-RFS although there is no research that has been published that demonstrates that these is any greater risk to residents than that posed by the surrounding flaming vegetation.

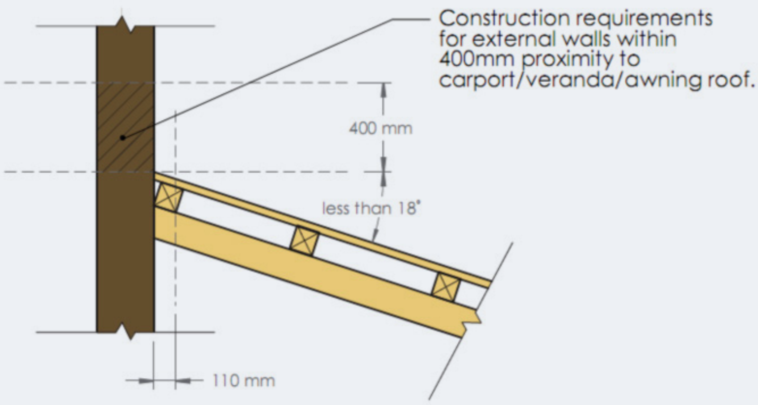
Building element	BAL–12.5 and BAL–19	BAL–29	BAL–40	BAL–FZ
Building subfloor space – enclosed				
Wall enclosing subfloor space	Less than 400 mm from the ground or an external horizontal surface[1] use timber framing provided the framing is clad with non-combustible material such as fibre cement or timber with density of 750 kg/m^3 or greater. 400 mm or more above the ground[1] there are no construction requirements any timber framing or cladding can be used.	All timber framing **provided** the framing is clad with non-combustible sheet material (6 mm fibre-cement) or bushfire-resisting timber.[2]	All timber framing **provided** the framing is clad with masonry, steel material or min 9 mm fibre-cement.	NSW building regulations do not recognise deemed-to-satisfy construction solutions within this BAL. Building designs will require an Performance Solution.
Posts, stumps, columns, etc	All durable timber species and suitable preservative treated timber as usual.			
Floor bearers and joists	All timber species and engineered timber products as usual.			
Flooring	All timber T & G, plywood and particleboard products as usual.			
Building subfloor space - open				
Posts, stumps, columns, etc	Bushfire-resisting timber[2]		Brick, steel or concrete stumps	NSW building regulations do not recognise deemed-to-satisfy construction solutions within this BAL. Building designs will require an Performance Solution.
Floor bearers and joists	Less than 400 mm above the ground use bushfire-resisting timbers[2] or line the underside of the floor framing with fibre cement or sheet metal (roofing), refer Figure 2. 400 mm or more above the ground there are no construction requirements any timber can be used.[4]		All timber framing **provided** the underside of the lowest joist or bearer is protected with a non-combustible material such as a metal sheeting or fibre cement sheeting.	
Flooring	Less than 400 mm from the ground provided the underside is lined with sarking or mineral wool or bushfire-resisting timbers[2] all timber T & G, plywood and particleboard products as usual. 400 mm or more above the ground there are no construction requirements any timber timber T & G, plywood and particleboard products as usual.		All timber species **provided** the underside of the lowest joist or bearer is protected with a non-combustible material such as a metal sheeting or fibre cement sheeting, all timber T & G, plywood and particleboard products as usual.	
Internal framing	All timber species and engineered timber products as usual.			
Internal joinery	Including doors, wall lining, ceiling linings, staircases, etc, all timber as usual.			
Fascia and barge boards	All durable timber species and suitable preservative treated timber as usual.	Bushfire-resisting timber[2]	AS1530.8.1	
Eaves linings and gables including joining strips	All durable timber species and suitable preservative treated timber as usual.	Bushfire-resisting timber[2]	AS1530.8.1	
Tile roof	Framing – all timber species and engineered timber framing members as usual.			
Sheet roof	Framing – all timber species and engineered timber framing members as usual.			
External windows				
Protected window frames (fitted with screen or shutter, refer to AS3959 for shutter and screen requirements for each BAL Level)	All durable timber species and suitable preservative treated timber as usual.			NSW building regulations do not recognise deemed-to-satisfy construction solutions within this BAL. Building designs will require an Performance Solution.
Unprotected window frames	400 mm or more above an external horizontal surface[1] all durable timber species and suitable preservative treated timber as usua.l Closer than 400 mm to an external horizontal surface[1] timber species with density 650 kg/m^3 or greater.[4]	Bushfire-resisting timber[2]	AS1530.8.1 complying system	

Building element	BAL–12.5 and BAL–19	BAL–29	BAL–40	BAL–FZ
External walls				
Framing for all wall surfaces	All structural timber and engineered wood products, as usual.			NSW building regulations do not recognise deemed-to-satisfy construction solutions within this BAL. Building designs will require an Performance Solution.
Wall surface less than 400 mm above the ground or an external horizontal surface[2]	Weatherboard plywood, hardboard with density of 750 kg/m^3 or greater[4] and log construction with density of 680 kg/m^3 or greater and minimum thickness of 70 mm.	Bushfire-resisting timber[2] and log construction with density of 680 kg/m^3 or greater and minimum thickness of 70 mm.	Wall surface made of non combustible material such as masonry, concrete, 9 mm fibre cement or steel sheeting. No limits on frame material.	
Wall surface 400 mm or more above the ground or an external horizontal surface[2]	All durable timber species and suitable preservative treated timber as usual.			
External door				
Protected door (fitted with screen or shutter and refer to AS3959 for shutter and screen requirements for each BAL Level)	All timber species as usual.			NSW building regulations do not recognise deemed-to-satisfy construction solutions within this BAL. Building designs will require an Performance Solution.
Unprotected door	All timber species **provided** the first 400 mm above the threshold is a minimum of 35 mm thick or protected by 400 mm kick plate. Alternatively the entire door is made from a timber species with density 650 kg/m^3 or greater.[4].	All timber species **provided** it is a minimum of 35 mm thick. Alternatively the entire door is made from bushfire- resisting timber.[2]	AS1530.8.1 complying system.	
Stairs/decks/ramps – enclosed sub-structure				
Wall enclosing subfloor space	Less than 400 mm from the ground or an external horizontal surface[1] use timber framing provided the framing is clad with non-combustible material such as fibre cement or timber with density of 750 kg/m3 or greater. 400 mm or more above the ground[1] there are no construction requirement any timber framing or cladding can be used.	All timber framing **provided** the framing is clad with non-combustible sheet material (6 mm fibre cement) or bushfire-resisting timber.[2]	All Timber framing **provided** the framing is clad with masonry, steel material or min 9 mm fibre cement.	NSW building regulations do not recognise deemed-to-satisfy construction solutions within this BAL. Building designs will require an Performance Solution.
Posts, stumps, columns, etc	All durable timber species and suitable preservative treated timber as usual.			
Floor bearers and joists	All timber species and suitable preservative treated timber as usual.			
Decking and stair treads	Bushfire-resisting timber[2]. Limited up to and including BAL-29.		Tiled or concrete decks	
Stairs/decks/ramps – open sub-structure				
Posts, stumps, columns, etc	Bushfire-resisting timber[2]		Metal, concrete or brick	NSW building regulations do not recognise deemed-to-satisfy construction solutions within this BAL. Building designs will require an Performance Solution.
Floor bearers and joists	Bushfire-resisting timber[2]		Metal	
Decking and Stair treads	Bushfire-resisting timber[2]		Tiled or concrete decks	

Building element	BAL–12.5 and BAL–19	BAL–29	BAL–40	BAL–FZ
Stairs/decks/ramps – open sub-structure				
Posts, stumps, columns, etc	Bushfire-resisting timber[2]		Metal, concrete or brick	NSW building regulations do not recognise deemed-to-satisfy construction solutions within this BAL. Building designs will require an Performance Solution.
Floor bearers and joists	Bushfire-resisting timber[2]		Metal	
Decking and stair treads	Bushfire-resisting timber[2]		Tiled or concrete decks	
Balustrades and handrails				
	Less than 125 mm from any glazing or any combustible wall handrails and balustrades shall made from non combustible material or bushfire-resisting timber.[2] 125 mm or more from the building handrails and balustrades have no requirement any timber can be used.[4]			NSW building regulations do not recognise deemed-to-satisfy construction solutions within this BAL. Building designs will require an Performance Solution.

***Notes**:*

1. An external horizontal surface or a ledge includes decks, carport roofs, awnings and similar elements or fittings having an angle less than 18 degrees to the horizontal and extending more than 110 mm in width from the wall or window or door. ***See diagram below***



2. Bushfire resisting timbers refer WoodSolutions Guide 04 Section 4.

3. Complying roof systems include conventional non combustible roof and materials (tile, metal sheet) ensuring any gaps over 3mm are protected by ember guards. For further detail on sealants, skylights, etc refer to AS 3959.

4. Timber with density of 750 kg/m³ or greater at 12 percent moisture content.

5. Timber with density of 650 kg/m³ or greater at 12 percent moisture content.

Disclaimer:

Whilst every effort has been made to ensure that this publication is in accordance with current information, it is not intended as an exhaustive statement of all relevant data. All comments in this information sheet are written with timber framed construction in mind and may exclude other forms of construction. In addition, successful design and construction depends upon numerous factors outside the scope of this publication. The authors and publishers accept no responsibility for errors in, or omissions from this publication, nor for specifications or work done or omitted in reliance on this publication.

Design tips to reduce risk

✔ **Design with a simple footprint**
Minimise external nooks and crannies, corners and spaces where debris (which can become fuel) or embers from a bushfire can accumulate.

✔ **Use a simple roof design**
Avoid roof valleys and skylights. Specify and install gutter guards to help keep the gutters clear and free of debris.

✔ **Raise window level**
Lift windows from floor level to at least 400 mm above an external surface which may collect smouldering embers or burning debris - this simplifies building requirements (up to BAL-29), without sacrificing views.

✔ **Enclose the subfloor area**
Reduce the risk of embers getting underneath a house by ensuring it is fully enclosed below the floor level and fitting vents with spark-proof metal screens.

✔ **Use appropriate cladding material**
Where cladding materials are mixed - each section must comply with the Standard requirements for external walls. Lightweight cladding (weatherboard, ply or fibre-cement sheet) building systems are described on pages 32 and 33.

✔ **Create a firebreak around the house**
Leave a firebreak between nearby vegetation and the house. This is an important part of garden design and can be as simple as having a pathway or lawn between the house perimeter and the nearest garden bed.

✔ **Use appropriate timber for external detailing**
Consider sourcing external decorative details such as finials and verandah brackets and slats from bushfire-resisting timbers or from E1 timbers.

✔ **Do not ignore the risk of an ordinary domestic fire starting inside**
Ensure adequate smoke alarms are installed and homeowners can reach them safely for testing and replacing batteries. What avenues for egress are there in case of fire? Are these adequate or does the design need to be modified? You may need to balance requirements such as protective screens over opening windows with a removal system that will permit using the window as an escape route from fire or other danger. Review the placement of external doors to enable escape from more than one direction.

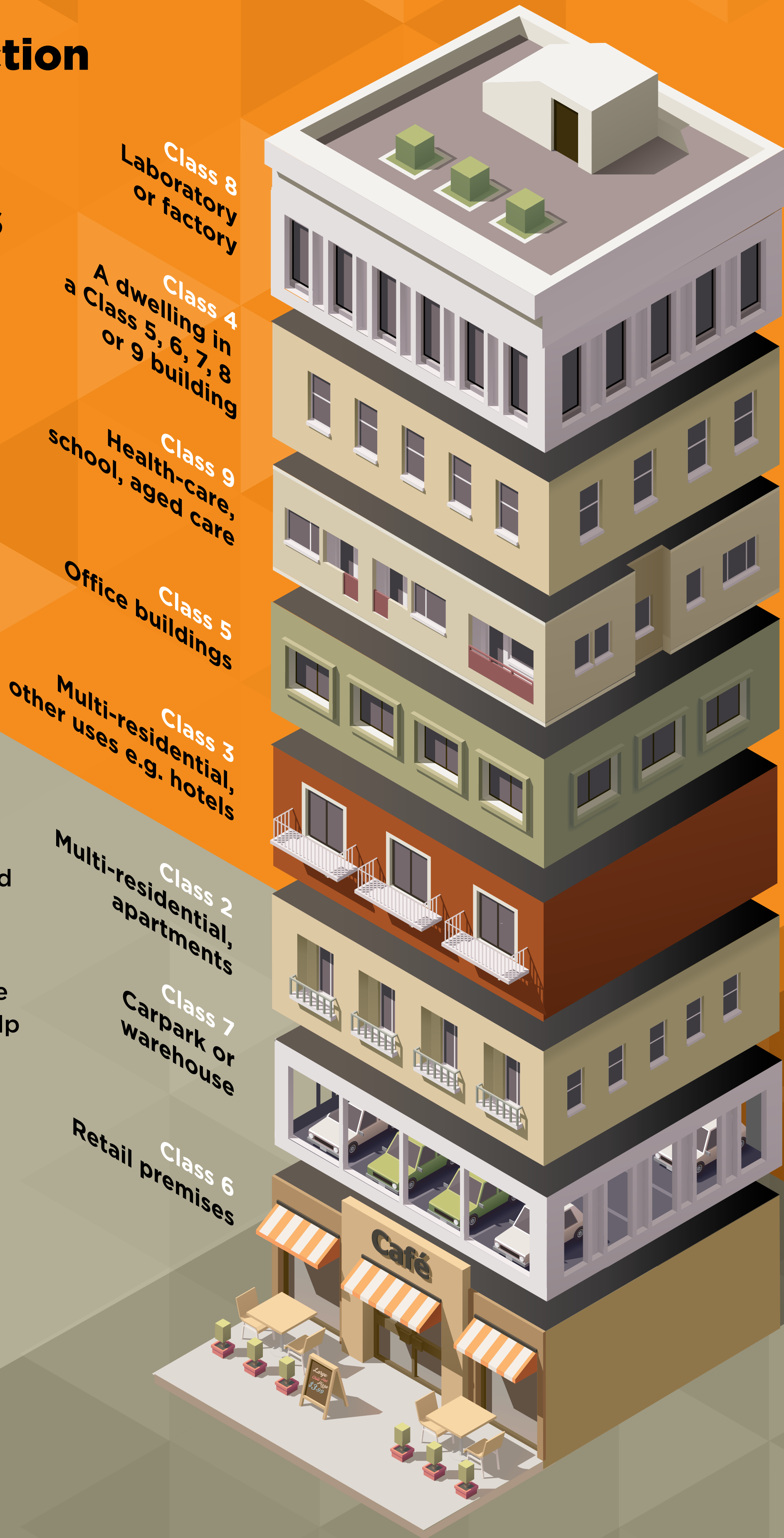
✔ **Consider installing a complying private bushfire shelter (bunker) in the higher BALs**
Building to the requirements in AS 3959 will still not guarantee that a house will survive a bushfire event on every occasion. Even though at the higher BALs (BAL-40 and BAL-FZ) the houses are to be built to a very high standard, consider installing a complying private bushfire shelter (PBS) to provide occupants a 'safe haven' in the event they cannot evacuate.

Notes

Notes

A Class Act.

Changes to the National Construction Code mean that more classes of mid-rise buildings can deliver the benefits of wood.



Now more projects with an effective height of up to 25m or 8 storeys, can more easily gain the environmental, economic and safety benefits of construction with timber systems.

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Timber service life design

Design guide for durability

Technical Design Guide issued by Forest and Wood Products Australia

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- Building with timber in bushfire-prone areas
- Designing for durability
- Timber finishes
- Stairs, balustrades and handrails
- Timber flooring and decking
- Timber windows and doors
- Fire compliance
- Acoustics
- Thermal performance

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WoodSolutions is an industry initiative designed to provide independent, non-proprietary information about timber and wood products to professionals and companies involved in building design and construction.

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Contents

Contents

Preface

By carefully considering the key factors affecting timber's durability, industry, specifiers and timber users can achieve timber structures that meet or exceed their needs and expectations. This document is based on currently available information. It is anticipated that future research will considerably improve reliability in timber design life predictions.

This guide provides information to assist timber industry employees, timber users and specifiers of timber to select members and structures with respect to their service life requirements. The information provided has been derived from historical performance and field and laboratory research and experience. The outcomes from a 10-year, multi-million dollar 'world first' research project to develop a probabilistic durability design method for timber have also been incorporated in this publication where appropriate.

The guide addresses specific hazards with respect to the service life of timber construction:

- In-ground decay
- Above-ground decay
- Weathering
- Termites
- Corrosion
- Marine borers.

More detailed information associated with timber performance for other hazards, including fire resistance and chemical degradation, should be obtained from other sources.

Better or more cost-effective performance is achieved with better knowledge. This guide will be updated to reflect contemporary knowledge and research outcomes. This may include coverage of alternative preservative treatment processes such as ACQ, Copper Azole, and others, which are now referenced in Australian Standards.

Other timber durability design resources that are outcomes from the Forest and Wood Products Australia Durability Design Project completed in 2007 are:

TimberLife Educational Software

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1. Wang, C-H., Leicester, R.H. and Nguyen, M.N. 'Manual No. 3: Decay in ground contact'.
2. Wang, C-H., Leicester, R.H. and Nguyen, M.N. 'Manual No. 4: Decay above ground'.
3. Nguyen, M.N., Leicester, R.H. and Wang, C-H. 'Manual No. 5: Atmospheric corrosion of fasteners in timber structures'.
4. Nguyen, M.N., Leicester, R.H. and Wang, C-H. 'Manual No. 6: Embedded corrosion of fasteners in timber structures'.
5. Nguyen, M.N., Leicester, R.H. and Wang, C-H. 'Manual No. 7: Marine borer attack'.
6. Leicester, R.H., Wang, C-H. and Nguyen, M.N. 'Manual No. 8: Termite attack'.
7. Nguyen, M.N., Leicester, R.H. and Wang, C-H. 'Manual No. 9: Service Life Models for timber structures protected by a building envelope'.

The computations for the service lives in this design guide have been based on equations derived in the above manuals. The relevant equations have been collated into a single manual titled as follows:

8. Wang, C-H., Leicester, R.H. and Nguyen, M.N. 'Manual No. 11: Equations for use in a service life design guide'.

1 Introduction

Timber structures and components can be designed to perform their intended function for a known life span, with minimal or programmed maintenance and where due recognition is given to all of the important aspects that relate to the durability of wood and other components of the timber system.

As defined in the ISO 15686-1:2000(E), durability is: "(the) capability of a building or its parts to perform its required function over a specified period of time under the influence of the agents anticipated in service."

Service life is: "(The) period of time after installation during which a building or its parts meets or exceeds the performance requirements."

That function may be aesthetic, structural or for amenity.

This definition does not negate the responsibility of suppliers, designers and specifiers to consider ongoing aspects relating to maintenance or repair.

The desired outcome can be expected when the whole custody chain influencing durability (from specifier and supplier to builder and end user) is addressed. This includes:

- design
- product quality and properties (fitness for purpose)
- detailing
- specification
- workmanship
- maintenance.
-

Wharf timbers to be recycled and re-used after about 60 years in-service.

2 Standards and Codes Requirements

Increasing consumer expectations and demands are being reflected in the performance requirements specified in standards, codes and regulations. The following brief overview of some of these is provided to enable suppliers, designers and specifiers to be better informed on these matters with respect to timbers durability requirements.

2.1 Consumer Protection

The Australian Trade Practices Act 1974 sets out direction with respect to the responsibilities and requirements for product manufacturers and suppliers with respect to false or misleading

representations. Requirements included in the issues addressed by Clause 53 of the Act are that corporations shall not:

“falsely represent that goods are of a particular standard, quality, value, grade, composition, style or model or have had a particular history or particular previous use”

“make a false or misleading representation concerning the existence, exclusion or effect of any condition, warranty, guarantee, right or remedy”

These requirements place clear onus on producers and manufacturers to ensure that they achieve product compliance and do not overstate any product performance levels including durability and life expectancy.

2.2 Other Regulatory Issues

There are many regulatory issues, current and pending, that will impact upon the production, sale and use of timber, including timbers durability and preservative treatment.

2.2.1 Building Regulation Framework

The building regulation framework in Australia is performance based, and specifically addresses health, safety, amenity and sustainability, as primary objectives. While the National Construction Code - Building Code of Australia (NCC-BCA) currently does not have specific durability performance requirements, it does have implicit requirements, and it contains both prescriptive deemed to comply solutions, acceptable construction practices and verification procedures.

In addition, the Australian Building Codes Board (ABCB) has published a durability guideline document that gives guidance on the implicit requirements of the BCA that should be followed by manufacturers and specifiers wishing to satisfy the BCA’s requirements.

The administration and application of the NCC-BCA is devolved by legislation to state and territory authorities and/or private certifiers who then have to interpret and apply relevant standards or acceptable solutions.

Roof overhangs provide good protection to timber walls below.

The hierarchy of building regulations in Australia for timber and durability is as follows:

- The NCC-BCA is adopted by all States and Territories under a Memorandum of Understanding (MOU) between the Federal Government and the States and Territories.
- The NCC-BCA, in turn, has primary referenced Standards and documents such as AS 1684 – Timber Framing Code and AS 1720.1 – Timber Structures Code and in some cases, individual State variations such as Construction Timbers in Queensland (CTIQ) which is an additional State variation applicable in Queensland.
- NCC-BCA primary referenced documents do, invariably in turn, call up secondary references such as the AS 1604 series for the preservative treatment of timber and AS 5604 on natural durability classifications.

Note: NCC-BCA secondary referenced documents may have equivalent legal status as primary referenced documents.

2.2.2 ABCB – 'Durability in Buildings – Guideline Document'

This document is specifically intended to provide guidance for manufacturers, appraisers, Standards Committees and others on the implicit durability performance requirements of the NCC-BCA.

The document defines durability as – "capability to perform a function over a specified period of time" and defines the minimum design life required for a building and its components or sub-systems as given in Table 2.1.

Table 2.1: ABCB Durability Design Life Guideline.

Design life of building (*dl*) (years)		Design life of components or sub-systems (years)		
		Category		
Category	No. of years	Readily accessible and economical to replace/repair	Moderate ease of access but difficult or costly to replace or repair	Not accessible or not economical to replace or repair
Short	$1<dl<15$	5 or *dl* (if $dl<5$)	*dl*	*dl*
Normal	50	5	15	50
Long	100 or more	10	25	100

Note: Houses are considered normal, with respective design life requirements of 5, 15 and 50 years.

The guideline requires consideration of all environmental and specific conditions that might affect durability including the following:

- environmental agents
- temperature
- radiation
- humidity
- rainfall
- wind
- soil type
- pollutants
- biological agents
- chemical effects, etc.

Specific conditions that are stated when considering durability requirements include:

- condensation
- cyclic changes
- agents due to usage, e.g. abrasion, maintenance
- ground contact
- intended use
- performance criteria
- expected environmental conditions
- composition, properties and performance of materials
- structural system
- shape and detailing
- workmanship, quality control, maintenance, etc.

2.2.3 Timber Preservation and Natural Durability Standards

The secondary NCC-BCA referenced standards relating to timber preservation and natural durability classifications are as follows:

- AS 1604.1- Specification for preservative treatment. Part 1 Sawn and round timber
- AS/NZS 1604.2 – Specification for preservative treatment. Part 2 Reconstituted wood-based products
- AS/NZS 1604.3 – Specification for preservative treatment. Part 3 Plywood
- AS/NZS 1604.4 – Specification for preservative treatment. Part 4 Laminated veneer lumber (LVL)
- AS/NZS 1604.5 – Specification for preservative treatment. Part 5 Glued laminated timber products
- AS 5604 – Timber – Natural durability ratings.

The AS 1604 series gives preservative treatment specifications for a range of decay and insect hazards, but they do not account for varying levels of hazard due to macro or micro climatic conditions, etc.

AS 5604 provides natural durability classifications for untreated timber for decay in and above ground, lyctus susceptibility, termite resistance and marine borer resistance.

2.2.4 Other Application Standards

There are an increasing number of other application standards that are being developed by civil engineering and other Standards committees where specific durability and life expectancy requirements are being included. Some of these are also NCC-BCA primary referenced documents.

Some examples of these are:

- Structural Design Requirements for Utility Service Poles (Power, etc), AS/NZS 4676
- Buildings and Constructed Assets- Service Life Planning – Part 1: General Principles, ISO 15686-1
- Earth-Retaining Structures, AS 4678.

The durability performance requirements contained in some of these standards are quite explicit and detailed. For example, AS 4678 requires each component to provide satisfactory performance over the design life of the structure which, in turn, must consider changes with time for:

- loads
- reliability
- environmental conditions
- durability and corrosion (chemical, biological, creep, damage, etc).

AS 4678 states that the design life for earth retaining structures (retaining walls) in residential applications is 60 years. It is assumed that this design life relates to retaining walls required to provide structural support to the actual dwelling.

Engineers required to design and certify retaining walls may be expected to comply with this standard, or an alternative Performance Solution to the NCC-BCA.

Use only Durability Class 1 hardwood or H5 Preservative treated timber for engineered retaining walls

3 Selection and Specification of Durability

Designing for durability is dependent upon two key factors. These are:

- **the performance requirements of the element or structure as dictated by minimum regulatory/standards requirements or other contractual specifications; and**
- **factors affecting durability.**

For structural design, available quantitative data enables designers to reach fairly precise conclusions regarding structural performance. This is now also possible with respect to durability design although perhaps with less certainty and greater variability.

Qualitative and quantitative assessment is possible by equating required performance levels to available research and historical durability evidence, coupled with a detailed consideration of the factors affecting durability.

Figure 3.1 provides a logical sequence to enable design and specification for timbers durability.

3.1 Performance Requirements

Performance requirements for durability must be determined or considered in a manner similar to that required for structural design as is indicated in Table 2.1, that is:

Design Considerations

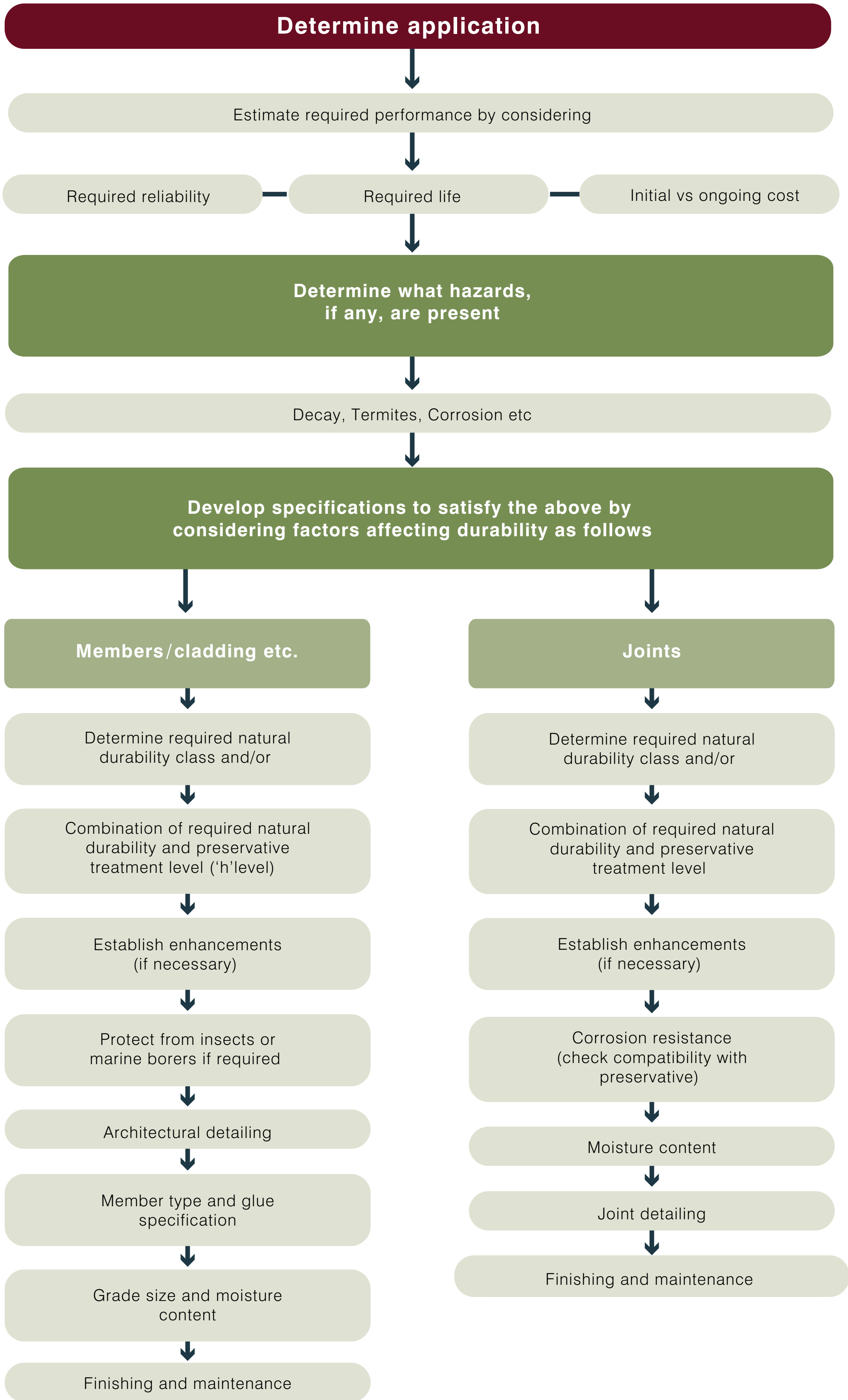
- Temporary/Permanent Structure
- Part of Building – envelope, cladding, roofing, structural framework, etc
- Typical Life Expectancy

Reliability Considerations

- Temporary/Permanent Structure
- Level of Safety (Loss of life or injury)
- Cost or Consequence of Failure
- Part of Building
- Cladding
- Structure

Cost considerations

- Initial costs
- Maintenance costs
- Replacement costs
- Costs incurred if in-service failure occurs.


Determine application
Estimate required performance by considering
Required reliability
Required life
Initial vs ongoing cost
Determine what hazards, if any, are present
Decay, Termites, Corrosion etc
Develop specifications to satisfy the above by considering factors affecting durability as follows
Members/cladding etc.
Determine required natural durability class and/or
Combination of required natural durability and preservative treatment level ('h'level)
Establish enhancements (if necessary)
Protect from insects or marine borers if required
Architectural detailing
Member type and glue specification
Grade size and moisture content
Finishing and maintenance
Joints
Determine required natural durability class and/or
Combination of required natural durability and preservative treatment level
Establish enhancements (if necessary)
Corrosion resistance (check compatibility with preservative)
Moisture content
Joint detailing
Finishing and maintenance

3.2 Hazards and Protection

The vast majority of timber is used in applications where its permanence is unquestioned. Protected from weathering, moisture, insects and strong chemicals, timber has documented satisfactory performance for centuries. The natural and calamitous hazards that timber and timber connectors may have to contend with do require consideration. These can be summarised as:

- fungal attack
  - in-ground
  - above ground
- insect attack
  - termites and borers
- corrosion of fasteners
- weathering
- marine borers
- chemical degradation
- fire.

The following Sections give guidance on durability design and performance against these hazards.

3.3 Hazard Levels, Natural Durability and Preservation

To enable appropriate selection and specification of natural durability and preservative treatment, hazard levels have been generalised and defined by AS 1604 and CTIQ in Queensland.

3.3.1 Decay Conditions

Timber will not be subjected to fungal attack unless four conditions are satisfied:

- The correct moisture: 0-20% Moisture Content – attack will not occur (too dry), 20-60% – sufficient moisture for attack to occur, >60% too wet with insufficient oxygen for attack to occur.
- Oxygen must be present. Timber completely submerged or saturated timber is rarely attacked and timber 600 mm or more below ground is rarely attacked due to lack of available oxygen.
- Temperature must be in the range of 5-40°C; 25°C to 40°C is ideal. At lower temperatures, fungal attack is retarded. At higher temperatures, the fungus will not survive.
- Food in the form of nutrients (carbohydrates, nitrogen, minerals, etc) must be present. These are usually provided by the timber itself, particularly sapwood, which is normally high in sugars and carbohydrates.

Removal of any one of these four conditions will prevent fungal attack although, in practice, it is usually the removal of moisture that requires the greatest consideration.

Consequently, timber is best protected from fungal action by:

- eliminating contact with moisture; or
- using species with a durability appropriate to the application or by using species (containing limited untreatable heartwood) that have been preservative treated (i.e. the nutritional source for the fungi is negated by insertion of a preservative) to a level appropriate to the hazard.

3.3.2 When treatment may be required

This is a difficult question that industry and users of timber face. The decision must be based on judgments that consider many factors, some of which are:

- the presence of a hazard (moisture, insect, decay, chemical, etc)
- the degree of structural reliability required (is the system loadsharing or non-loadsharing, the cost of failure and if failure occurs, the potential for death or injury)
- the desired or expected service life of the structure
- the natural durability of the timber (resistance to decay or insect attack)
- the type or design of the building or component
- the presence of sapwood (only sapwood can be effectively treated unless the timber is mechanically incised or specially processed as is proposed using microwave technology).

Figure 3.2 provides guidance in flow chart form (for structures that are considered permanent) to determine if preservative treatment is required. In considering this, the following should be noted:

- Only sapwood (both hardwoods and softwoods), can consistently be effectively preservative treated (unless the timber is incised).
- The sapwood of some species, i.e. cypress and Douglas fir cannot be effectively penetrated.
- Plantation softwoods and some hardwood species have wide sapwood bands and are ideal for preservative treatment, particularly in round form.

This guide should only be used as a first approximation as other factors such as the design life of the structure and specific local hazards will also require consideration.

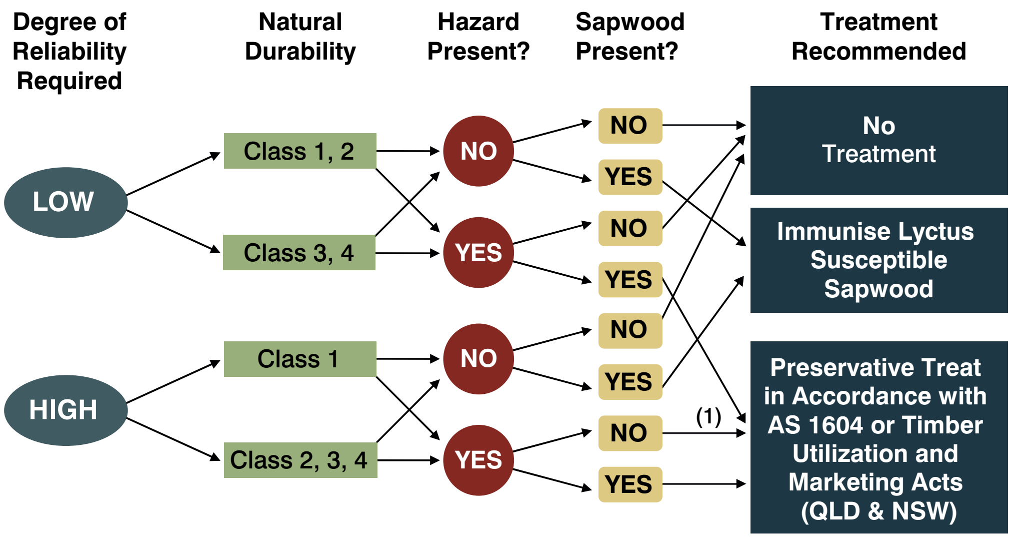


Figure 3.2: Guide to preservative treatment.

Note: Incise to enable adequate penetration.

3.3.3 Hazard Levels

Table 3.1 gives the standard levels of hazard relevant to preservative treatment for decay and insects adopted in Australian Standards and State Legislation. The degree of hazard increases with the 'H' number, with H1 representing timber fully protected from moisture and termites. The 'H' level should be used to specify a level of preservative treatment.

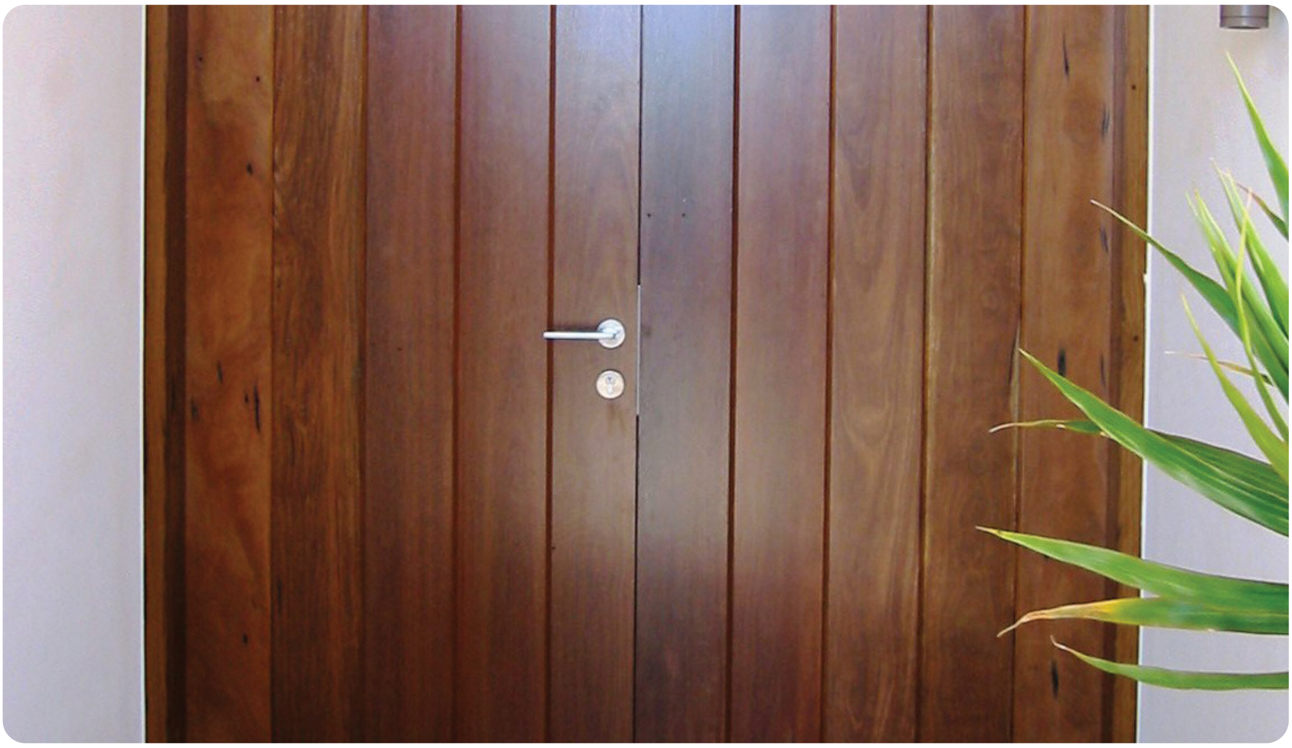
It should be noted that the Hazard Class system in AS 1604 is very general in nature and does not account for macro and micro climatic variation across Australia. Also, depending upon the application, there can be a significant difference in performance (life expectancy) even within one Hazard Class. For example, in H3, well ventilated free draining vertical surfaces are in fact a much lower hazard when compared to horizontal surfaces and where moisture can be trapped.

Sections 4 and 5 provide more detailed and accurate life expectancy predictions that reflect a number of the additional parameters and factors influencing performance including macro and micro climatic influences.

Table 3.1: Hazard levels for specification of preservative treated timber as specified in AS 1604.

<table>
<tr><th colspan="2">Hazard Class</th><th>Exposure</th><th>Specific Service Conditions</th><th>Biological Hazard</th><th>Typical Use</th></tr>
<tr><td colspan="2">H1</td><td>Inside, above ground</td><td>Protected from the weather, well ventilated and protected from termites</td><td>Insects other than termites (e.g. lyctid borer)</td><td>Framing, flooring, furniture, interior joinery or other protected applications</td></tr>
<tr><td colspan="2">H2</td><td>Inside, above ground</td><td>Protected from wetting.
Nil leaching,</td><td>Borers and termites</td><td>Framing, flooring, and similar uses as above</td></tr>
<tr><td colspan="2">H3</td><td>Outside, above ground</td><td>Subject to periodic moderate wetting and leaching</td><td>Moderate decay, borers and termites</td><td>Weatherboards, fascia barges, pergolas, decks, window and door joinery etc</td></tr>
<tr><td colspan="2">H4</td><td>Outside in-ground</td><td>Subject to severe wetting and leaching</td><td>Severe decay, borers and termites</td><td>Fence posts, greenhouses, pergola posts, and non-critical landscaping</td></tr>
<tr><td colspan="2">H5</td><td>Outside in-ground contact or in fresh water</td><td>Subject to extreme wetting, leaching and/ or where the critical use requires a higher degree of reliability</td><td>Very severe decay, borers and termites.</td><td>Piles, poles, structural retaining walls, cooling tower fill, or structural members in permanent ground contact or wet conditions</td></tr>
<tr><td rowspan="2">H6 or H6SW</td><td>H6</td><td>Marine waters, northern and southern</td><td rowspan="2">Subject to prolonged immersion in sea water</td><td rowspan="2">Marine wood borers and decay</td><td rowspan="2">Boat hulls, marine piles, cross bracing, steps, landings etc</td></tr>
<tr><td>H6SW</td><td>Marine waters southern only</td></tr>
</table>

Note: Refer to AS 1604 or State Timber Utilisation and Marketing Acts (QLD and NSW) for detailed information on Hazard 'H' levels.



Recycled durability class 1 hardwood used for external doors.

3.3.4 Natural Durability and Life Expectancy

Table 3.2 gives general guidance according to AS 5604 on the probable life of untreated timber used in a range of environments related to the hazard that they are exposed to. It should be noted that these are typical values and the natural variability of durability and hazard will lead to considerable variation around these values. Sections 4 and 5 give more explicit guidance.

The natural durability ratings for a wide range of timber species are published in a number of Australian Standards and these are continuously being updated with AS 5604 – Timber – Natural durability ratings, being the most recent. This publication now provides two distinct decay classes for both in-ground and above ground decay resistance of timber species. AS 5604 also provides ratings of species for termite, lyctus and marine borer resistance. In addition, CTIQ also provides durability ratings and includes a wider range of species than AS 5604, and in particular for imported species.

Table 3.2: General guide to probable life expectancy according to AS 5604.

Natural durability class	Probable heartwood life expectancy (years)		
	Fully protected from the weather and termites	Above ground exposed to the weather but protected from termites	In-ground contact and exposed to termites
Class 1 Highly Durable	50+	40+	25+
Class 2 Durable	50+	15 to 40	15 to 25
Class 3 Moderately Durable	50+	7 to 15	5 to 15
Class 4 Non-durable	50+	0 to 7	0 to 5

Large overhangs provide good protection.

4 Decay of Timber In-Ground Contact

This Section provides estimates of the structural life of timber placed in ground contact. The equations used for these estimates are given in Report number 8 referred to in the Preface.

The estimates are derived from a model based initially on 35 year tests of small timber stakes embedded in-ground at various sites around Australia. It should be emphasised that there are various reasons as to why the in-ground behaviour of small stakes differs considerably from that of large members, particularly poles. These include the occurrence of splitting and in some cases, the downwards movement of preservatives. Hence, the data derived from small stakes, while extremely useful for formulating a model, requires field data of full size members to calibrate it before it can be used for predictive purposes. The model has been calibrated by data on a limited number of poles in NSW. This provides a degree of a reality check on the model, but because of the great variety of timber, treatments and climates found around Australia, a considerable amount of further field calibrations must be made before the model is considered to give reliable predictions.

Since the computational model has been made on the basis of data obtained from in-ground stake tests, the decay classes based on these tests (given in Table 4.1) have been used herein. These decay classes relate to the outer heartwood of the species listed.

For round poles, the estimated service life given in the tables relate to an estimate of the time taken for decay to reduce the bending strength of a pole to 70% of its initial value. The estimate is a typical or average value. Only attack by decay has been considered; the model does not include any allowance for attack by other biological and mechanical degradation agents. For example, it does not consider the effects of attack by termites.

For the case of rectangular sawn timber sections, two values of the design life are given for the case of treated timber. One relates to a section deemed to be 100% sapwood and therefore fully treated; the other relates to a section that contains 20% untreatable heartwood, in accordance with the specifications of AS: 1604.1. It should be noted that the predicted life is for timber sited in exposed locations such as occurs for fence posts; the predictions should be conservative when applied to timber sited in protected locations such as occurs with house stumps placed in dry ground under a house.

4.1 Application

To estimate the service life a timber species has, use the following procedure:

- Determine the natural durability class in-ground from Table 4.1.
- Determine the structure location zone from Figure 4.1.
- Determine the typical service life for various applications and combinations of timber, cross sections, treatments and natural durability from Tables 4.2 to 4.13.
- For round poles, add on the extra service life afforded by maintenance treatments given in Table 4.14.

Table 4.1: Timber natural durability classification for in-ground decay.

Trade name	Botanical name	In-ground durability class
Ash, alpine	*Eucalyptus delegatensis*	4
Ash, Crow's	*Flindersia australis*	1
Ash, mountain	*Eucalyptus regnans*	4
Ash, silvertop	*Eucalyptus sieberi*	3
Balau (selangan batu)	*Shorea* spp.	2
Bangkirai	*Shorea laevis*	2
Beech, myrtle	*Nothofagus cunninghamii*	4
Belian (ulin)	*Eusideroxylon zwageri*	1

Table 4.1 *(continued)*: ***Timber natural durability classification for in-ground decay.***

Trade name	Botanical name	In-ground durability class
Blackbutt	*Eucalyptus pilularis*	2
Blackbutt, New England	*Eucalyptus andrewsii*	2
Blackbutt, WA	*Eucalyptus patens*	2
Blackwood	*Acacia melanoxylon*	4
Bloodwood, red	*Corymbia gummifera*	1
Bloodwood, white	*Corymbia trachyphloia*	1
Bollywood	*Litsea reticulata*	4
Box, brush	*Lophostemon confertus*	3
Box, grey	*Eucalyptus moluccana*	1
Box, grey, coast	*Eucalyptus bosistoana*	1
Box, long leaved	*Eucalyptus goniocalyx*	3
Box, red	*Eucalyptus polyanthemos*	1
Box, steel	*Eucalyptus rummeryi*	1
Box, swamp	*Lophostemon suaveolens*	2
Box, yellow	*Eucalyptus melliodora*	1
Box,white	*Eucalyptus albens*	1
Brigalow	*Acacia harpophylla*	1
Brownbarrel	*Eucalyptus fastigata*	4
Bullich	*Eucalyptus megacarpa*	3
Calantas (kalantas)	*Toona calantas*	2
Candlebark	*Eucalyptus rubida*	4
Cedar, red, western	*Thuja plicata*	3
Cypress	*Callitris glaucophylla*	2
Fir, Douglas (Oregon)	*Pseudotsuga menziesii*	4
Gum, blue, southern	*Eucalyptus globulus*	3
Gum, blue, Sydney	*Eucalyptus saligna*	3
Gum, grey	*Eucalyptus propinqua*	1
Gum, grey, mountain	*Eucalyptus cypellocarpa*	3
Gum, maiden's	*Eucalyptus maidenii*	3
Gum, manna	*Eucalyptus viminalis*	4
Gum, mountain	*Eucalyptus dalrympleana*	4
Gum, red, forest	*Eucalyptus tereticornis*	1
Gum, red, river	*Eucalyptus camaldulensis*	2
Gum, rose	*Eucalyptus grandis*	3
Gum, salmon	*Eucalyptus salmonophloia*	2
Gum, scribbly	*Eucalyptus haemastoma*	3
Gum, shining	*Eucalyptus nitens*	4
Gum, spotted	*Corymbia maculata,* incl. *corymbia citriodora*	2
Gum, sugar	*Eucalyptus cladocalyx*	1
Gum, yellow	*Eucalyptus leucoxylon*	2
Hardwood, Johnstone River	*Backhousia bancroftii*	3
Hemlock, Western	*Tsuga heterophylla*	4
Ironbark, grey	*Eucalyptus paniculata*	1
Ironbark, red	*Eucalyptus sideroxylon*	1
Ironbark, red (broad-leaved)	*Eucalyptus fibrosa*	1
Ironbark, red (narrow-leaved)	*Eucalyptus crebra*	1
Ironwood Cooktown	*Erythrophloeum chlorostachys*	1
Jam, raspberry	*Acacia acuminata*	1
Jarrah	*Eucalyptus marginata*	2

Table 4.1 *(continued)****: Timber natural durability classification for in-ground decay.***

Trade name	Botanical name	In-ground durability class
Kapur	*Dryobalanops* spp.	3
Karri	*Eucalyptus diversicolor*	3
Keruing	*Dipterocarpus* spp.	3
Kwila (merbau)	*Intsia bijuga*	3
Mahogany, Philippine, red, dark	*Shorea* spp.	3
Mahogany, Philippine, red, light	*Shorea, Pentacme, Parashorea* spp.	4
Mahogany, red	*Eucalyptus resinifera*	2
Mahogany, white	*Eucalyptus acmenoides*	1
Mahogany, white	*Eucalyptus umbra*	1
Mahonany, southern	*Eucalyptus botryoides*	3
Mallet, brown	*Eucalyptus astringens*	2
Marri	*Corymbia calophylla*	3
Meranti, red, dark	*Shorea* spp.	4
Meranti, red, light	*Shorea* spp.	4
Mersawa	*Anisoptera* spp.	4
Messmate	*Eucalyptus obliqua*	3
Messmate, Gympie	*Eucalyptus cloeziana*	1
Oak, bull	*Allocasuarina luehmannii*	1
Oak, white, American	*Quercus alba*	4
Peppermint, black	*Eucalyptus amygdalina*	4
Peppermint, broad leaved	*Eucalyptus dives*	3
Peppermint, narrow leaved	*Eucalyptus radiata*	4
Peppermint, river	*Eucalyptus elata*	4
Pine, black	*Prumnopitys amara*	4
Pine, Caribbean	*Pinus caribaea*	4
Pine, celery-top	*Phyllocladus aspleniifolius*	4
Pine, hoop	*Araucaria cunninghamii*	4
Pine, Huon	*Lagarostrobos franklinii*	3
Pine, kauri	*Agathis robusta*	4
Pine, King William	*Athrotaxis selaginoides*	3
Pine, radiata	*Pinus radiata*	4
Pine, slash	*Pinus elliottii*	4
Ramin	*Gonystylus* spp.	4
Redwood	*Sequoia sempervirens*	2
Rosewood, New Guinea	*Pterocarpus indicus*	3
Satinay	*Syncarpia hillii*	2
Stringybark, Blackdown	*Eucalyptus sphaerocarpa*	2
Stringybark, brown	*Eucalyptus baxteri*	3
Stringybark, red	*Eucalyptus macrorhyncha*	3
Stringybark, white	*Eucalyptus eugenioides*	3
Stringybark, yellow	*Eucalyptus muelleriana*	3
Tallowwood	*Eucalyptus microcorys*	1
Taun	*Pometia* spp.	3
Teak, Burmese	*Tectona grandis*	2
Tingle, red	*Eucalyptus jacksonii*	4
Tingle, yellow	*Eucalyptus guilfoylei*	2
Tuart	*Eucalyptus gomphocephala*	1
Turpentine	*Syncarpia glomulifera*	1

Table 4.1 (continued): Timber natural durability classification for in-ground decay.

Trade name	Botanical name	In-ground durability class
Wandoo	*Eucalyptus wandoo*	1
Woolybutt	*Eucalyptus longifolia*	1
Yate	*Eucalyptus cornuta*	2
Yertchuk	*Eucalyptus consideniana*	2

Zone D has the greatest in-ground decay potential.

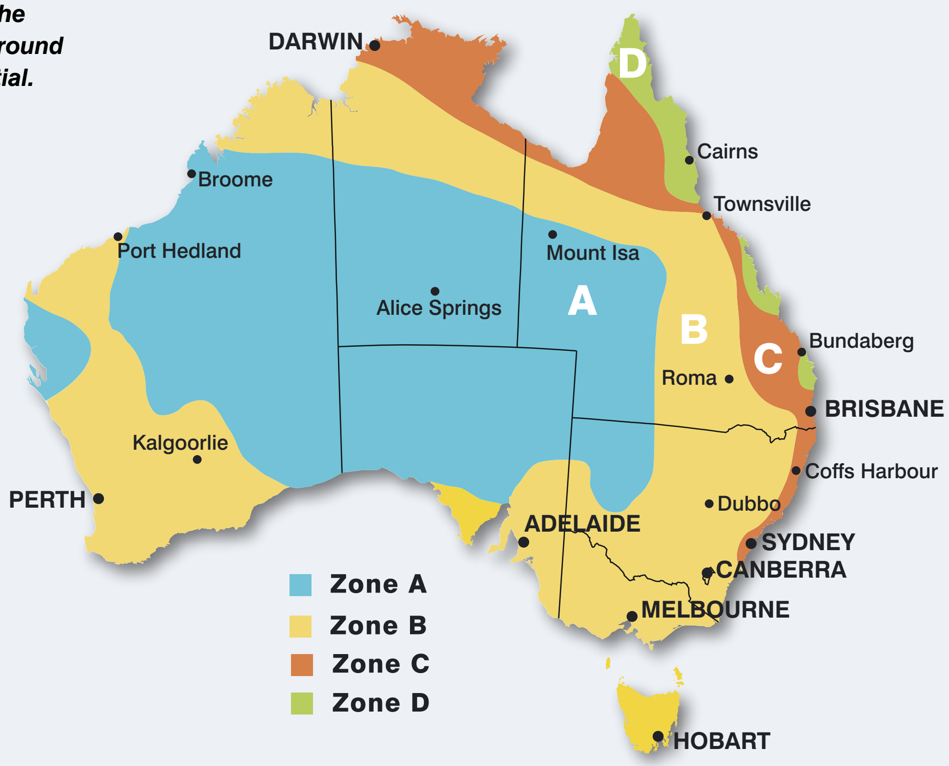


Figure 4.1: In-ground decay hazard zones for Australia.

4.1.1 Round Poles

Table 4.2: Typical service life of round poles against in-ground decay in Zone A.

Timber type	In-ground durability class(1)	Treatment(2)	Typical service life (years) Pole diameter 200 mm	Pole diameter 300 mm	Pole diameter 400 mm
Treated softwood	4	H4	>100	>100	>100
		H5	>100	>100	>100
Treated hardwood	1	H4	>100	>100	>100
		H5	>100	>100	>100
	2	H4	>100	>100	>100
		H5	>100	>100	>100
	3	H4	90	>100	>100
		H5	>100	>100	>100
	4	H4	70	90	>100
		H5	80	>100	>100
Untreated hardwood(3)	1	—	>100	>100	>100
	2	—	70	90	>100

Notes:
1. See Table 4.1.
2. As per AS 1604.1. for CCA and creosote.
3. De-sapped poles.

Table 4.3: Typical service life of round poles against in-ground decay in Zone B.

Timber type	In-ground durability class(1)	Treatment(2)	Typical service life (years)		
			Pole diameter 200 mm	Pole diameter 300 mm	Pole diameter 400 mm
Treated softwood	4	H4	60	80	100
		H5	100	>100	>100
Treated hardwood	1	H4	50	80	90
		H5	80	>100	>100
	2	H4	50	70	70
		H5	80	100	>100
	3	H4	40	45	60
		H5	50	60	70
	4	H4	30	35	45
		H5	40	45	50
Untreated hardwood(3)	1	—	45	60	80
	2	—	25	30	40

Notes:
1. See Table 4.1.
2. As per AS 1604.1. for CCA and creosote.
3. De-sapped poles.

Table 4.4: Typical service life of round poles against in-ground decay in Zone C.

Timber type	In-ground durability class(1)	Treatment(2)	Typical service life (years)		
			Pole diameter 200 mm	Pole diameter 300 mm	Pole diameter 400 mm
Treated softwood	4	H4	40	50	60
		H5	60	80	100
Treated hardwood	1	H4	35	50	60
		H5	60	80	90
	2	H4	35	45	50
		H5	50	70	70
	3	H4	25	30	35
		H5	40	45	50
	4	H4	20	25	30
		H5	30	35	40
Untreated hardwood(3)	1	—	30	40	50
	2	—	15	20	25

Notes:
1. See Table 4.1.
2. As per AS 1604.1 for CCA and creosote.
3. De-sapped poles.

Table 4.5: Typical service life of round poles against in-ground decay in Zone D.

Timber type	In-ground durability class(1)	Treatment(2)	Typical service life (years)		
			Pole diameter 200 mm	Pole diameter 300 mm	Pole diameter 400 mm
Treated softwood	4	H4	35	45	50
		H5	60	70	80
Treated hardwood	1	H4	30	45	50
		H5	50	70	70
	2	H4	30	40	40
		H5	45	60	60
	3	H4	25	30	35
		H5	35	40	45
	4	H4	20	25	25
		H5	30	30	35
Untreated hardwood(3)	1	—	25	30	40
	2	—	10	15	20

Notes:
1. See Table 4.1.
2. As per AS 1604.1 for CCA and creosote.
3. De-sapped poles.

Square Posts

Table 4.6: Typical service life of square posts against in-ground decay in Zone A.

Timber type	In-ground durability class(1)	Treatment(2)	Typical service life (years)			
			100 x 100 (mm)	150 x 150 (mm)	200 x 200 (mm)	250 x 250 (mm)
Treated softwood full penetration(3)	4	H4	>100	>100	>100	>100
		H5	>100	>100	>100	>100
Treated softwood 80% penetration(4)	3 and 4	H4	50	60	70	90
		H5	50	70	90	>100
Untreated hardwood(3)	1	—	90	>100	>100	>100
	2	—	45	60	70	80

Notes:
1. See Table 4.1.
2. As per AS 1604.1 for CCA and creosote.
3. It is assumed that preservative treatment penetrates full cross-section.
4. It is assumed that 20% of cross-section is not penetrated by preservative treatment.

Table 4.7: Typical service life of square posts against in-ground decay in Zone B.

Timber type	In-ground durability class(1)	Treatment(2)	Typical service life (years)			
			100 x 100 (mm)	150 x 150 (mm)	200 x 200 (mm)	250 x 250 (mm)
Treated softwood full penetration(3)	4	H4	50	60	70	80
		H5	80	90	>100	>100
Treated softwood 80% penetration(4)	3 and 4	H4	15	20	30	30
		H5	15	20	30	35
Untreated hardwood(3)	1	—	30	40	45	50
	2	—	15	20	20	25

Notes:
1. See Table 4.1.
2. As per AS 1604.1 for CCA and creosote.
3. It is assumed that preservative treatment penetrates full cross-section.
4. It is assumed that 20% of cross-section is not penetrated by preservative treatment.

Table 4.8: Typical service life of square posts against in-ground decay in Zone C.

Timber type	In-ground durability class(1)	Treatment(2)	Typical service life (years)			
			100 x 100 (mm)	150 x 150 (mm)	200 x 200 (mm)	250 x 250 (mm)
Treated softwood full penetration(3)	4	H4	35	40	45	50
		H5	50	60	70	80
Treated softwood 80% penetration(4)	3 and 4	H4	9	15	15	20
		H5	9	15	15	20
Untreated hardwood(3)	1	—	20	25	30	35
	2	—	9	10	15	15

Notes:

1. See Table 4.1.

2. As per AS 1604.1 for CCA and creosote.

3. It is assumed that preservative treatment penetrates full cross-section.

4. It is assumed that 20% of cross-section is not penetrated by preservative treatment.

Table 4.9 Typical service life of square posts against in-ground decay in Zone D.

Timber type	In-ground durability class(1)	Treatment(2)	Typical service life (years)			
			100 x 100 (mm)	150 x 150 (mm)	200 x 200 (mm)	250 x 250 (mm)
Treated softwood full penetration(3)	4	H4	30	35	40	45
		H5	45	50	60	70
Treated softwood 80% penetration(4)	3 and 4	H4	8	10	15	20
		H5	8	10	15	20
Untreated hardwood(3)	1	—	15	20	25	25
	2	—	8	10	10	15

Notes:

1. See Table 4.1.

2. As per AS 1604.1 for CCA and creosote.

3. It is assumed that preservative treatment penetrates full cross-section.

4. It is assumed that 20% of cross-section is not penetrated by preservative treatment.

Rectangular Posts

Table 4.10: Typical service life of rectangular posts against in-ground decay in Zone A.

Timber type	In-ground durability class(1)	Treatment(2)	Typical service life (years)(5)			
			200 x 75 (mm)	200 x 100 (mm)	300 x 100 (mm)	300 x150 (mm)
Treated softwood full penetration(3)	4	H4	>100	>100	>100	>100
		H5	>100	>100	>100	>100
Treated softwood 80% penetration(4)	3 and 4	H4	80	80	90	90
		H5	>100	>100	>100	>100
Untreated hardwood(3)	1	—	90	>100	>100	>100
	2	—	45	50	50	60

Notes:

1. See Table 4.1.

2. As per AS 1604.1 for CCA and creosote.

3. It is assumed that preservative treatment penetrates full cross-section.

4. It is assumed that 20% of cross-section is not penetrated by preservative treatment.

5. Design service life given in brackets are where the member is stressed in bending about its minor axis.

Table 4.11: Typical service life of rectangular posts against in-ground decay in Zone B.

Timber type	In-ground decay class(1)	Treat-ment(2)	Typical service life (years)(5)			
			200 x 75 (mm)	200 x 100 (mm)	300 x 100 (mm)	300 x150 (mm)
Treated softwood full penetration(3)	4	H4	45	50	50	60
		H5	70	80	80	>100
Treated softwood 80% penetration(4)	3 and 4	H4	35	30	35	35
		H5	40	45	50	50
Untreated hard-wood(3)	1	—	30	35	35	45
	2	—	15	15	15	20

Notes:

1. See Table 4.1.

2. As per AS 1604.1 for CCA and creosote.

3. It is assumed that preservative treatment penetrates full cross-section.

4. It is assumed that 20% of cross-section is not penetrated by preservative treatment.

5. Design service life given in brackets are where the member is stressed in bending about its minor axis.

Table 4.12: Typical service life of rectangular posts against in-ground decay in Zone C.

Timber type	In-ground decay class(1)	Treat-ment(2)	Typical service life (years)(5)			
			200 x 75 (mm)	200 x 100 (mm)	300 x 100 (mm)	300 x150 (mm)
Treated softwood full penetration(3)	4	H4	30	35	35	45
		H5	50	60	60	70
Treated softwood 80% penetration(4)	3 and 4	H4	20	25	25	25
		H5	25	30	30	35
Untreated hard-wood(3)	1	—	20	20	20	25
	2	—	9	10	10	15

Notes:

1. See Table 4.1.

2. As per AS 1604.1 for CCA and creosote.

3. It is assumed that preservative treatment penetrates full cross-section.

4. It is assumed that 20% of cross-section is not penetrated by preservative treatment.

5. Design service life given in brackets are where the member is stressed in bending about its minor axis.

Table 4.13: Typical service life of rectangular posts against in-ground decay in Zone D.

Timber type	In-ground decay class(1)	Treat-ment(2)	Typical service life (years)(5)			
			200 x 75 (mm)	200 x 100 (mm)	300 x 100 (mm)	300 x150 (mm)
Treated softwood full penetration(3)	4	H4	30	30	30	35
		H5	45	50	50	60
Treated softwood 80% penetration(4)	3 and 4	H4	20	20	20	20
		H5	20	25	25	35
Untreated hard-wood(3)	1	—	15	20	20	20
	2	—	8	9	9	10

Notes:

1. See Table 4.1.

2. As per AS 1604.1 for CCA and creosote.

3. It is assumed that preservative treatment penetrates full cross-section.

4. It is assumed that 20% of cross-section is not penetrated by preservative treatment.

5. Design service life given in brackets are where the member is stressed in bending about its minor axis.

4.2 Maintenance of Timber In-ground Contact

A maintenance procedure can stop or slow down timber degradation, and thus extend service life. This is illustrated in Figure 4.2. Table 4.14 presents the extra life gained considering four types of maintenance procedures. This extra life is simply added to the value of the design life determined above.

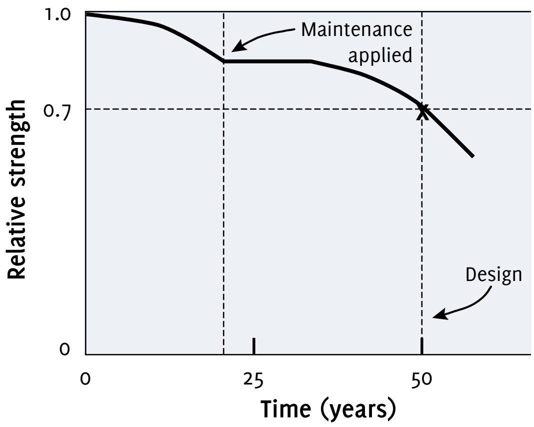


Figure 4.2: Illustration of the effect of a maintenance procedure.

Table 4.14: Effect of maintenance procedures.

Maintenance procedure	Extra service life for each application of the maintenance procedure (years)
External diffusing chemical barrier	5
External non-diffusing chemical barrier	2
External physical barrier	0
Insertion of internal diffusing chemicals(1)	5(2)

Notes:

1. In addition to increasing the service life for resistance to decay, the use of internal diffusing chemicals is also useful for other reasons. First it provides a very effective deterrent to termite attack. Another benefit is that in the case of treated hardwood poles, the use of these chemicals can be used to ensure that some untreated heartwood always remains; hence, the residual structure is not totally reliant on a thin skin of treated sapwood that may fail in a brittle and catastrophic manner.

2. The potential for extra life due to the use of internal diffusing chemicals tends to vary with the type of pole, and is greater for hardwood than for softwood poles.

Degradation of basement column after 100 years in service in Brisbane.
Note: the concrete slab and part of the footing have been cut away to expose the in-ground portion.

5 Decay of Timber Above-Ground Exposed to the Weather

This Section provides estimates of the service life of timber, above ground, exposed to the weather and out of ground contact. The equations used for these estimates are given in Report number 8 referred to in the Preface.

Figures 5.1 and 6.1 give guidance on the definition of exposure to the weather.

Figure 5.2 provides a general guide to the level of decay hazard likely to be encountered in Australia. It should be noted that this map generally reflects the influence of both moisture and temperature relative to decay on a macro climatic regional basis.

The estimates are based on measurements of the decay of small pieces of timber exposed for 20 years at a number of test sites around Australia. A limited number of species were tested at each site. Most of the tests used heartwood timber, although some data on sapwood timber was also obtained. The model used for these estimates has been checked against data obtained from fencing and decking from a limited number of houses in Melbourne and Brisbane. Because of the wide range of species and climates possible in practical applications, a considerable amount of further field calibrations need to be made for the model to be considered to give reliable predictions.

The tables relate to the effects of decay only. Attacks by other biological agents such as termites or the effects of mechanical degradation are also not considered. See Sections 6 and 7 for these agents.

In the tables, the service life for the onset of decay refers to a theoretical estimate by the current version of the decay model of the mean time taken to develop decay to a depth of 2 mm; similarly, the service life for timber replacement refers to an estimate of the mean time taken to develop decay to a depth of 10 mm. These serviceability limits are defined as the times to the occurrence of decay and the need for replacement, respectively.

It should be noted that for simplicity in the presentation of data, the tables shown do not demonstrate the full scope of the decay model. The influences of many parameters have been omitted, such as the effects of timber orientation and the effects of shielding from sun and rain. In addition, no mention is made of the aesthetic degradation of the timber, one of the major design considerations in the use of timber outdoors. Examples of aesthetic degradation include discolouration, surface checking and distortion. Section 6 provides guidance in this regard.

5.1 Application

To estimate the typical service life of a timber member, use the following procedure:

- Determine the natural durability class for the species above ground from Table 5.1.
- Determine the decay hazard zone for the application from Figure 5.2.
- Determine the service life (or depth of decay for the case of cross-arms) for various applications (Figures 5.3 to 5.7) and combinations of timber, cross sections, treatments and natural durability from Tables 5.2 to 5.11.

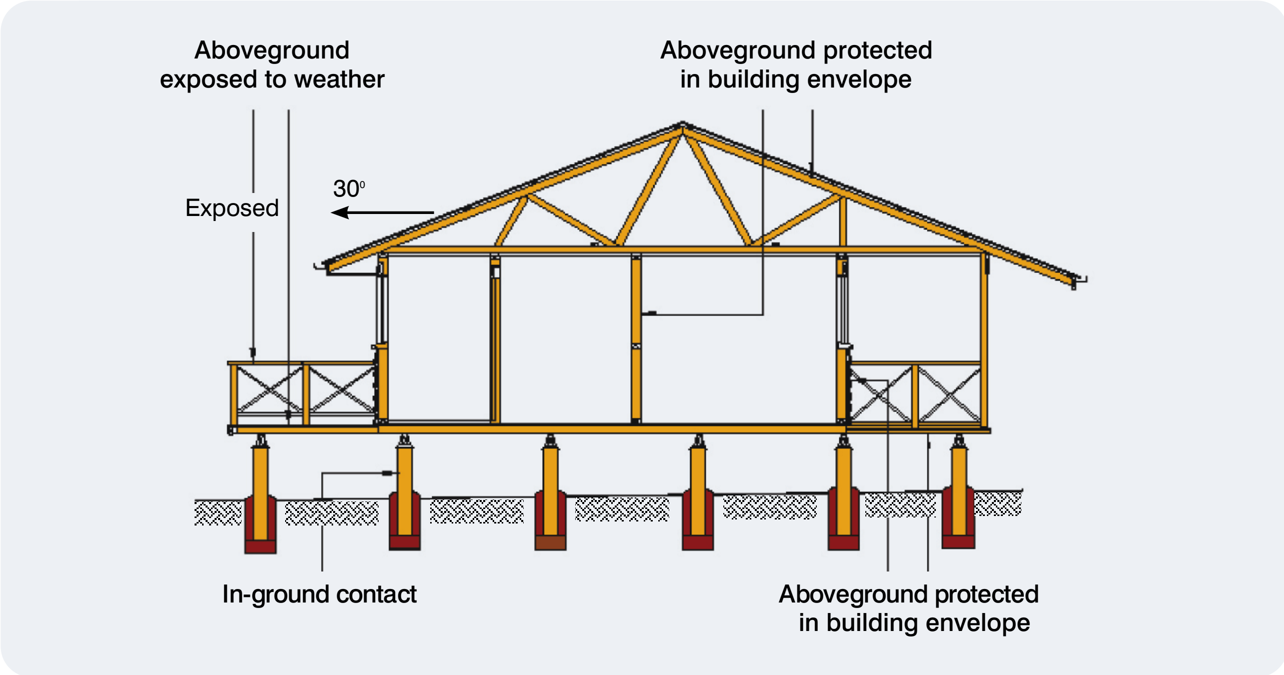


Figure 5.1: Weather exposure (see Figure 6.1 for further explanation).

Above-ground durability test site in South-East Queensland.

Table 5.1: Timber classification for above-ground decay.

Trade name	Botanical name	Above-ground durability class
Ash, alpine	*Eucalyptus delegatensis*	3
Ash, Crow's	*Flindersia australis*	1
Ash, mountain	*Eucalyptus regnans*	3
Ash, silvertop	*Eucalyptus sieberi*	2
Balau (selangan batu)	*Shorea* spp.	1
Bangkirai	*Shorea laevis*	1
Beech, myrtle	*Nothofagus cunninghamii*	3
Belian (ulin)	*Eusideroxylon zwageri*	1
Blackbutt	*Eucalyptus pilularis*	1
Blackbutt, New England	*Eucalyptus andrewsii*	2
Blackbutt, WA	*Eucalyptus patens*	1
Blackwood	*Acacia melanoxylon*	3
Bloodwood, red	*Corymbia intermedia*	1
Bloodwood, white	*Corymbia trachyphloia*	1
Bollywood	*Litsea reticulata*	4
Box, brush	*Lophostemon confertus*	3
Box, grey	*Eucalyptus moluccana*	1
Box, grey, coast	*Eucalyptus bosistoana*	1
Box, long leaved	*Eucalyptus goniocalyx*	2
Box, red	*Eucalyptus polyanthemos*	1
Box, steel	*Eucalyptus rummeryi*	1
Box, swamp	*Lophostemon suaveolens*	1
Box, yellow	*Eucalyptus melliodora*	1
Box,white	*Eucalyptus albens*	1
Brigalow	*Acacia harpophylla*	1
Brownbarrel	*Eucalyptus fastigata*	3
Bullich	*Eucalyptus megacarpa*	2
Calantas (kalantas)	*Toona calantas*	1
Candlebark	*Eucalyptus rubida*	3
Cedar, red, western	*Thuja plicata*	2
Cypress	*Callitris glaucophylla*	1
Fir, Douglas (Oregon)	*Pseudotsuga menziesii*	4
Gum, blue, southern	*Eucalyptus globulus*	2
Gum, blue, Sydney	*Eucalyptus saligna*	2
Gum, grey	*Eucalyptus propinqua*	1
Gum, grey, mountain	*Eucalyptus cypellocarpa*	2
Gum, maiden's	*Eucalyptus maidenii*	2
Gum, manna	*Eucalyptus viminalis*	3

Table 5.1 *(continued)***: Timber classification for above-ground decay.**

Trade name	Botanical name	Above-ground durability class
Gum, mountain	*Eucalyptus dalrympleana*	3
Gum, red, forest	*Eucalyptus tereticornis*	1
Gum, red, river	*Eucalyptus camaldulensis*	1
Gum, rose	*Eucalyptus grandis*	2
Gum, salmon	*Eucalyptus salmonophloia*	1
Gum, scribbly	*Eucalyptus haemastoma*	2
Gum, shining	*Eucalyptus nitens*	3
Gum, spotted	*Corymbia maculata,* incl. *corymbia citriodora*	1
Gum, sugar	*Eucalyptus cladocalyx*	1
Gum, yellow	*Eucalyptus leucoxylon*	2
Hardwood, Johnstone River	*Backhousia bancroftii*	2
Hemlock, western	*Tsuga heterophylla*	4
Ironbark, grey	*Eucalyptus paniculata*	1
Ironbark, red	*Eucalyptus sideroxylon*	1
Ironbark, red (broad-leaved)	*Eucalyptus fibrosa*	1
Ironbark, red (narrow-leaved)	*Eucalyptus crebra*	1
Ironwood, Cooktown	*Erythrophloeum chlorostachys*	1
Jam, raspberry	*Acacia acuminata*	1
Jarrah	*Eucalyptus marginata*	2
Kapur	*Dryobalanops* spp.	2
Karri	*Eucalyptus diversicolor*	2
Keruing	*Dipterocarpus* spp.	3
Kwila	*Intsia bijuga*	1
Mahogany, Philippine, red, dark	*Shorea* spp.	2
Mahogany, Philippine, red, light	*Shorea, Pentacme, Parashorea* spp.	3
Mahogany, red	*Eucalyptus resinifera*	1
Mahogany, white	*Eucalyptus acmenoides*	1
Mahogany, white	*Eucalyptus umbra*	1
Mahogany, southern	*Eucalyptus botryoides*	2
Mallet, brown	*Eucalyptus astringens*	1
Marri	*Corymbia calophylla*	3
Meranti, red, dark	*Shorea* spp.	3
Meranti, red, light	*Shorea* spp.	4
Mersawa	*Anisoptera* spp.	3
Messmate	*Eucalyptus obliqua*	3
Messmate, Gympie	*Eucalyptus cloeziana*	1
Oak, bull	*Allocasuarina luehmannii*	1
Oak, white, American	*Quercus alba*	3
Peppermint, black	*Eucalyptus amygdalina*	3
Peppermint, broad leaved	*Eucalyptus dives*	2
Peppermint, narrow leaved	*Eucalyptus radiata*	3
Peppermint, river	*Eucalyptus elata*	3
Pine, black	*Prumnopitys amara*	4
Pine, Caribbean	*Pinus caribaea*	4
Pine, celery-top	*Phyllocladus aspleniifolius*	2
Pine, hoop	*Araucaria cunninghamii*	4
Pine, Huon	*Lagarostrobos franklinii*	3
Pine, kauri	*Agathis robusta*	4
Pine, King William	*Athrotaxis selaginoides*	2

Table 5.1 *(continued)*: ***Timber classification for above-ground decay.***

Trade name	Botanical name	Above-ground durability class
Pine, radiata	*Pinus radiata*	4
Pine, slash	*Pinus elliottii*	4
Ramin	*Gonystylus* spp.	4
Redwood	*Sequoia sempervirens*	1
Rosewood, New Guinea	*Pterocarpus indicus*	2
Satinay	*Syncarpia hillii*	1
Stringybark, Blackdown	*Eucalyptus sphaerocarpa*	1
Stringybark, brown	*Eucalyptus baxteri*	2
Stringybark, red	*Eucalyptus macrorhyncha*	2
Stringybark, white	*Eucalyptus eugenioides*	2
Stringybark, yellow	*Eucalyptus muelleriana*	2
Tallowwood	*Eucalyptus microcorys*	1
Taun	*Pometia* spp.	2
Teak, Burmese	*Tectona grandis*	1
Tingle, red	*Eucalyptus jacksonii*	3
Tingle, yellow	*Eucalyptus guilfoylei*	1
Tuart	*Eucalyptus gomphocephala*	1
Turpentine	*Syncarpia glomulifera*	1
Wandoo	*Eucalyptus wandoo*	1
Woolybutt	*Eucalyptus longifolia*	1
Yate	*Eucalyptus cornuta*	1
Yertchuk	*Eucalyptus consideniana*	1

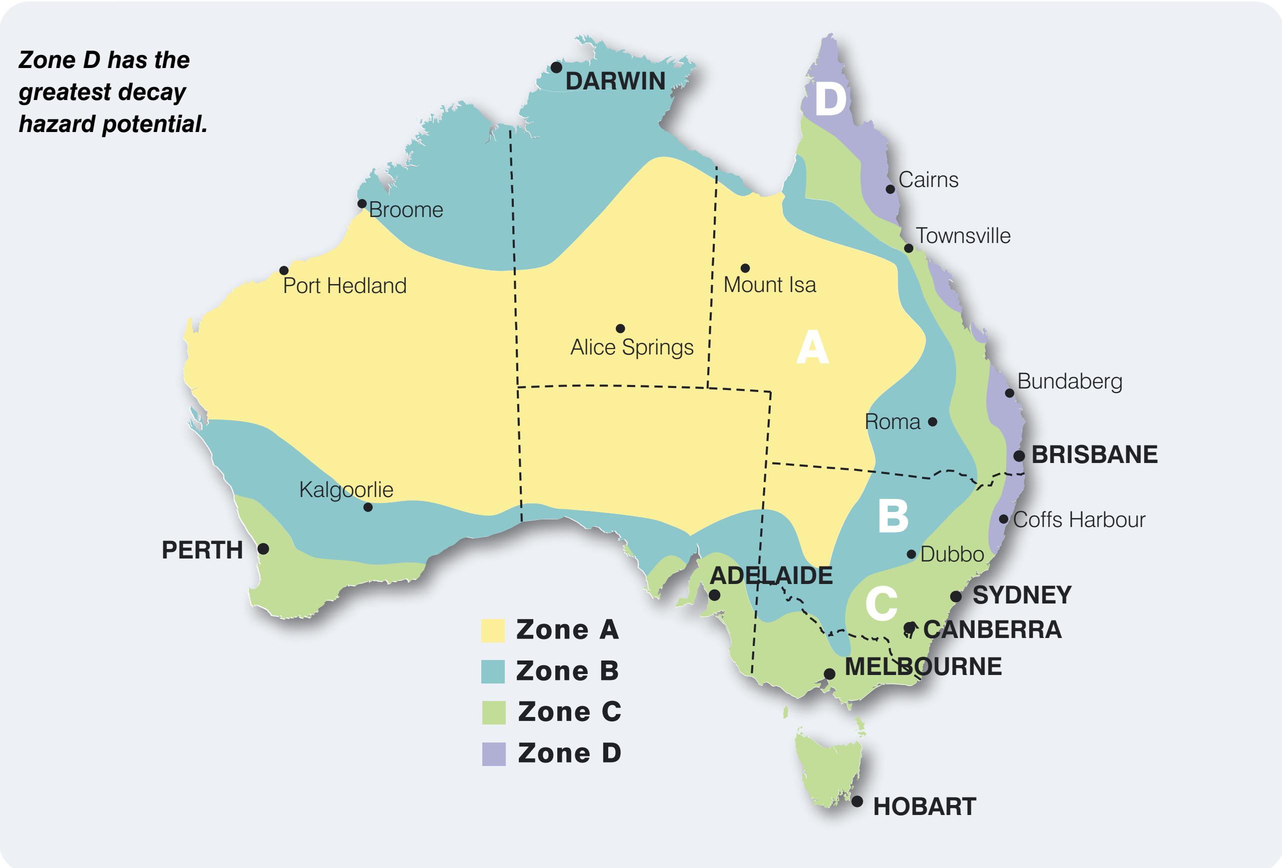


Figure 5.2: Above ground decay hazard zones for Australia.

5.1.1 Fencing and similar applications

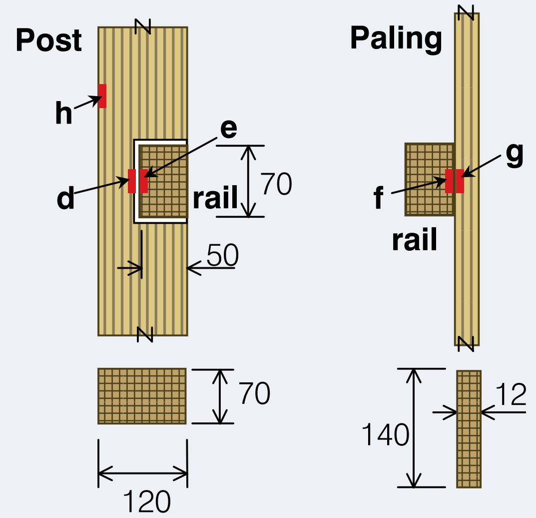


Figure 5.3: Typical dimensions of fencing and locations of interest for service lives. (For in-ground decay of post, refer to Section 4.)

Table 5.2: Typical service life for onset of decay in fencing. *(See Figure 5.3 for location in the assembly.)*

Climate zone	Timber type	Above-ground durability class[1]	Treatment[2]	Typical service life (years)				
				d	e	f	g	h
A	Treated sapwood	all	H3	70	70	>100	>100	>100
	Untreated heartwood	1	—	35	35	60	70	60
		2	—	30	30	45	60	45
		3	—	15	15	25	35	25
		4	—	9	9	15	20	15
	Untreated sapwood	all	—	3	3	5	7	5
B	Treated sapwood	all	H3	50	50	90	>100	90
	Untreated heartwood	1	—	30	30	45	60	45
		2	—	25	25	35	50	35
		3	—	15	15	20	30	20
		4	—	7	7	10	15	10
	Untreated sapwood	all	—	3	3	4	6	4
C	Treated sapwood	all	H3	40	40	70	90	70
	Untreated heartwood	1	—	20	20	35	45	35
		2	—	20	20	30	40	30
		3	—	10	10	15	20	15
		4	—	6	6	9	10	9
	Untreated sapwood	all	—	2	2	3	5	3
D	Treated sapwood	all	H3	35	35	60	80	60
	Untreated heartwood	1	—	20	20	30	40	30
		2	—	15	15	25	35	25
		3	—	9	9	15	20	15
		4	—	5	5	8	10	8
	Untreated sapwood	all	—	2	2	3	4	3

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.

Table 5.3: Typical service life for replacement of timber in fencing. *(See Fig. 5.3 for location in the assembly.)*

Climate zone	Timber type	Above-ground durability class[1]	Treatment[2]	Typical service life (years)				
				d	e	f	g	h
A	Treated sapwood	all	H3	>100	>100	>100	>100	>100
	Untreated heartwood	1	—	80	80	>100	>100	>100
		2	—	60	60	>100	>100	>100
		3	—	35	35	60	80	60
		4	—	20	20	30	40	30
	Untreated sapwood	all	—	7	7	10	15	10
B	Treated sapwood	all	H3	>100	>100	>100	>100	>100
	Untreated heartwood	1	—	60	60	>100	>100	>100
		2	—	50	50	80	>100	80
		3	—	30	30	45	60	45
		4	—	15	15	25	35	25
	Untreated sapwood	all	—	6	6	9	10	9
C	Treated sapwood	all	H3	100	100	>100	>100	>100
	Untreated heartwood	1	—	50	50	80	>100	80
		2	—	40	40	70	90	70
		3	—	25	25	35	50	35
		4	—	10	10	20	25	20
	Untreated sapwood	all	—	5	5	7	10	7
D	Treated sapwood	all	H3	80	80	>100	>100	>100
	Untreated heartwood	1	—	45	45	70	90	70
		2	—	35	35	60	80	60
		3	—	20	20	30	45	30
		4	—	10	10	20	25	20
	Untreated sapwood	all	—	4	4	6	9	6

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.

5.1.2 Domestic decking

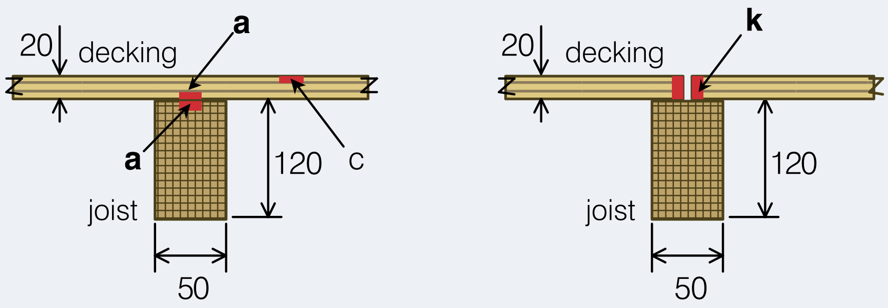


Figure 5.4: Typical dimensions of decking and locations of interest for service lives.

Table 5.4: Typical service life for onset of decay in decking. *(See Figure. 5.4 for location in the assembly.)*

Climate zone	Timber type	Above-ground durability class[1]	Treatment[2]	Typical service life (years)		
				a	c	k
A	Treated sapwood	all	H3	60	80	60
	Untreated heartwood	1	—	30	40	30
		2	—	25	35	25
		3	—	15	20	15
		4	—	8	10	8
	Untreated sapwood	all	—	3	4	3
B	Treated sapwood	all	H3	50	60	50
	Untreated heartwood	1	—	25	35	25
		2	—	20	25	20
		3	—	10	15	10
		4	—	7	9	7
	Untreated sapwood	all	—	2	3	2
C	Treated sapwood	all	H3	40	50	40
	Untreated heartwood	1	—	20	25	20
		2	—	15	20	15
		3	—	9	10	9
		4	—	5	7	5
	Untreated sapwood	all	—	2	3	2
D	Treated sapwood	all	H3	35	45	35
	Untreated heartwood	1	—	20	25	20
		2	—	15	20	15
		3	—	8	10	8
		4	—	5	6	5
	Untreated sapwood	all	—	2	2	2

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.

Table 5.5: Typical service life for replacement of timber in decking. *(See Figure 5.3 for location in the assembly.)*

Climate zone	Timber type	Above-ground durability class[1]	Treatment[2]	Typical service life (years)		
				a	c	k
A	Treated sapwood	all	H3	>100	>100	>100
	Untreated heartwood	1	—	70	90	70
		2	—	60	80	60
		3	—	30	40	30
		4	—	20	25	20
	Untreated sapwood	all	—	6	8	6
B	Treated sapwood	all	H3	>100	>100	>100
	Untreated heartwood	1	—	60	80	60
		2	—	45	60	45
		3	—	25	35	25
		4	—	15	20	15
	Untreated sapwood	all	—	5	7	5
C	Treated sapwood	all	H3	90	>100	90
	Untreated heartwood	1	—	45	60	45
		2	—	35	50	35
		3	—	20	25	20
		4	—	10	15	10
	Untreated sapwood	all	—	4	5	4
D	Treated sapwood	all	H3	80	100	80
	Untreated heartwood	1	—	40	50	40
		2	—	30	40	30
		3	—	20	25	20
		4	—	10	15	10
	Untreated sapwood	all	—	4	5	4

Notes:

1. *See Table 5.1.*
2. *As per AS 1604.1 for CCA only.*
3. *CCA is not approved for use in domestic decking*

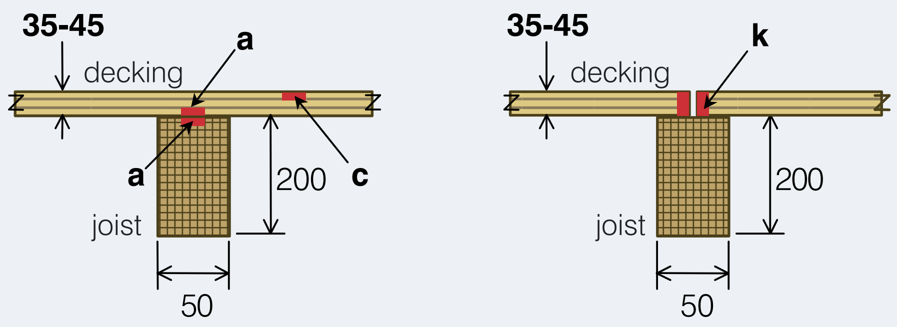


Figure 5.5: Typical dimensions of commercial decking and locations of interest for service lives.

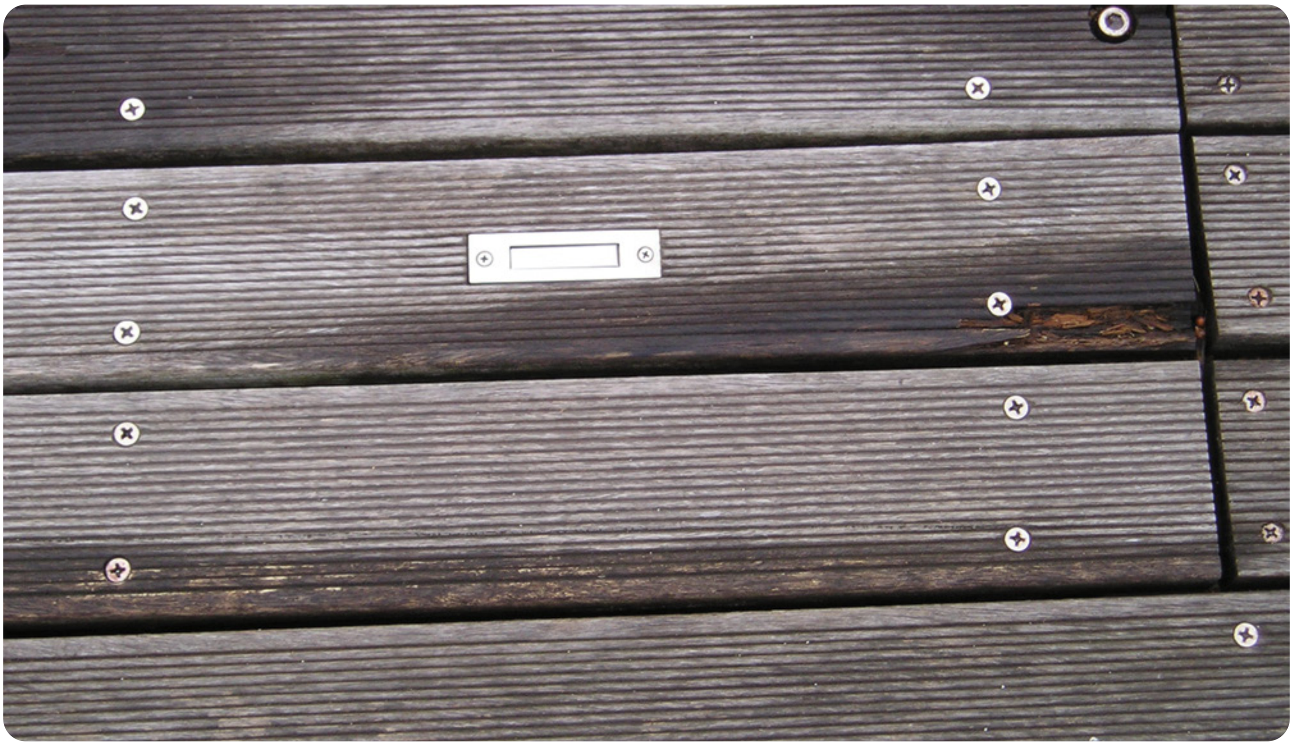
Table 5.6: Typical service life for onset of decay in decking. *(See Figure 5.5 for location in the assembly.)*

Climate zone	Timber type	Above-ground durability class(1)	Treatment(2)	Typical service life (years)		
				a	c	k
A	Treated sapwood	all	H3	60	80	60
	Untreated heartwood	1	—	30	40	30
		2	—	25	35	25
		3	—	15	20	15
		4	—	8	10	8
	Untreated sapwood	all	—	3	4	3
B	Treated sapwood	all	H3	50	60	50
	Untreated heartwood	1	—	25	35	25
		2	—	20	25	20
		3	—	10	15	10
		4	—	7	9	7
	Untreated sapwood	all	—	2	3	2
C	Treated sapwood	all	H3	40	50	40
	Untreated heartwood	1	—	20	25	20
		2	—	15	20	15
		3	—	9	10	9
		4	—	5	7	5
	Untreated sapwood	all	—	2	3	2
D	Treated sapwood	all	H3	35	45	35
	Untreated heartwood	1	—	20	25	20
		2	—	15	20	15
		3	—	8	10	8
		4	—	5	6	5
	Untreated sapwood	all	—	2	2	2

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.



Decay in untreated sapwood on edges of decking boards.

Table 5.7: Typical service life for replacement of timber in decking. *(See Figure 5.5 for location in the assembly.)*

Climate zone	Timber type	Above-ground durability class[1]	Treatment[2]	Typical service life (years)		
				a	c	k
A	Treated sapwood	all	H3	>100	>100	>100
	Untreated heartwood	1	—	70	90	70
		2	—	60	80	60
		3	—	30	40	30
		4	—	20	25	20
	Untreated sapwood	all	—	6	8	6
B	Treated sapwood	all	H3	>100	>100	>100
	Untreated heartwood	1	—	60	80	60
		2	—	45	60	45
		3	—	25	35	25
		4	—	15	20	15
	Untreated sapwood	all	—	5	7	5
C	Treated sapwood	all	H3	90	>100	90
	Untreated heartwood	1	—	45	60	45
		2	—	35	50	35
		3	—	20	25	20
		4	—	10	15	10
	Untreated sapwood	all	—	4	5	4
D	Treated sapwood	all	H3	80	100	80
	Untreated heartwood	1	—	40	50	40
		2	—	30	40	30
		3	—	20	25	20
		4	—	10	15	10
	Untreated sapwood	all	—	4	5	4

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.

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5.1.4 Pergolas and similar applications

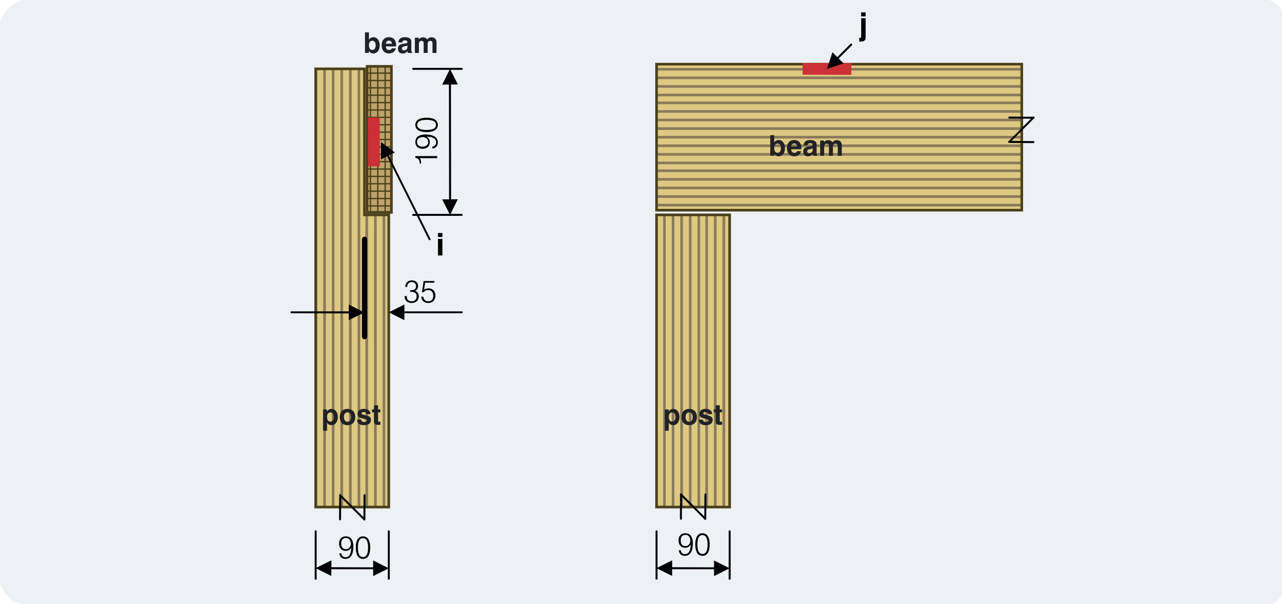


Figure 5.6: Typical dimensions of pergola and locations of interest for service lives.

Table 5.8: Typical service life for onset of decay in pergolas. *(See Figure 5.6 for location in the assembly.)*

Climate zone	Timber type	Above-ground durability class(1)	Treatment(2)	Typical service life (years)	
				i	j
A	Treated sapwood	all	H3	50	80
	Untreated heartwood	1	—	25	40
		2	—	20	35
		3	—	10	20
		4	—	7	10
	Untreated sapwood	all	—	3	4
B	Treated sapwood	all	H3	40	60
	Untreated heartwood	1	—	20	35
		2	—	15	25
		3	—	10	15
		4	—	6	9
	Untreated sapwood	all	—	2	3
C	Treated sapwood	all	H3	30	50
	Untreated heartwood	1	—	15	25
		2	—	15	20
		3	—	8	10
		4	—	4	7
	Untreated sapwood	all	—	2	3
D	Treated sapwood	all	H3	30	45
	Untreated heartwood	1	—	15	25
		2	—	10	20
		3	—	7	10
		4	—	4	6
	Untreated sapwood	all	—	1	2

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.

Table 5.9: Typical service life for replacement of timber in pergolas.
(See Fig. 5.6 for location in the assembly.)

Climate zone	Timber type	Above-ground durability class[1]	Treatment[2]	Typical service life (years)	
				i	j
A	Treated sapwood	all	H3	>100	>100
	Untreated heartwood	1	—	60	90
		2	—	50	80
		3	—	25	40
		4	—	15	25
	Untreated sapwood	all	—	5	8
B	Treated sapwood	all	H3	90	>100
	Untreated heartwood	1	—	45	80
		2	—	40	60
		3	—	20	35
		4	—	10	20
	Untreated sapwood	all	—	4	7
C	Treated sapwood	all	H3	70	>100
	Untreated heartwood	1	—	35	60
		2	—	30	50
		3	—	15	25
		4	—	9	15
	Untreated sapwood	all	—	3	5
D	Treated sapwood	all	H3	60	100
	Untreated heartwood	1	—	30	50
		2	—	25	40
		3	—	15	25
		4	—	8	15
	Untreated sapwood	all	—	3	5

Notes:

1. See Table 5.1.

2. As per AS 1604.1 for CCA only.

5.1.5 Decay of timber cross-arms and similar

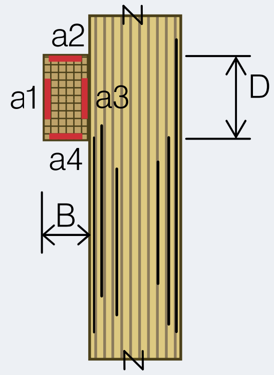


Figure 5.7: Timber cross-arms: dimensions and decay zones to be considered.

Note: The decay zones a1-a4 shown in Figure 5.7 are intended to indicate the general location of the decay and not the actual geometry of the decay attack. In particular, decay in the zones a1 and a2 would be due to water entry and retention at splits and checks. This will initiate decay below the wood surface. In fact, the surface may remain free of decay if the surface temperatures arising from solar radiation are high enough to kill fungi.

Table 5.10: Typical decay depths of cross-arms in Zones A and B. *(See Figure 5.7 for location in the assembly.)*

Zone	Timber		Cross-arms, at 20 years						
			Dimension (mm)		Typical decay depths (mm)				
			B	D	a1 NW[1]	a1 SE[1]	a2	a3	a4
A	Heartwood	Class 1	100	100	0	0	1	0	0
		Class 2	100	100	0	0	1	0	0
		Class 3	100	100	1	1	3	1	0
		Class 4	100	100	5	3	10	5	1
	Sapwood	Untreated	100	100	>20	18	>20	>20	10
		H3 treated(2)	100	100	0	0	0	0	0
B	Heartwood	Class 1	100	100	0	0	1	0	0
		Class 2	100	100	1	0	1	1	0
		Class 3	100	100	2	1	4	2	1
		Class 4	100	100	7	4	14	7	2
	Sapwood	Untreated	100	100	>20	>20	>20	>20	14
		H3 treated(1)	100	100	0	0	0	0	0

Notes:

1. 'NW' and 'SE' indicate the facing direction. 'NW' is for facing north and west; 'SE' is for facing south and east.

2. Note that AS1604 permits 20% of the cross-section to be heartwood timber and not penetrated by preservatives. The decay depth for the untreated heartwood timber should be estimated as the decay depth of the corresponding class of heartwood.

CCA treated sapwood outperforming durability class 2 heartwood.

Table 5.11: Typical decay depths of cross-arms in Zones C and D. *(See Figure 5.7 for location in the assembly.)*

Zone	Timber		Cross-arms, at 20 years						
			Dimension (mm)		Typical decay depths (mm)				
					a1				
			B	D	NW[1]	SE[1]	a2	a3	a4
C	Heartwood	Class 1	100	100	1	0	2	1	0
		Class 2	100	100	1	1	2	1	0
		Class 3	100	100	3	2	7	3	1
		Class 4	100	100	12	7	>20	12	3
	Sapwood	Untreated	100	100	>20	>20	>20	>20	>20
		H3 treated[2]	100	100	0	0	0	0	0
D	Heartwood	Class 1	100	100	1	1	2	1	0
		Class 2	100	100	1	1	3	1	0
		Class 3	100	100	4	3	10	4	1
		Class 4	100	100	14	9	>20	14	4
	Sapwood	Untreated	100	100	>20	>20	>20	>20	>20
		H3 treated[2]	100	100	0	0	1	0	0

Notes:

1. 'NW' and 'SE' indicate the facing direction. 'NW' is for facing north and west; 'SE' is for facing south and east.

2. Note that AS1604 permits 20% of the cross-section to be heartwood timber and not penetrated by preservatives. The decay depth for the untreated heartwood timber should be estimated as the decay depth of the corresponding class of heartwood.

6 Weathering, Finishing, Good Practice, Maintenance and Other Considerations

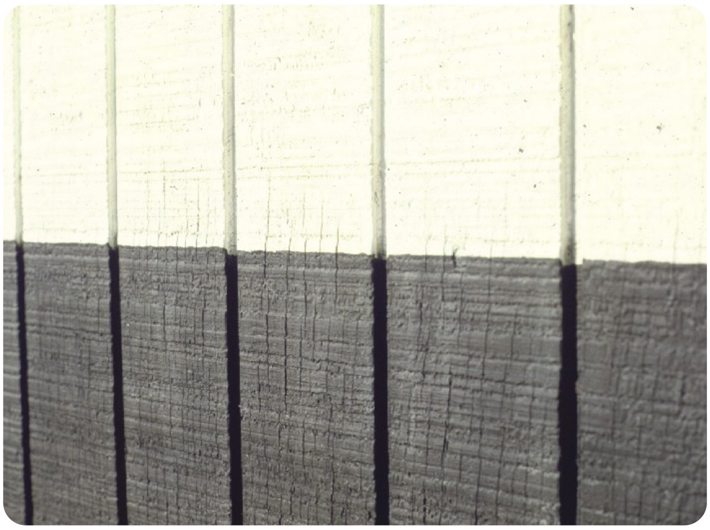
Section 5 refers to the performance of uncoated wood. This Section provides advice and general recommendations associated with finishing, detailing and good practice.

6.1 Weathering and Finishing

Protection from weathering can be afforded by the following means:

- Application and maintenance of finishes including paints, stains and water repellents
- Architectural and design detailing including overhangs, capping, verandahs, shading, etc.

6.1.1 Coatings – General



Light coloured finishes are preferred to dark colours as they are less prone to checking and distortion arising.

It is difficult to give useful quantitative information on the effects of coating systems in general. Paint systems have an initial beneficial effect in delaying the onset of moisture entry and hence of decay. However, once cracks occur, moisture enters the wood, and the paint systems then inhibit drying and hence may accelerate the onset and progress of decay. The rate of decay and checking of wood can also be accelerated if the coating is a dark colour, because this then encourages the wood to absorb the heat from the sun, resulting in shrinkage and checks developing.

From in-service performance data and recent research it has been found that low quality and or poorly maintained acrylic paints, applied to low durability timber, may actually speed up the onset and progress of decay by a factor of two. This is caused by the paint system permitting moisture entry and then trapping the moisture in the timber.

Conversely, a quality acrylic paint system applied to a highly durable timber such as a Class 1 timber or CCA-treated pine, will extend the service life by delaying the effects of weathering and subsequent water entry.

It has also been found from research that the application and regular maintenance of pigmented oil based stain finishes or water repellent preservatives on low durability timber will extend service life by inhibiting the onset of decay and weathering due to the water repellency and preservative nature of these products.

Hence, while high quality coating systems should be beneficial if they are applied and maintained in accordance with manufacturers' recommendations, they may also be either beneficial or detrimental to the long term performance of exposed wood, depending on a large number of parameters.

Most commercial finishes do not provide a complete moisture seal, but a suitable finish will reduce movement from moisture uptake and loss and will also reduce the effects of weathering. To obtain the full benefit of coating systems, end grain and surfaces of joints should be sealed with an oil based primer, stain or water repellent to maximise service life.

Bottom half of panel maintained with water repellant finish as indicated by 'water bucket' test.

6.1.2 Finishing

Timber absorbs and desorbs moisture in sympathy with its environment. Generally, the denser the species, the less reactive it is to rapid moisture changes. On the other hand, denser species tend to have greater overall percentage movement, therefore permanent moisture changes will lead to greater movement than generally occurs with less dense species.

Movement (expansion and contraction) in timber can be greatly reduced by providing protective moisture barriers. By far the most economical of these is attained by the application of suitable paints, stains or water repellents.

It should be noted that these do not confer a total seal and that given sufficient time, timber will reach a moisture content in equilibrium with its environment.

The following points should be considered when deciding upon the efficacy of finishes required to minimise moisture changes and subsequent movement:

- pale colours absorb less heat, therefore the effects of drying and accelerated decay and distortion due to raised temperatures are minimised
- oil based paint systems are generally better 'moisture barriers than acrylic systems
- good quality primers and undercoats (oil or acrylic) are designed to seal the timber and provide a key for top coats
- stains and water repellents require more frequent re-application to maintain a water resistant finish than paints and
- sawn surfaces provide a better key for stains and water repellents than dressed surfaces, particularly for denser species.

Table 6.1 provides a summary of finishes and maintenance appropriate for timber used externally.

Table 6.1: Exterior wood finishes: types, treatments and maintenance.

Finish	Initial Treatment	Appearance of Wood	Cost of Initial Treatment	Maintenance Procedure	Maintenance Period of Surface Finish	Maintenance Cost
Paint	Prime and two top coats	Grain and natural colour obscured	Medium to high	Clean and apply top coat or remove and repeat initial treatment if desired	7 – 10 years(1)	Medium
Clear (film forming)	Four coats (minimum)	Grain and natural colour unchanged if adequately maintained	High	Clean and stain bleached areas and apply two more coats	2 years or when breakdown begins	High
Water Repellent(3)	One or two coats of clear material, or preferably dip applied	Grain and natural colour; visibly becoming darker and rougher textured	Low	Clean and apply sufficient material	1 – 3 years or when preferred	Low to medium
Stains	One or two brush coats	Grain visible; coloured as desired	Low to Medium	Clean and apply sufficient material	3 – 6 years or when preferred	Low to Medium
Organic Solvents Preser-vatives (4)	Pressure, steeping, dipping, brushing	Grain visible; coloured as desired	Low to Medium	Brush down and reapply	2 – 3 years or when preferred	Medium
Waterborne Preservatives	Pressure	Grain visible; greenish or brownish; fading with age	Medium	Brush down to remove surface dirt	None unless stained, painted or varnished	Low to medium for stained or painted

Notes:

1. This table is a compilation of data from the observations of many researchers.

2. Using top quality acrylic latex paints.

3. With or without added preservatives. Addition of preservative helps control mildew and mould growth.

4. Pentachlorophenol, tri-n-butyltin oxide, copper naphthenate and similar materials.

6.2 Design Detailing

6.2.1 General

Architectural and structural detailing are critical considerations to ensure durable structures. The following are some key factors that should be considered:

- shielding – overhangs, pergolas, vegetation, capping, flashing, fascias, barges, etc
- isolation – damp proof course's, sarking, claddings, etc
- moisture traps – housed joints, free draining, well ventilated, end grain
- ventilation and condensation – cold climates, warm climates, sarking, foil, insulation, etc
- joint detailing.

Figures 6.1 to 6.6 provide examples of the above.

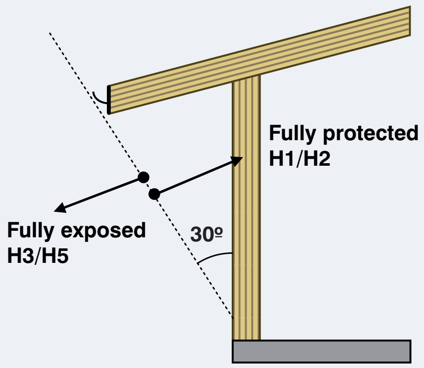


Figure 6.1: Architectural detailing – shielding.

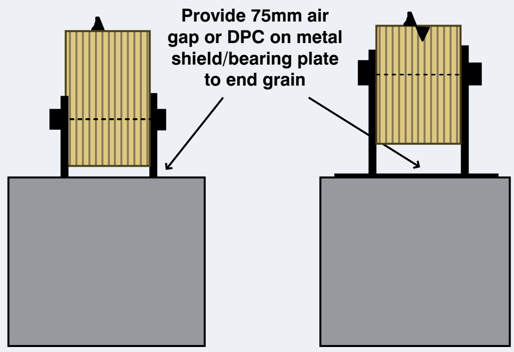
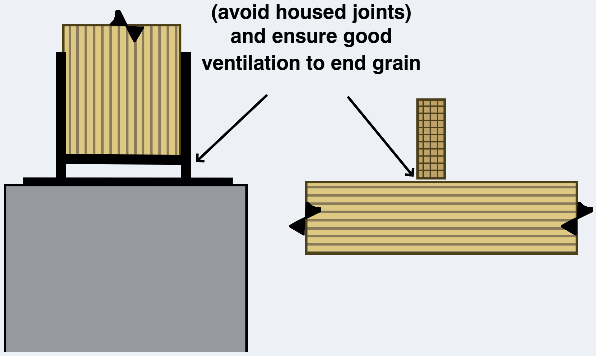
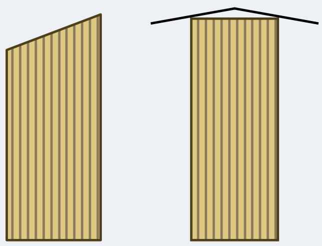


Figure 6.2: Isolation of timber from moisture traps.



A well-ventilated, free-draining post support.

Figure 6.3 Moisture traps.



Capping protects top and end grain of projected beam.

Figure 6.4 Weather protection.

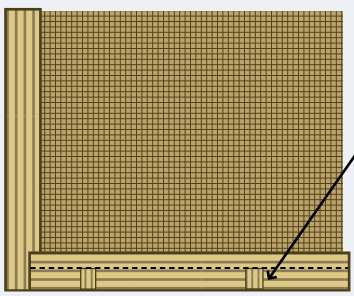
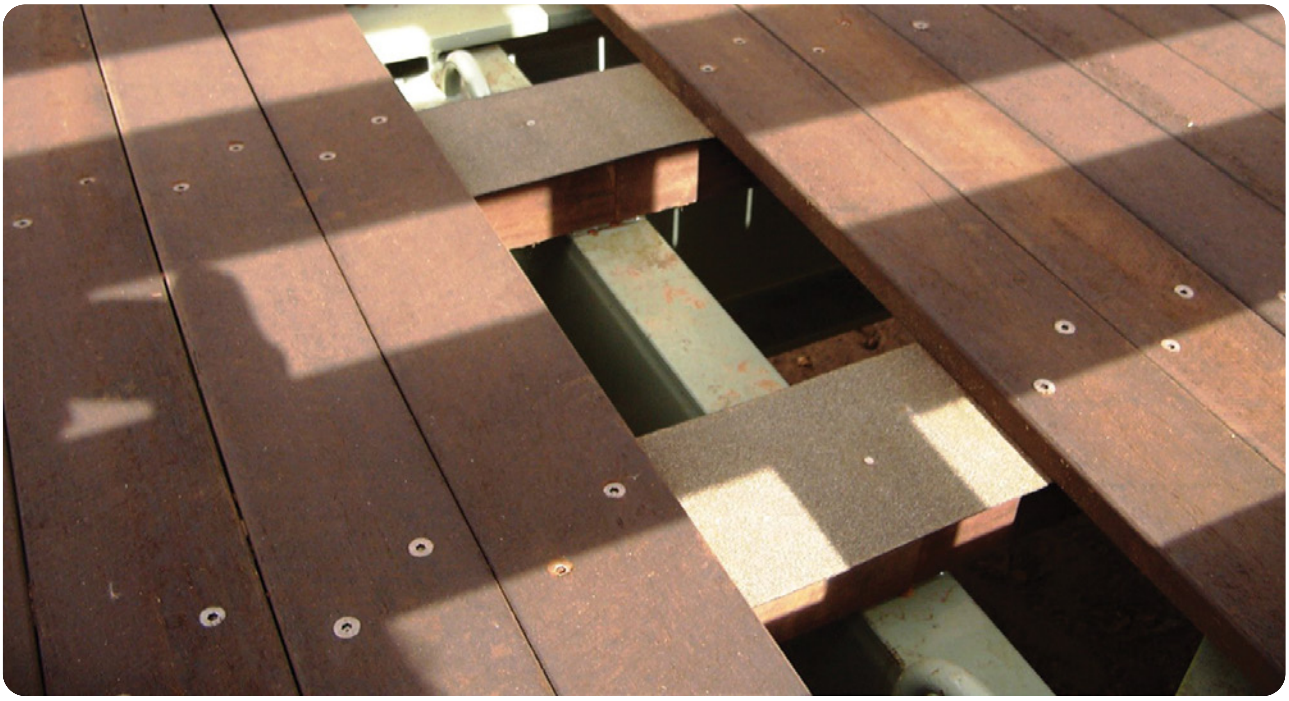


Figure 6.5 Drainage holes.



Good detailing (staggered screws and DPC over joists) used for this prefabricated bridge.

6.2.2 Other Considerations

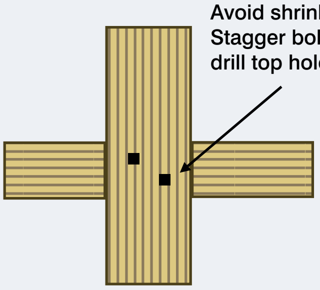
Successful structures rely heavily upon detailing. Attention to detail and simplicity will usually provide the most economical durable connections. The following factors require consideration:

- minimising moisture traps and contact areas
- avoiding restraint due to shrinkage
- allowing for shrinkage or differential movement
- using the correct fastener
- use of corrosive resistant metals.

Shrinkage Restraint

Shrinkage restraint at joints needs to be considered, particularly where unseasoned timber is used. Where shrinkage restraint occurs, stresses perpendicular to grain may be induced that can cause splitting and subsequent moisture ingress or loss of structural integrity. To avoid shrinkage restraint, the following should be considered:

- minimise moisture content changes – finishes + end grain sealant
- align fasteners along member axis
- use single fasteners
- use connections that allow some movement
- use seasoned timber
- drill holes 10% oversize in unseasoned timber.



Good handrail detail – sloped end grain and sloped bracket to take handrail that will be fixed from underside.

Figure 6.6: Good detailing.

Allow for Shrinkage/Movement

Allowance may also need to be made for shrinkage and differential movement at connections and in construction. Failure to do so may lead to a breakdown of the building envelope, allowing ingress of moisture. Measures than can be taken to avoid this include:

- If unseasoned timber is used (e.g. floor joists), specify species with similar shrinkage values.
- Where timber is mixed with steel and/or concrete construction, (e.g. bearers or beams supporting buildings), use seasoned timber to avoid differential movement.
- Allowing for vertical movement in unseasoned framing by leaving adequate clearance to the top of masonry veneer.
- Allowing adequate clearance at the top of unseasoned members faced fixed to members that will not shrink.

Moisture Traps

Moisture traps should also be avoided particularly where connections and joints are exposed to the weather. In addition, in exposed situations, horizontal contact areas between members should be kept to a minimum and where possible, all joints should be free draining. If necessary, drainage holes should be included in the joint detail. Timber enclosed in sockets or "shoes" exposed to the weather should be avoided.

Fastener Selection

Fastener selection is also important when detailing joints for durability. In external applications in particular, where moisture content and temperature variations will induce timber movement, fasteners should be selected to provide restraint against shrinkage and swelling and to minimise loosening of joints due to vibration or impact loads, etc.

To highlight this, the following joints can be considered:

- cladding to framing
- heavy decking to joists.

In the cladding to framing example, if the cladding is left unprotected (i.e. not painted), cyclic moisture changes will induce constant shrinkage and swelling that will induce tension into the connector (usually a nail). The connector therefore has to be designed to resist these forces and it has been found from practical experience that:

- bullet head, plain shank nails are satisfactory for hardwood cladding where cladding is painted and nails are punched and stopped
- plain shank, flat head nails (greater resistance to 'pull through') are satisfactory for painted softwood cladding
- galvanised, deformed shank (ring or annular) flat head nails are required for unpainted preservative treated softwood cladding fixed to pine framing
- 'T' head machine driven nails are unsatisfactory (pull through and withdrawal) for use with unpainted cladding (or decking).

Plain shank decking nails in pine have 'worked out' with cyclic wetting and drying.

Incorrect use of non-galvanised 'T' head nails in decking.

In the second example of **heavy decking** (38 – 75 mm thick) to joists, movement due to seasonal moisture changes and traffic vibration, etc, can cause local crushing under decking spikes and withdrawal of spikes. To overcome this, fasteners with larger diameter heads and greater holding power provide more positive fixing, e.g. coach screws with washers, Type 17 self-drilling countersunk screws (for up to 50 mm thick decking) and where necessary, coach bolts (these can be re-tightened during programmed maintenance).

Bituminous DPC fixed to top of deck joists.

Deck screws should have been staggered to prevent splitting of joists.

No splitting of joists where deck screws were staggered.

6.3 Type of Member and Glue

The type of member selected for a particular application can also be a deciding factor in the durability of structures. For example, glued-laminated timber or sheet products exposed to the weather will, (when left unpainted or, finished with products that allow moisture ingress resulting in shrinkage/swelling), check along lines adjacent to the glue-lines. This is in sharp contrast to solid timber where seasoning checks tend to occur randomly. The consequences are that major moisture traps and lines of shear strength weakness can occur.

The successful use of glued timber products (engineered wood products) exposed to the weather is therefore dependent upon using durable timber and excluding moisture. This can best be achieved by either using architectural detailing (a roof) or by naturally durable or preservative treated glued timber products treated after gluing that are painted or finished and regularly maintained with a moisture excluding envelope.

The durability of glue must also be considered.

Beams built up by mechanical means (nail laminated and nail plated) also require consideration with regard to durability. Joins in these beams provide a potential moisture trap where used exposed to the weather. In addition, the plate joined beams may need special consideration where a corrosive environment exists. In weather-exposed applications, Z275 galvanised coatings are not recommended or suitable for long-term durability.

Generally, nail plated timber products are not recommended for use in weather exposed applications as the plates work loose with cyclic wetting and drying.

6.4 Timber Grade and Size

Australian Standard grading rules usually provide a suitable range of grades that can be selected from for specific applications. For example:

- For hardwood milled products, select – medium feature, standard and high feature grades are described in AS 2796 and for softwoods, AS 4785.2 provides various grades depending upon species.
- For stress graded timber, Structural Grades No. 1 to 5 are available with additional appearance grades optional. Refer to AS 2082 and AS 2858.

With regard to weather exposed applications, the general structural grades may not provide for, or limit defects that can have a bearing on durability. Additional requirements that may need to be considered with regard to durability are untreated sapwood, sapwood orientation (i.e. it should be placed to the outside of joints or exposed to higher levels of ventilation), open defects, loose knots, voids and splits, etc. Additional considerations are required to be specified for commercial decking. For example:

- limiting open defects on the top surface
- laying decking with the 'heart side' down.

The size and proportions of the cross-section of members should be considered when detailing for durability. This is particularly so for unseasoned timber where shrinkage and movement due to moisture changes plays an important part.

Consideration should be given to the following:

- Members with breadth to depth ratios not exceeding about 3:1 are less prone to cupping, i.e. decking exposed to the weather.
- Narrower board products expand/contract less than wider boards, i.e. smaller gaps in flooring result where narrower boards are used also, less stress is induced in fixings where shrinkage occurs.
- Stockier members are usually less prone to the effects of bowing and slender members are usually less prone to the effects of spring.
- Thinner members dry out quickly.

6.5 Moisture Content

Timber properties are greatly affected by the level of moisture content in the material.

Seasoned timber kept dry (MC $< 20\%$) will not decay and similarly, fully immersed timber, where oxygen is excluded, will not decay. In addition, fewer insect pests attack seasoned timber.

Seasoned timber also offers the following advantages with respect to durability:

- more dimensionally stable
- easier to treat, paint and can be glued and
- more resistant to the transmission of heat and electricity.

6.6 Maintenance

Unless designed and specified for very specific purposes or for a short life span, all structures require maintenance. This is particularly so for a building or structure's external envelope, or other weather exposed applications.

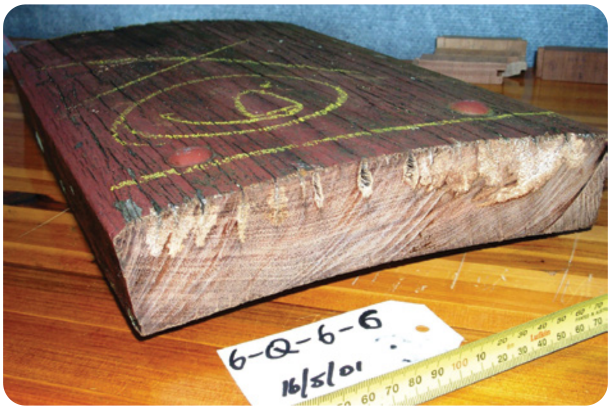
The purpose of maintenance is to ensure that the original condition of a material will remain intact so that it can continue to effectively perform its intended function be it functional or for aesthetic reasons..

Maintenance must therefore be considered at the design stage as the level and intensity of maintenance is a function of original design and materials specification. This is where initial costs must be weighed up against future maintenance or repair costs.

Table 6.2 provides general guidance on the selection and scheduling of a number of maintenance procedures for timber structures.

Public boardwalk in process of maintenance with decking oil.

Poor maintenance of stair tread.



Section of stair tread showing poor maintenance has led to premature decay.

Table 6.2: Selection and scheduling of maintenance.

Item	Suggested Maintenance and Inspection Periods	Remarks
i) Finishes **– external** **- internal**	Refer to Table 6.1 As required but approximately every 10-15 years.	
ii) Building Envelope - cladding, roofing, weatherproofing	Varies depending upon initial quality of materials, however, ten year inspections would be warranted for most products.	These can be designed for specific lives from 5 years to 100+ years.
iii) Termite Protection **- Mechanical Barriers** **- Chemical Barriers**	Approximately 10 years. Replenish at intervals in accordance with manufacturers registration labels.	Refer to AS 3660.1
iv) Ventilation - **- subfloor, wall and roof**	Ensure vents remain unblocked. Clean where necessary – 10 years.	Vents are often covered over during new work. This must be avoided or new vents installed.
v) Vapour Barriers	Check integrity of vapour barriers in roofs, under floors, approximately at 15 year intervals.	
vi) Metal Fasteners **- Corrosion** **- Integrity**	Varies depending upon initial quality of materials and presence of hazards. If unseasoned timber is used, re-tighten bolts, screws, etc, after 6 months and 12 months. If nails become loose, re-punch or re-nail where necessary.	If corrosion present, repair or replace immediately to prevent further ingress of moisture/dirt. Use of hot-dipped galvanised fasteners overcomes many fixing problems. Use stainless steel in marine environments.
vii) Plumbing	Repair or replace leaking or defective plumbing immediately and re-establish finish (inspection cycles determined by above).	Presence of moisture increases possibility of decay and termite attack.
viii) Decay	If noticed, repair or replace defective material immediately and re-establish finish (inspection cycles determined by above).	
ix) Supplementary preservatives, end grain sealants and end grain plating	Require inspection and/or maintenance about 3-5 year intervals, depending upon type and application.	These are usually used in heavy engineering applications, such as wharves, bridges and posts in ground.
x) Cleaning	Clean surfaces as required. Use of blowers rather than hosing down is far better, particularly for decks.	Build up of dirt, etc, on timber surfaces will increase potential for decay via moisture traps, etc.

6.7 Fire

Refer to the NCC-BCA and Australian Standard AS 1720, Part 4 and also woodsolutions.com.au

6.8 Chemical

Timber is resistant to mild acids, however, strong acids (pH less than 2) and strong alkalis (pH greater than 10) can cause degradation of the chemical components of timber. The degree of degradation is dependent upon many factors including species of timber (softwoods are more resistant to attack by acids and alkalis than hardwoods), type of chemical (oxidising acids are worse than non-oxidising) and exposure conditions.

Examples of timber applications where timber's resistance to chemical attack is of great benefit include:

- enclosed swimming pool structures
- tanneries
- chemical storage buildings such as fertiliser sheds
- wastewater treatment works
- piles in acidic soils (peaty conditions)
- water reservoir roof structures.

As many variables are involved in adverse chemical environments, industry and recognised research sources should be consulted for specific advice.

7 Insect Attack

Timber structures are best protected from damage by insects by consideration given to correct design and construction procedures and accurate specification, including species selection and where necessary, preservative treatment. The main insects that may cause damage to structures or contents are:

- **termites**
- **lyctus beetles**
- **furniture beetles (a low risk in Australia).**

7.1 Termites

Termites that attack timber can be classified into two types, subterranean and dry wood. Subterranean termites pose by far the most significant economic risk to structures in Australia, but it should be kept in mind that adoption of simple and cost effective procedures can greatly reduce the risk of termite attack and subsequent damage.

7.1.1 Subterranean Termites

The best protection in areas where subterranean termites are prevalent is to provide simple and inexpensive measures during construction, to eliminate moisture traps and to provide proper ventilation to enable drying out of timber. Adopting the following good practices will assist:

- eliminate/minimise cracks in concrete foundations. Install slabs and footings to AS 2870 with concrete vibrated or compacted.
- ensure building sites and under buildings are clear of debris, trees and organic matter.
- do not landscape (gardens, planters, etc) against building or foundations or in contact with timber.
- include ant caps (termite shields) in accordance with AS 3660.1
- minimise untreated timber in contact with the soil. Ensure crawl spaces have adequate clearance for inspection and ventilation.

In addition to proper design and construction, in areas where subterranean termites present a higher hazard, chemical treatment of the soil or installation of additional physical barriers should be applied in accordance with AS 3660.1. Additional protection for structural elements can also be achieved by the use of either naturally termite resistant or chemically treated timber or both.

7.1.2 Limiting the risk of termite damage

This following specifies the level of termite control recommended for limiting the risk of termite damage to new houses and other buildings. The equations used for these estimates are given in Report number 8 referred to in the Preface.

The specifications given have been chosen so that the theoretical risk of attack on all Australian houses is the same, for a great range of conditions of location, house type and termite management measures. The requirements have been computed by use of a model calibrated with quantitative estimates given by a very small number of experts and a termite tally of some 5000 houses. The model has been applied to determine the level of inspection required so that the theoretical risk of attack by termites within the first 50 years is 20%. This level is probably slightly better than the level of apparent risk that is currently accepted in Australia. Similar specifications can be developed for reduced levels of risk. The specifications are indicative only. For development of a model that can be used with confidence, further expert opinion and field data are necessary.

To apply this section, it is first necessary to evaluate the hazard scores of various parameters influencing termite hazard (Figure 7.1 and Tables 7.1 to 7.7 and Appendix 2). These scores are then totalled (Table 7.8). Finally the hazard score totals are used to assess the acceptance of termite control procedures according to the rules given in Table 7.9.

To illustrate the application of this procedure, some example Hazard Scores have been highlighted in the Tables and commentary provided under Table 7.9.

In the following, the term 'risk' is used to indicate the probability that a house is attacked by termites. Factors that affect this risk are termed 'hazards'.

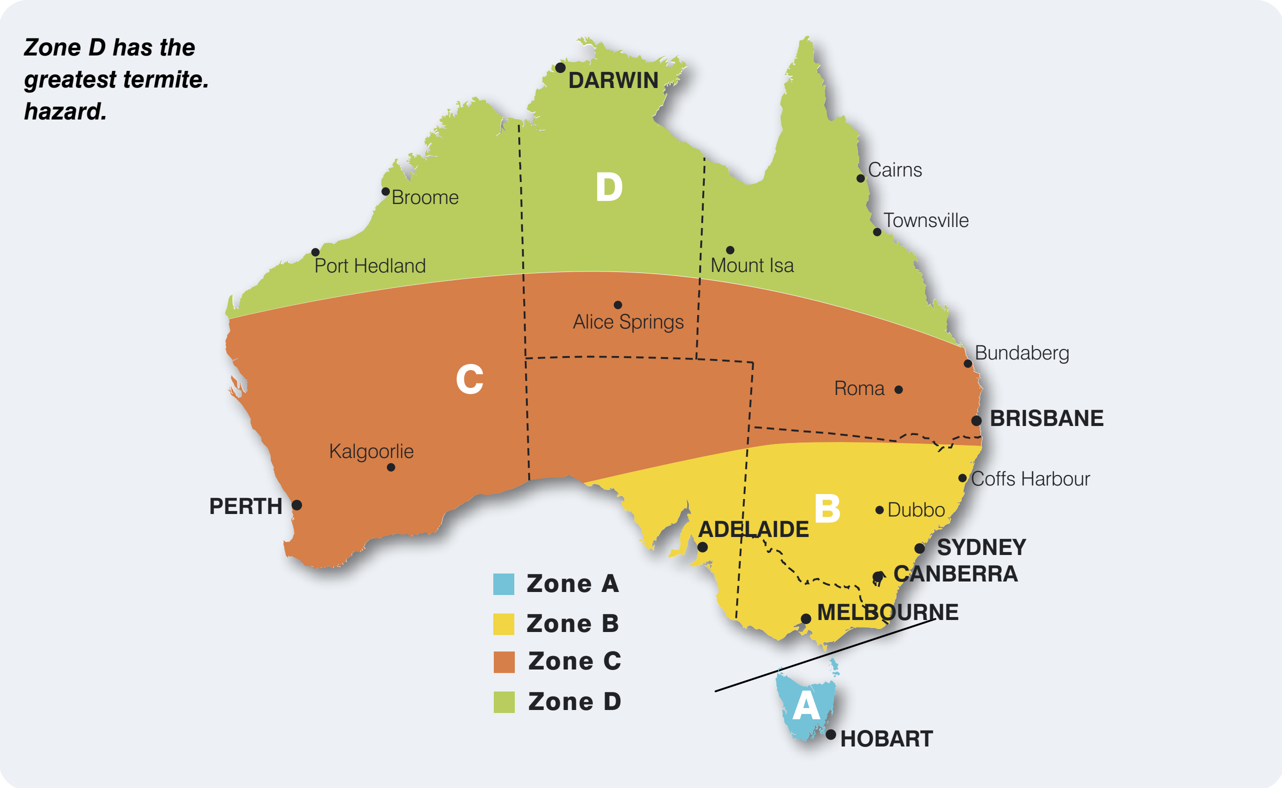


Figure 7.1: Termite hazard zones for Australia.

Table 7.1: Hazard score for location zone.

Location Zone	Hazard score
B	0
C	2
D	4

Note: See Figure 7.1. Recommendations for Zone A are given after Table 7.9.

Table 7.2: Hazard score for age of suburb.

Age of suburb	Hazard score
<10 yrs	0
10-70 yrs	2
>70 yrs	4

Note: Suburb refers to areas within which at least 20% of the land is covered by buildings.

Table 7.3: Hazard score for distance to nearest boundary fence, established housing or bush land.

Distance to nearest built-up suburb	Hazard score
>8 m	0
2—8 m	0.5
<2 m	1.0

Table 7.4: Hazard score for food sources for termites.

Hazard related to substantial food sources*	Hazard score
low	0
medium	0.5
high	1.0

Note: See Table A.2.1 in Appendix 2.

Table 7.5: Hazard score for contact of house with ground.

Hazard related to ground contact*	Hazard score
low	0
medium	1
high	2

Note: See Table A.2.2 in Appendix 2.

Table 7.6: Hazard score for type of construction material.

Hazard related to type of construction materials*	Hazard score
low	0
medium	1
high	2

Note: See Table A.2.3 in Appendix 2.

Table 7.7: Hazard score for environment favourable to termites.

Hazard related to favourable environmental conditions*	Hazard score
low	0
medium	1
high	2

Note: See Table A.2.4 in Appendix 2.

Table 7.8: Evaluation of hazard score total.

Hazard factor	Hazard score
Location zone	**0**
Age of suburb	**2.0**
Distance to built-up suburbs	**0.5**
Food sources	**0.5**
Ground contact	**0**
Construction material	**1.0**
Environmental conditions	**0**
Hazard score total = 4.0	

For the example given above (highlighted in yellow), a Total Hazard Score of 4 was obtained. The highlighted areas of Table 7.9 show the termite strategies that, if adopted, will provide at least the apparent risk of attack than is currently considered acceptable in Australia.

Table 7.9: Specification of termite management requirements.

Barrier type(1)	Period between inspections (yrs)(2)	Period between treatments (yrs)(3)	Maximum acceptable hazard score total
Graded crushed stone	<1	-	9.5
	1-5	-	7.5
	>5	-	3.5
Stainless steel mesh	<1	-	10.0
	1-5	-	8.0
	>5	-	4.0
Toxic chemical	<1	T_m	no limit
		$2T_m$	no limit
		$>8T_m$	10.5
	1-5	T_m	13.5
		$2T_m$	10.5
		$>8T_m$	7.5
	>5	T_m	6.5
		$2T_m$	5.0
		$>8T_m$	4.0
Repellant chemical	<1	T_m	14.0
		$2T_m$	11.0
		$>8T_m$	8.5
	1-5	T_m	9.5
		$2T_m$	8.0
		$>8T_m$	6.5
	>5	T_m	5.0
		$2T_m$	4.0
		$>8T_m$	3.5
No barrier(4)	<1	-	5.5
	1-5	-	4.0
	>5	-	2.5

Notes:

1. For barriers placed and maintained according to AS 3660.1.

2. For inspections carried out in according to AS 3660.2.

3. T_m denotes the period between re-treatments as recommended by the chemical manufacturer.

4. The term 'no barrier' denotes the absence of a house perimeter barrier, such as that provided by graded crushed stone, stainless mesh or chemicals.

7.1.2 Drywood Termites

Drywood termites do not require contact with the ground and as there is little external evidence of infestation, they are difficult to detect. Their presence is widespread throughout the Pacific region, however, in Australia, at present, preventative measures against drywood termites is only considered warranted in the coastal lowlands north of Cooktown, QLD and tropical regions further north. For West Indian termites (a notifiable pest in QLD) found in isolated pockets in coastal Queensland, the Queensland Government conduct a 'containment' program using fumigation treatment of structures.

Protection for drywood termites is most economically provided by the use of termite resistant species (cypress, ironbark and other t species – Refer AS 5604) and/or by preservative treatment of the timber, particularly pine, to H2 level.

7.2 Powder Post Beetle (Lyctus)

In Queensland and New South Wales, State legislation (Timber Users Marketing acts), prohibits the sale of lyctus susceptible sapwood. In other states, Australian Standards grade descriptions usually limit the amount of lyctus susceptible sapwood permitted for most products. If protection from lyctus is required, then this can be achieved by using timber species that are not lyctus susceptible, by eliminating susceptible sapwood or by preservative treatment of sapwood.

7.3 Furniture Beetles

As protection is afforded by climate (cold and temperate regions not affected) and by surface films, enclosure in a structure, and by elevated temperatures (i.e. unsarked roof cavities), these insects are not of great concern. If protection is required for highly critical members, then preservative treatment should be considered for the species that are susceptible.

Termite damage to non-resistant timber.

8 Corrosion of Fasteners

The interaction of moisture and chemicals on metals can cause a breakdown of the fibres around the metal fasteners. Where moisture is present, this breakdown can lead to additional moisture traps and loosening of joints with a propensity for decay. To avoid this problem, metal fasteners should be detailed and specified using material with the required resistance to corrosion, appropriate to the life of the structure. Table 8.1 provides a general guide for the selection of appropriate levels of corrosion resistance.

Table 8.1: Selecting corrosive resistant fasteners.

Material	Applications	Remarks
Stainless Steel 304	Chemical, Industrial & Marine including within 1800 mm of swimming pools	Grade 316 is preferred for marine environments. Additional protection via coatings should be applied to grade 304.
Monel	Marine	Usually used in boat building, nails/screws available.
Silicon Bronze, Copper, Brass	Marine	Usually used in boat building, nails and screws available. Do not bring in contact with aluminum. Nails also available for acidic species, i.e. western red cedar cladding.
Hot Dipped Galvanised & Mechanically Plated	External exposed to weather and low corrosivity. Industrial and marine environments. Note: Z275 coatings not suitable for long term weather exposed applications	Where in contact with moist CCA treated timber, additional protection using plastic sheaths or bituminous or epoxy coatings are suggested for bolts. Other protective coatings can be applied to other types of connectors.
Plated (Zinc, Cadmium) and Gold Passified.	Internal exposed to view or protected from the weather and corrosive environments.	Care required with handling and installation to avoid damage of the protective coating.
Mild Steel	Fully protected from the weather, moisture or corrosive gases.	Use zinc dust paint systems to provide a base for conventional paints.

Note: Life expectancy of zinc coatings is determined primarily by the weight or thickness of the zinc. As a minimum, hot dipped galvanised fasteners should have a coating thickness of 42 microns.

Corrosion of metal fasteners needs to be considered in terms of the type of exposure of the fastener. Most timber connections and fasteners have an 'exposed' portion (exposed to atmosphere) and an 'embedded' portion (embedded in the timber).

Corrosion of the embedded portion of the fastener will be dictated by moisture content of the timber, the timbers natural 'pH', availability of oxygen and any electrolytic action that may be facilitated via other influences such as preservative treatment of the timber, such as CCA treatment, (copper vs zinc). The natural pH of many species of timbers are given in Table 8.2.

Corrosion of the 'exposed' portion of the fastener will be dictated by all of the above factors, but will also be influenced by air-borne contaminants such as salt deposition and in industrial areas, other chemicals.

Most timbers are slightly acidic (pH 3.5 to 5.5 with species such as western red cedar and kapur being at the low end) therefore when moisture is present and the metals in contact with the timber have a low resistance to corrosion (unprotected steel) chemical reactions are set up that cause a strength loss in the surrounding timber (dark staining around steel fasteners).

To prevent deterioration of timber around metal (particularly fasteners) where moisture is present, the following can be employed:

- Use non-corrosive or protected metals. (i.e. galvanised, coated, stainless steel or monel metals)
- Countersink and plug or 'stop' fasteners.
- Avoid the use of dissimilar metals in contact with each other (copper as in CCA and ACQ, etc, with zinc).
- Grease, coat or sheath fasteners in contact with CCA treated timber, i.e. shrink wrap with prophylatics or coat with bituminous or epoxy paints.

Information for estimating the service life of fasteners with respect to embedded corrosion is given in Sections 8.1 below. Information for estimating the service life of fasteners subjected to atmospheric corrosion is given in Section 8.2. For the case of bolts a special procedure combining embedded corrosion and enhanced atmospheric corrosion needs to be considered and this is given in Section 8.3. The enhanced atmospheric corrosion occurs due to the accumulation of rainwater and airborne chemicals within loose fitting bolt holes.

8.1 Embedded Corrosion – Nails, Screws, and Teeth of Nail Plates

8.1.1 Estimate of Service Life

The estimated service lives given in this Section are based on a corrosion model developed for the FWPA project. The equations used for these estimates are given in Report number 8 referred to in the Preface.

The model is based on relatively short-term laboratory and field experiments. The model used requires further field calibrations for two aspects. First, the extrapolation from short term to long term needs to be verified. Second, the model relies on an estimate of the moisture content of the timber, and the procedure used for this requires a check to be made on a larger number and variety of houses and other structures than has been done.

The houses examined for this study comprised a set of typical single-storey houses. Most of the houses were of brick veneer wall construction, including walls both with and without sarking. There was moderate air leakage into and out of these wall systems. Both tiled and sheet metal roofs were to be found among these houses. All metal roofs and some of the tiled roofs were sarked. Many of the houses contained sub-floors; these sub-floor areas were ventilated either by gratings or by weep holes. The above comprises quite a range of housing types, and accordingly the model used to assess the building environment is based on a composite of these various housing types. In addition, averaged values are used for features that influence the local climate such as the prevailing wind, vegetation, elevation, shielding from other buildings, etc. Hence, the model can, at best, be described as providing an example of an environment that is not unusual in Australian housing. If predictions for specific houses are required, then more elaborate models must be used, however the available field data is not adequate to calibrate such models.

Figure 8.1 shows some typical installations of fasteners embedded in wood subjected to corrosion. The typical service life, either in bending or in tension, given in Table 8.4 is taken as the mean estimate of the time taken for the embedded part of the steel fastener to lose 30% of its initial strength.

For fasteners embedded in untreated timber, the following procedure is used to derive an estimate of the design life:

- From Table 8.2 determine the acidity class of timber
- From Figure 8.2 determine the Zone of application
- From Tables 8.3 determine the Hazard Score
- From Table 8.4 determine the Hazard Rating
- Using the Hazard Rating determine the structural service life from Table 8.5 for the embedded metal fasteners.

The contribution of a zinc coating (alone) to the service life of a fastener embedded in untreated timber is given in Table 8.6.

For fasteners embedded in CCA-treated timber, the following procedure is used to derive an estimate of the design life:

- From Table 8.2 determine the acidity class of timber
- From Figure 8.2 determine the Zone of application
- From Tables 8.3 determine the Hazard Score
- From Table 8.7 determine the Hazard Rating
- Using the Hazard Rating determine the structural service life from Table 8.8 for the embedded metal fasteners.

The contribution of a zinc coating (alone) to the structural service life of a fastener embedded in CCA-treated timber is given in Table 8.9.

Note: In the following section, reference is made only to CCA treated timber. For ACQ and Copper Azole treated timber, however, the effects of these treatments on the corrosion rates of zinc coated fasteners has been found to be significantly greater than CCA, with some research indicating rates greater than twice that of CCA.

Figure 8.1: Typical installation of fasteners embedded in wood subjected to corrosion.
(Red marks denote where corrosion is considered.)

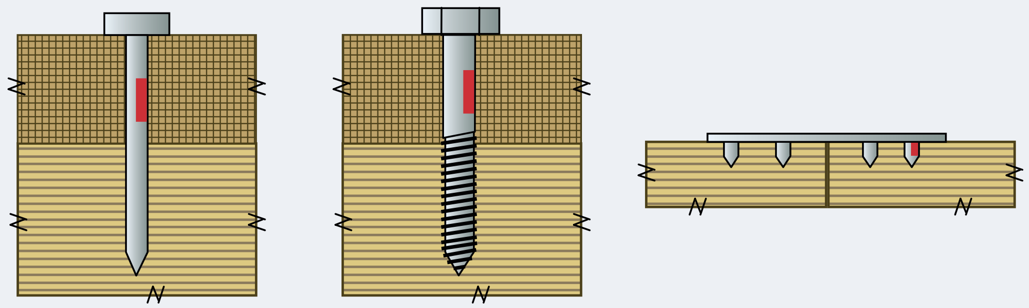


Table 8.2: Acidity pH value of commonly used timber and acidity classification.

Trade name	Botanical name	Acidity class	Measured pH[(1)]
Ash, alpine	*Eucalyptus delegatensis*	3	3.6
Ash, Crows	*Flindersia australis*	1	5.1
Ash, mountain	*Eucalyptus regnans*	2	4.7
Ash, silvertop	*Eucalyptus sieberi*	3	3.5
Balau (selangan batu)	*Shorea* spp.	2	-
Bangkirai	*Shorea laevis*	2	-
Beech, myrtle	*Nothofagus cunninghamii*	2	-
Belian (ulin)	*Eusideroxylon zwageri*	2	-
Blackbutt	*Eucalyptus pilularis*	3	3.6
Blackbutt, New England	*Eucalyptus andrewsii*	3	-
Blackbutt, WA	*Eucalyptus patens*	3	-
Blackwood	*Acacia melanoxylon*	2	-
Bloodwood, red	*Corymbia gummifera*	3	3.6
Bloodwood, white	*Corymbia trachyphloia*	3	-
Bollywood	*Litsea reticulata*	3	3.9
Box, brush	*Lophostemon confertus*	2	4.5
Box, grey	*Eucalyptus moluccana*	3	3.5
Box, grey, coast	*Eucalyptus bosistoana*	3	3.4
Box, long leaved	*Eucalyptus goniocalyx*	3	-
Box, red	*Eucalyptus polyanthemos*	3	-
Box, steel	*Eucalyptus rummeryi*	3	-
Box, swamp	*Lophostemon suaveolens*	2	-
Box, yellow	*Eucalyptus melliodora*	3	-
Box,white	*Eucalyptus albens*	3	-
Brigalow	*Acacia harpophylla*	2	-
Brownbarrel	*Eucalyptus fastigata*	3	3.3
Bullich	*Eucalyptus megacarpa*	3	-
Calantas (kalantas)	*Toona calantas*	2	-
Candlebark	*Eucalyptus rubida*	3	-
Cedar, red, western	*Thuja plicata*	3	3.3
Cypress	*Callitris glaucophylla*	1	5.4
Fir, Douglas (Oregon)	*Pseudotsuga menziesii*	3	3.5
Gum, blue, southern	*Eucalyptus globulus*	3	-
Gum, blue, Sydney	*Eucalyptus saligna*	3	3.6

Table 8.2** (continued)**: Acidity pH value of commonly used timber and acidity classification.

Trade name	Botanical name	Acidity class	Measured pH(1)
Gum, grey	*Eucalyptus propinqua*	3	3.8
Gum, grey, mountain	*Eucalyptus cypellocarpa*	3	3.6
Gum, maiden's	*Eucalyptus maidenii*	3	-
Gum, manna	*Eucalyptus viminalis*	3	-
Gum, mountain	*Eucalyptus dalrympleana*	3	-
Gum, red, forest	*Eucalyptus tereticornis*	2	4.2
Gum, red, river	*Eucalyptus camaldulensis*	3	-
Gum, rose	*Eucalyptus grandis*	1	5.1
Gum, salmon	*Eucalyptus salmonophloia*	3	-
Gum, scribbly	*Eucalyptus haemastoma*	3	-
Gum, shining	*Eucalyptus nitens*	3	-
Gum, spotted	*Corymbia maculata,* incl. *Corymbia citriodora*	2	4.5
Gum, sugar	*Eucalyptus cladocalyx*	3	-
Gum, yellow	*Eucalyptus leucoxylon*	3	-
Hardwood, Johnstone River	*Backhousia bancroftii*	2	-
Hemlock, western	*Tsuga heterophylla*	2	4.9
Ironbark, grey	*Eucalyptus paniculata*	3	4.0
Ironbark, red	*Eucalyptus sideroxylon*	3	-
Ironbark, red (broad-leaved)	*Eucalyptus fibrosa*	3	-
Ironbark, red (narrow-leaved)	*Eucalyptus crebra*	3	4.0
Ironwood Cooktown	*Erythrophloeum chlorostachys*	2	-
Jam, raspberry	*Acacia acuminata*	2	-
Jarrah	*Eucalyptus marginata*	3	3.3
Kapur	*Dryobalanops* spp.	3	3.3
Karri	*Eucalyptus diversicolor*	2	4.2
Keruing	*Dipterocarpus* spp.	1	5.1
Kwila (merbau)	*Intsia bijuga*	2	-
Mahogany, Philippine, red, dark	*Shorea* spp.	2	-
Mahogany, Philippine, red, light	*Shorea, Pentacme, Parashorea* spp.	2	-
Mahogany, red	*Eucalyptus resinifera*	3	3.0
Mahogany, white	*Eucalyptus acmenoides*	3	3.5
Mahogany, white	*Eucalyptus umbra*	3	-
Mahonany, southern	*Eucalyptus botryoides*	3	-
Mallet, brown	*Eucalyptus astringens*	3	-
Marri	*Eucalyptus calophylla*	3	
Meranti, red, dark	*Shorea* spp.	3	3.9
Meranti, red, light	*Shorea* spp.	2	5.0
Mersawa	*Anisoptera* spp.	2	4.5
Messmate	*Eucalyptus obliqua*	3	3.2
Messmate, Gympie	*Eucalyptus cloeziana*	3	-
Oak, bull	*Allocasuarina luehmannii*	2	-
Oak, white, American	*Quercus alba*	2	-
Peppermint, black	*Eucalyptus amygdalina*	3	-
Peppermint, broad leaved	*Eucalyptus dives*	3	-
Peppermint, narrow leaved	*Eucalyptus radiata*	3	3.2
Peppermint, river	*Eucalyptus elata*	3	-
Pine, black	*Prumnopitys amara*	2	-

Table 8.2** (continued)**: Acidity pH value of commonly used timber and acidity classification.

Trade name	Botanical name	Acidity class	Measured pH[1]
Pine, caribbean	*Pinus caribaea*	3	3.9
Pine, celery-top	*Phyllocladus aspleniifolius*	2	-
Pine, hoop	*Araucaria cunninghamii*	1	5.2
Pine, Huon	*Lagarostrobos franklinii*	2	4.6
Pine, kauri	*Agathis robusta*	2	-
Pine, King William	*Athrotaxis selaginoides*	2	-
Pine, radiata	*Pinus radiata*	2	4.8
Pine, slash	*Pinus elliotii*	2	-
Ramin	*Gonystylus* spp.	1	5.2
Redwood	*Sequoia sempervirens*	2	-
Rosewood, New Guinea	*Pterocarpus indicus*	2	-
Satinay	*Syncarpia hillii*	2	-
Stringybark, Blackdown	*Eucalyptus sphaerocarpa*	3	-
Stringybark, brown	*Eucalyptus capitellata*	3	-
Stringybark, red	*Eucalyptus macrorhyncha*	3	-
Stringybark, white	*Eucalyptus eugenioides*	3	-
Stringybark, yellow	*Eucalyptus muelleriana*	3	4
Tallowwood	*Eucalyptus microcorys*	3	3.5
Taun	*Pometia* spp.	2	-
Teak, Burmese	*Tectona grandis*	2	4.5
Tingle, red	*Eucalyptus jacksonii*	3	-
Tingle, yellow	*Eucalyptus guilfoylei*	3	-
Tuart	*Eucalyptus gomphocephala*	3	-
Turpentine	*Syncarpia glomulifera*	3	3.5
Wandoo	*Eucalyptus wandoo*	3	-
Woolybutt	*Eucalyptus longifolia*	3	-
Yate	*Eucalyptus cornuta*	3	-
Yertchuk	*Eucalyptus consideniana*	3	-

Note:
1. The natural pH for additional species can be found in "Manual No. 6: Embedded corrosion of fasteners in exposed timber structures" by Nguyen, M.N., Leicester, R.H. and Wang, C-H.

Figure 8.2: Hazard zone for embedded corrosion.

Table 8.3: Hazard scores for untreated and CCA-treated timber.

Microclimates[1]	**Hazard scores for various microclimates**					
	Zone A(2)		**Zone B(2)**		**Zone C(2)**	
	Marine(3)	**Other**	**Marine**	**Other**	**Marine**	**Other**
Subfloor(7)	14	12	16	14	18	16
Wall cavity(7)	12	12	14	14	16	16
Roof space(7)	11	9	13	11	15	13
Outdoor						
Sheltered/partly sheltered(4)	19	12	23	16	26	19
Exposed vertical surface(5)	21	14	27	20	35	28
Exposed horizontal surface(6)	24	17	35	28	49	42

Notes:
1. Enclosed sub-floor spaces have the minimum BCA ventilation requirements. Ventilated wall cavities are those typical of brick veneer and suspended timber floors. Sealed roof spaces are those with a sheet metal roof or sarked tile roof with no or little eaves or roof cavity ventilation.
2. See hazard zone map in Figure 8.2.
3. Climate zone is 'Marine' when distance to coast <1 km.
4. For example: house cladding.
5. For example: fencing.
6. For example: decking.
7. Typical ventilation conditions are assumed for the building envelope.

Table 8.4: Definition of hazard ratings for fasteners embedded in untreated timber.

Hazard score		**Hazard rating**
Hardwoods	**Softwoods**	
<12	<14	$HR_{un}1$
12~19	14~22	$HR_{un}2$
>19	>22	$HR_{un}3$

Note: The Hazard score is defined in Table 8.3.

Table 8.5: Typical service life for fasteners embedded in untreated timber.

Fasteners				Typical service life (yrs)		
Commercial name	**Thickness or diameter of steel (mm)**	**Thickness of zinc coating (μm)**	**Hazard rating**	**Class 1**	**Class 2**	**Class 3**
Nail plate Metal web	0.95	20	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 80	>100 60 35
Nail plate Metal web	2.0	20	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 85
Plain steel nail	2.8	0	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
Galvanised nail	2.8	50	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
Plain steel nail	3.75	0	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
Galvanised nail	3.75	50	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
No. 10 steel screw	3.2	0	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
No. 10 galvanised screw	3.2	40	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
No. 14 steel screw	4.5	0	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100
No. 14 galvanised screw	4.5	40	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 >100

Note: The hazard rating is defined in Table 8.4.

Table 8.6: Typical protection due to zinc coating for fasteners embedded in untreated timber.

Thickness of zinc coating (μm)	Hazard Rating	Typical protection in untreated timber (yrs)		
		Acidity Class 1	Acidity Class 2	Acidity Class 3
10	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 100 25	>100 16 5	>100 5 1
20	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 100	>100 65 20	100 20 7
40	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 80	>100 80 25
50	$HR_{un}1$ $HR_{un}2$ $HR_{un}3$	>100 >100 >100	>100 >100 >100	>100 >100 40

Note: The hazard rating is defined in Table 8.4.

Table 8.7: Definition of hazard ratings for fasteners embedded in CCA-treated timber.

Hazard score	Hazard rating
<12	$HR_{tr}1$
12~17	$HR_{tr}2$
18~23	$HR_{tr}3$
24~30	$HR_{tr}4$
>30	$HR_{tr}5$

Note: The hazard score is defined in Table 8.3.

Table 8.8: Typical service life for fasteners embedded in CCA-treated timber.

Fasteners			Hazard rating	Typical service life (yrs)
Commercial name	**Thickness or diameter of steel (mm)**	**Thickness of zinc coating (μm)**		
Nail plate Metal web	0.95	20	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 25 8 4 3
Nail plate Metal web	2.0	20	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 35 12 6 5
Plain steel nail	2.8	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 25 11 7 5
Galvanised nail	2.8	50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 95 25 15 10
Plain steel nail	3.75	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 30 15 10 7
Galvanised nail	3.75	50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 100 30 17 12
No. 10 steel screw	3.2	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 25 12 8 6
No. 10 galvanised screw	3.2	40	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 70 20 12 8
No. 14 steel screw	4.5	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 35 16 10 8
No. 14 galvanised screw	4.5	40	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 80 25 15 10

Note: The hazard rating is defined in Table 8.7.

Table 8.9: Protection due to zinc coating for fasteners embedded in CCA-treated timber.

Thickness of zinc coating (μm)	Hazard rating	Typical protection (yrs)
10	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 5 0 0 0
20	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 15 3 0 0
40	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 45 10 4 2
50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 70 15 8 5

Note: The hazard rating is defined in Table 8.7.

8.1.2 Other Coatings

No model has yet been developed for the effect of coating systems other than zinc on the performance of embedded fasteners. However a rough estimate could probably be made on the basis of the information in the standard AS/NZS 2312 Guide to the Protection of Iron and Steel against Exterior Atmospheric Corrosion.

8.2 Atmospheric Corrosion – Plates, Webs, Washers

8.2.1 Typical Service Life

The estimated service lives given in this Section are based on a corrosion model developed for the FWPA project. The equations used for these estimates are given in Report 08 referred to in the Preface.

The model is based on short-term laboratory and field experiments. The model used requires further field calibrations for two aspects. First, the extrapolation from short term to long term needs to be verified. Second the model relies on an estimate of airborne salt and moisture within a building envelope and exposed elements; to obtain reliable results the procedure used for this requires a check to be made on a larger number and variety of houses and environments than has been done.

The houses examined for this study comprised a set of typical single-storey houses. Most of the houses were of brick veneer wall construction, including walls both with and without sarking. There was moderate air leakage into and out of these wall systems. Both tiled and sheet metal roofs were to be found among these houses. All metal roofs and some of the tiled roofs were sarked. Many of the houses contained sub-floors; these sub-floor areas were ventilated either by gratings or by weep holes. The above comprises quite a range of housing types, and accordingly the model used to assess the building environment is based on a composite of these various housing types. In addition, averaged values are used for features that influence the local climate such as the prevailing wind, vegetation, elevation, shielding from other buildings, etc. Hence, the model can at best be described as providing an example of an environment that is not unusual in Australian housing. If predictions for specific houses are required, then more elaborate models must be used, and the available field data is not adequate to calibrate such models.

Typical installations of fasteners subjected to atmospheric corrosion are shown in Figure 8.3. The typical service life estimates are taken as the estimate of the mean time taken for metal fasteners to lose 30% of their initial tension strength and for washers 30% of their initial bending strength. A special aspect of the tables is that in computing the design life for connectors nominally located at the coastline, allowance is made for the possibility of airborne salt spray, a very severe hazard situation. Note: Areas within 1800 mm of swimming pool edges are a severe corrosion hazard and should be treated the same as Zone E, subjected to airborne salt spray less than 1 km from coastline.

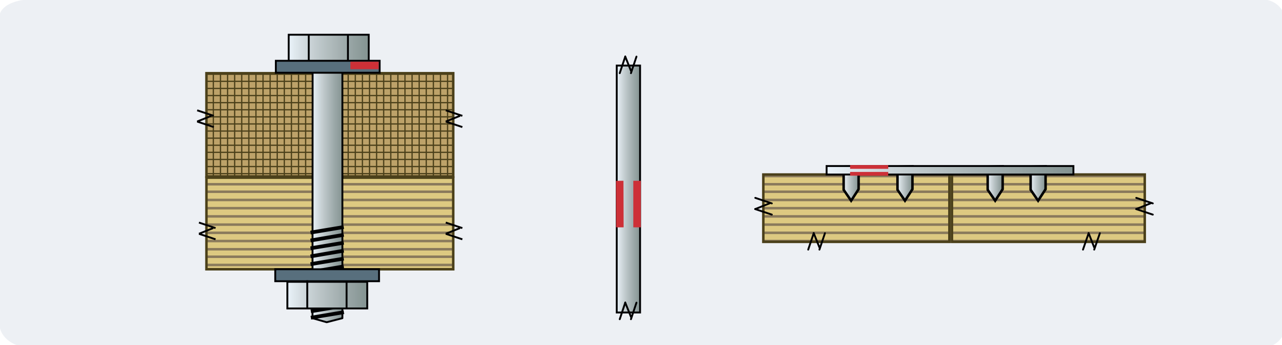


Figure 8.3: Typical fastener installation subjected to atmospheric corrosion.
(Red marks denote where corrosion is considered.)

Figure 8.4: Coastal zones related to corrosion due to airborne salt.

The case of fasteners that are in contact with exposed wood is considered herein. Particularly for the case of CCA treated wood, these represent a particularly corrosive environment as the contact surface is usually subjected to high levels of moisture, salt and oxygen. An example of how the performance of these connectors may be assessed is given for the case of bolted joints in Section 8.3.

The following procedure is used to determine an estimate of the typical service life:

Determine the coastal zone from Figure 8.4

Determine the hazard scores according to the criteria given in Tables 8.10 to 8.14

Once this is done, the scores are added to produce a total hazard score as in Table 8.15. NOTE: An example is highlighted in yellow in Tables 8.11 to 8.15.

A hazard rating can then be derived as defined in Table 8.16

Using these hazard ratings, the structural design life for exposed metal fasteners can be read from Table 8.17.

The contribution of a hot-dipped zinc coating (alone) to the design life of a fastener is given in Table 8.18.

Table 8.10: Hazard score for coastal zone.

Hazard zone	Hazard score
A	3.2
B	3.3
C	3.5
D	4.3
E	4.9

Corrosion of nail plates on deck joists after 6 years exposure near surf beach.

Table 8.11: Hazard score for coastal exposure.

Coastal exposure	Hazard score
Sheltered bay	1.1
Partially closed bay	1.3
Very open bay	1.8
Open surf	2.3

Note: For definition of coastal exposure see Appendix 1.

Corrosion of HDG nails close to pool edge.

Table 8.12: Hazard score for site classification.

Site classification	Hazard score
Open to sea	1.0
Urban (suburb)	0.3
Urban (city centre)	0.0
Other site	0.7

Table 8.13: Hazard score for microclimate.

Microclimate(1)		Hazard score
Wall cavity(2)		0.3
Roof space(2)		0.2
Sub-floor(2)		0.4
Out-door	Sheltered from rain	1.0
	Exposed to rain	0.7

Notes:
1. For information on the building envelope refer to Note 1 in Table 8.2.
2. Typical ventilation conditions are assumed for the building envelope.

Table 8.14: Hazard score for pollution.

Industry type	Hazard score			
	L = 1	L = 5	L = 10	L ≥ 20
Heavy industry (steel works, petrochemical)	3	1	0.5	0.0
Moderate industry (paper mills, large manufacturing)	1	0.5	0	0
Light industry (assembly plants)	0.5	0	0	0
No industry	0.0	0.0	0.0	0.0

Note: L is the distance to the industry (km).

Table 8.15: The total hazard score.

Item	Hazard score
Coastal zone	4.9
Coastal exposure	2.3
Site classification	0.3
Microclimate	1.0
Pollution	0.5
Total hazard score	9.0

Table 8.16: Definition of hazard rating.

Total hazard score	Hazard rating
<6	$HR_{atm}1$
$\leq 6 < 7$	$HR_{atm}2$
$\leq 7 < 8$	$HR_{atm}3$
≥ 8	$HR_{atm}4$

Note: The hazard score is defined in Table 8.15.

Table 8.17: Typical service life.

Fastener			Hazard rating(1)	Typical service life (years)(2)			
Type	**Thickness of steel (mm)**	**Thickness of zinc (μm)**		***L* = 0 (km)**	***L* = 1 (km)**	***L* = 10 (km)**	***L* = 50 (km)**
Plates and webs	1.0	0	HR$_{atm}$1	20	35	40	50
			HR$_{atm}$2	8	20	20	30
			HR$_{atm}$3	nr*	8	10	15
			HR$_{atm}$4	nr*	nr*	5	8
	1.0	20	HR$_{atm}$1	>100	>100	>100	>100
			HR$_{atm}$2	>100	>100	>100	>100
			HR$_{atm}$3	70	>100	>100	>100
			HR$_{atm}$4	15	90	>100	>100
	2.0	0	HR$_{atm}$1	50	80	90	>100
			HR$_{atm}$2	20	45	50	80
			HR$_{atm}$3	7	20	25	40
			HR$_{atm}$4	nr*	8	10	20
	2.0	20	HR$_{atm}$1	>100	>100	>100	>100
			HR$_{atm}$2	>100	>100	>100	>100
			HR$_{atm}$3	70	>100	>100	>100
			HR$_{atm}$4	20	100	>100	>100
	6.0	0	HR$_{atm}$1	>100	>100	>100	>100
			HR$_{atm}$2	80	>100	>100	>100
			HR$_{atm}$3	30	80	>100	>100
			HR$_{atm}$4	9	35	50	80
	6.0	20	HR$_{atm}$1	>100	>100	>100	>100
			HR$_{atm}$2	>100	>100	>100	>100
			HR$_{atm}$3	100	>100	>100	>100
			HR$_{atm}$4	25	>100	>100	>100
Washers	1.6	0	HR$_{atm}$1	40	70	80	>100
			HR$_{atm}$2	15	35	45	70
			HR$_{atm}$3	6	15	20	35
			HR$_{atm}$4	nr*	7	10	15
	1.6	20	HR$_{atm}$1	>100	>100	>100	>100
			HR$_{atm}$2	>100	>100	>100	>100
			HR$_{atm}$3	70	>100	>100	>100
			HR$_{atm}$4	15	100	>100	>100
	2.5	0	HR$_{atm}$1	70	>100	>100	>100
			HR$_{atm}$2	30	60	80	>100
			HR$_{atm}$3	10	30	40	60
			HR$_{atm}$4	nr*	10	20	30
	2.5	20	HR$_{atm}$1	>100	>100	>100	>100
			HR$_{atm}$2	>100	>100	>100	>100
			HR$_{atm}$3	80	>100	>100	>100
			HR$_{atm}$4	20	>100	>100	>100

Notes:
** nr = Not Recommended because service life <5 years.*
1. The hazard rating is defined in Table 8.16.
2. L is the distance to the coast (km).

Table 8.18: Typical protection due to zinc coatings.

Thickness of zinc coating (μm)	Hazard rating(1)	Typical protection (years)(2) L = 0 (km)	L = 1 (km)	L = 10 (km)	L = 50 (km)
10	$HR_{atm}1$	>100	>100	>100	>100
	$HR_{atm}2$	70	>100	>100	>100
	$HR_{atm}3$	20	80	>100	>100
	$HR_{atm}4$	4	30	45	90
20	$HR_{atm}1$	>100	>100	>100	>100
	$HR_{atm}2$	>100	>100	>100	>100
	$HR_{atm}3$	70	>100	>100	>100
	$HR_{atm}4$	15	90	>100	>100
50	$HR_{atm}1$	>100	>100	>100	>100
	$HR_{atm}2$	>100	>100	>100	>100
	$HR_{atm}3$	>100	>100	>100	>100
	$HR_{atm}4$	70	>100	>100	>100

Notes:
1.The hazard rating is defined in Table 8.16.
2. L is the distance to the coast (km).

8.3.2 Other Coatings

The effect of coatings, other than zinc, can be estimated from the recommendations in the standard AS/NZS 2312 (2002) Guide to the Protection of Iron and Steel Against Exterior Atmospheric Corrosion.

8.3 Bolts

The information here is tentative. There has been no corrosion research directed specifically on bolted timber joints, and the field data is either anecdotal or meagre. It is known that bolted joints can form a very special case of embedded fastener, because they are often placed in oversized holes pre-drilled into the timber. The holes allow moisture, salt and oxygen to enter, a situation that does not occur with other embedded fasteners. To provide some sort of indication of the long duration strength of bolted joints, the assumption is made that the worst corrosion occurs near the neck of the bolt and this is either due to the usual embedded corrosion mechanism or due to atmospheric corrosion that is enhanced if the connector is near a beach. Other limitations on the accuracy of the model used here are the same as those given in Sections 8.1 and 8.2. The definition of typical service life, either in bending or in tension, is the mean estimate of the time taken for the embedded part of the bolt fastener to lose 30% of its initial strength.

A typical bolt embedded in wood is shown in Figure 8.5.

The service life controlled by atmospheric corrosion for fasteners in both CCA treated and untreated timber is determined by first evaluating the hazard rating HRatm as indicated in Section 8.2; then the design life is taken from Table 8.19 for bolts in bending, and Table 8.20 for bolts in tension. The contribution of a hot-dipped zinc coating (alone) to the service life of a fastener is given in Table 8.21.

For bolts embedded in CCA-treated timber, an additional check for the effects of embedded corrosion is needed and can be undertaken as follows:

- From Figure 8.2 determine the hazard Zone of application
- From Tables 8.3 determine the Hazard Score
- From Table 8.7 determine the Hazard Rating
- Using the Hazard Rating, determine the typical structural service life of a bolt in bending from Table 8.22 and in tension from Table 8.23.

The contribution of a zinc coating (alone) to the design life of a fastener embedded in CCA-treated timber is given by Table 8.24.

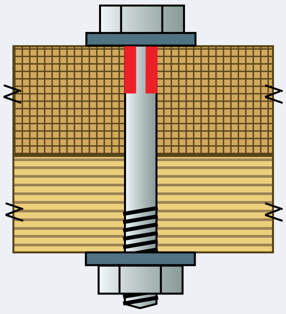


Figure 8.5: A typical bolt embedded in wood. (Red marks denote where corrosion is considered.)

Table 8.19: Typical service life due to atmospheric corrosion for bolts embedded in untreated and CCA treated timber subjected to bending.

Fastener			Hazard rating(1)	Typical service life (years)(2)			
Type	Diameter of steel (mm)	Thickness of zinc (μm)		*L* = 0 (km)	*L* = 1 (km)	*L* = 10 (km)	*L* = 50 (km)
M6 Steel Bolt	5.2	0	$HR_{atm}1$	10	30	90	>100
			$HR_{atm}2$	nr*	15	50	70
			$HR_{atm}3$	nr*	7	25	40
			$HR_{atm}4$	nr*	nr*	10	20
M6 Galvanised Bolt	5.2	30	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	80	>100	>100	>100
			$HR_{atm}3$	25	>100	>100	>100
			$HR_{atm}4$	5	50	>100	>100
M10 Steel Bolt	8.8	0	$HR_{atm}1$	25	60	>100	>100
			$HR_{atm}2$	9	30	100	>100
			$HR_{atm}3$	nr*	15	45	80
			$HR_{atm}4$	nr*	5	25	40
M10 Galvanised Bolt	8.8	50	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	>100	>100	>100	>100
			$HR_{atm}3$	50	>100	>100	>100
			$HR_{atm}4$	10	>100	>100	>100
M16 Steel Bolt	14.5	0	$HR_{atm}1$	45	>100	>100	>100
			$HR_{atm}2$	15	60	>100	>100
			$HR_{atm}3$	6	25	90	>100
			$HR_{atm}4$	nr*	10	45	70
M16 Galvanised Bolt	14.5	50	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	>100	>100	>100	>100
			$HR_{atm}3$	60	>100	>100	>100
			$HR_{atm}4$	15	>100	>100	>100

Notes:

** nr = Not Recommended because service life <5 years.*

1. The hazard rating is defined in Table 8.16.

2. L is the distance to the coast (km).

Table 8.20: Typical service due to atmospheric corrosion for bolts embedded in untreated and CCA treated timber subjected to tension.

Fastener			Hazard rating[1]	Typical service life (years)[2]			
Type	**Diameter of steel (mm)**	**Thickness of zinc (μm)**		***L* = 0 (km)**	***L* = 1 (km)**	***L* = 10 (km)**	***L* = 50 (km)**
M6 Steel Bolt	5.2	0	$HR_{atm}1$	20	45	>100	>100
			$HR_{atm}2$	7	25	80	>100
			$HR_{atm}3$	nr*	10	40	60
			$HR_{atm}4$	nr*	nr*	20	30
M6 Galvanised Bolt	5.2	30	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	80	>100	>100	>100
			$HR_{atm}3$	25	>100	>100	>100
			$HR_{atm}4$	5	50	>100	>100
M10 Steel Bolt	8.8	0	$HR_{atm}1$	40	90	>100	>100
			$HR_{atm}2$	15	45	>100	>100
			$HR_{atm}3$	5	20	80	>100
			$HR_{atm}4$	nr*	9	35	60
M10 Galvanised Bolt	8.8	50	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	>100	>100	>100	>100
			$HR_{atm}3$	60	>100	>100	>100
			$HR_{atm}4$	15	>100	>100	>100
M16 Steel Bolt	14.5	0	$HR_{atm}1$	70	>100	>100	>100
			$HR_{atm}2$	25	90	>100	>100
			$HR_{atm}3$	10	40	>100	>100
			$HR_{atm}4$	nr*	15	70	>100
M16 Galvanised Bolt	14.5	50	$HR_{atm}1$	>100	>100	>100	>100
			$HR_{atm}2$	>100	>100	>100	>100
			$HR_{atm}3$	60	>100	>100	>100
			$HR_{atm}4$	15	>100	>100	>100

Notes:

** nr = Not Recommended because service life <5 years.*

1. The hazard rating is defined in Table 8.16.

2. L is the distance to the coast (km).

Table 8.21: Typical service life related to atmospheric corrosion due to zinc coatings on bolts embedded in untreated and CCA treated timber.

Thickness of zinc coating (μm)	Hazard rating[1]	Typical service life protection (years)[2]			
		***L* = 0 (km)**	***L* = 1 (km)**	***L* = 10 (km)**	***L* = 50 (km)**
30	$HR_{atm}1$	>100	>100	>100	>100
	$HR_{atm}2$	70	>100	>100	>100
	$HR_{atm}3$	20	>100	>100	>100
	$HR_{atm}4$	4	45	>100	>100
50	$HR_{atm}1$	>100	>100	>100	>100
	$HR_{atm}2$	>100	>100	>100	>100
	$HR_{atm}3$	50	>100	>100	>100
	$HR_{atm}4$	10	>100	>100	>100

Notes:

1. The hazard rating is defined in Table 8.16.

2. L is the distance to the coast (km).

Table 8.22: Typical service life due to embedded corrosion for bolts embedded in CCA-treated timber subject to bending.

Fasteners			Hazard rating	Design service life (yrs)
Commercial name	Thickness or diameter of steel (mm)	Thickness of zinc coating (μm)		
M6 Steel Bolt	5.2	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 40 20 12 9
M6 Galvanised Bolt	5.2	30	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 70 25 15 10
M10 Steel Bolt	8.8	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 70 35 20 15
M10 Galvanised Bolt	8.8	50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 50 30 20
M16 Steel Bolt	14.5	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 55 35 25
M16 Galvanised Bolt	14.5	50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 70 40 30

Note: The hazard rating is defined in Table 8.16.

Table 8.23: Typical service life related to embedded corrosion for bolts embedded in CCA-treated timber subject to tension.

Fasteners			Hazard rating	Typical service life (yrs)
Commercial name	**Thickness or diameter of steel (mm)**	**Thickness of zinc coating (μm)**		
M6 Steel Bolt	5.2	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 60 30 17 13
M6 Galvanised Bolt	5.2	30	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 90 35 20 15
M10 Steel Bolt	8.8	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 50 30 25
M10 Galvanised Bolt	8.8	50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 65 40 30
M16 Steel Bolt	14.5	0	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 80 50 40
M16 Galvanised Bolt	14.5	50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 >100 95 60 45

Note: The hazard rating defined in Table 8.16.

Table 8.24: Typical protection from embedded corrosion due to zinc coatings on bolts embedded in CCA-treated timber.

Thickness of zinc coating (μm)	Hazard rating	Protection (yrs)
30	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 30 7 4 2
50	$HR_{tr}1$ $HR_{tr}2$ $HR_{tr}3$ $HR_{tr}4$ $HR_{tr}5$	>100 70 15 8 5

Note: The hazard rating is defined in Table 8.16.

9 Marine Borers

Protection for marine piles or timber in marine contact is best afforded by:

- **using species with high natural resistance such as turpentine, or in cooler southern waters, swamp box, river red gum and white mahogany**
- **using timbers impregnated with chemical preservatives (requires a wide sapwood band) including plantation softwoods and spotted gum**
- **using mechanical barriers and floating collars.**

For a few species which are naturally resistant (either because of high silica content or naturally toxic extractives), the bark if left intact may provide up to 2-5 years additional protection in southern zones.

Species with wide sapwood bands can be effectively treated with preservatives to provide resistance to marine borers. CCA is effective against Limnoria while creosote type preservatives are effective against teredinids although exceptions can occur. Double treatment (CCA followed by creosote) provides service life extended by as much as 45% to 3 times that of single treatments. CCA eucalypts in northern Queensland might last 8 years, creosote treated eucalypts perhaps 20 years while double treatment should last 25-30 years or more. Accordingly a double treatment should be considered when a high marine hazard exists as in tropical waters.

Mechanical barriers also offer excellent protection to marine piles. Mechanical barriers include metallic sheathing, plastic barriers or for more permanent work concrete encasement such as poured concrete collars or piles driven through concrete or fibre cement pipes (high water to mud line). Where piles are encased in pipes, sand is usually placed between the timber and the pipe to provide mechanical support to the pipe and act as an indicator if a hole occurs in the pipe. In zones where Sphaeroma is active, even barriers restricted to the tidal zone can greatly extend the service life.

Care should be taken with all marine piles to ensure that any damaged sapwood, splits, knots or other imperfections are given additional mechanical protection so as to impede attack by borers.

Regular scheduling of inspection and maintenance procedures for all waterfront structures (piles in particular) is imperative to ensure a long serviceable life.

The typical service life for marine piles given in the following tables relate to an estimate of the time taken for borer attack to reduce the cross section of a pile to 200 mm in diameter. This corresponds with the requirements currently used for pile replacement by many authorities.

9.1 Scope and Application

This following provides estimates of the typical service life for timber sections attacked by marine borers. The attack patterns are depicted in Figure 9.2. The design life estimates are based on the assumption that the net pile diameter will be 200 mm at the end of the service life. The estimated service lives given in this Section are based on a model developed for the FWPA project. The equations used for these estimates are given in Report number 8 referred to in the Preface.

It is assumed that:

- Untreated hardwood piles of marine borer resistance Classes 1 and 2 have heartwood diameters of 300 or 400 mm as given in Tables 9.4 to 9.10 (marine piles are not de sapped, and where possible they are installed with bark on), or marine durability classes 1 to 4 of hardwood piles with sapwood treated to H6 level in accordance with AS 1604.1.
- Treated piles, both hardwood and softwood, have the original sapwood retained and the diameters of 300 or 400 mm include both treated sapwood and heartwood timber.
- The minimum thickness of sapwood that is fully treated for treated hardwood piles of marine borer resistance Classes 1 to 4 is 20 mm.
- The minimum thickness of sapwood that is fully treated for treated softwood piles of marine borer resistance Class 4 is 50 mm.
- AS 1604.1 specifies that H6 treatment level with CCA alone or with creosote alone is appropriate only to southern waters, which correspond approximately to the marine hazard zones A to D in Figure 9.1, whereas double-treatment is applicable to all zones.

The following procedure should be used to estimate the typical service life of a marine pile:

- Determine the timber marine borer resistance class from Table 9.1
- Determine the location zone from Figure 9.1
- Determine the salinity class of the seawater from Table 9.2.
- Determine whether the water surrounding piles is calm or surf from Table 9.3.
- The estimated design service lives are given in Tables 9.4 to 9.10 for round piles.

Table 9.1: Timber marine borer resistance classification.

Trade name	Botanical name	Marine borer resistance class
Alder, blush	*Sloanea australis*	4
Alder, brown	*Caldcluvia paniculosa*	4
Alder, pink	*Gillbeea adenopetala*	4
Alder, rose	*Caldcluvia australiensis*	4
Amberoi	*Pterocymbium* spp.	4
Apple, rough-barked	*Angophora floribunda*	4
Apple, smooth-barked	*Angophora costata*	4
Ash, alpine	*Eucalyptus delegatensis*	4
Ash, Blue Mountains	*Eucalyptus oreades*	4
Ash, Crow's	*Flindersia australis*	4
Ash, mountain	*Eucalyptus regnans*	4
Ash, pink	*Alphitonia petriei*	4
Ash, silver	*Flindersia bourjotiana, Flindersia schottiana*	4
Ash, silvertop	*Eucalyptus sieberi*	4
Ash, white	*Eucalyptus fraxinoides*	4
Baltic, red (pine, Scots)	*Pinus sylvestris*	4
Baltic, white (spruce, Norway)	*Picea abies*	4
Beech, myrtle	*Nothofagus cunninghamii*	4
Beech, negrohead	*Nothofagus moorei*	4
Beech, silver	*Nothofagus menziesii*	4
Belian	*Eusideroxylon zwageri*	1
Birch, white, Australia	*Schizomeria ovata*	4
Blackbutt	*Eucalyptus pilularis*	3
Blackbutt, New England	*Eucalyptus andrewsii, Eucalyptus campanulata*	2
Blackbutt, Western Australian	*Eucalyptus patens*	3
Blackwood	*Acacia melanoxylon*	4
Bloodwood, red	*Corymbia gummifera*	3
Bollywood	*Cinnamomum baileyanum, Litsea* spp.	4
Box, brush	*Lophostemon confertus*	2
Box, grey	*Eucalyptus macrocarpa, Eucalyptus moluccana* *Eucalyptus woollsiana*	2
Box, grey, coast	*Eucalyptus bosistoana*	3
Box, ironwood	*Choricarpia leptopetala* *Choricarpia subargentea*	4
Box, kanuka	*Tristania exiliflora, Tristania laurina*	4
Box, long-leaved	*Eucalyptus goniocalyx*	4
Box, swamp	*Lophostemon suaveolens*	2
Brownbarrel	*Eucalyptus fastigata*	4
Bullich	*Eucalyptus megacarpa*	4
Calophyllum	*Calophyllum* spp.	4
Candlebark	*Eucalyptus rubida*	4

Trade name	Botanical name	Marine borer resistance class
Carabeen, yellow	*Sloanea woolsii*	4
Cedar, red	*Toona australis*	4
Cedar, western red	*Thuja plicata*	4
Cheesewood, white	*Alstonia scholaris*	4
Coachwood	*Ceratopetalum apetalum*	4
Cypress, black	*Callitris endlicheri*	3
Cypress	*Callitris glaucophylla*	2
Fir, amabilis	*Abies amabilis*	4
Fir, Douglas (Oregon)	*Pseudotsuga menziesii*	4
Geronggang	*Cratoxylon arborescens*	4
Gum, blue, southern	*Eucalyptus globulus*	4
Gum, blue, Sydney	*Eucalyptus saligna*	3
Gum, grey	*Eucalyptus canaliculata, Eucalyptus major, Eucalyptus propinqua, Eucalyptus punctata*	2
Gum, grey, mountain	*Eucalyptus cypellocarpa*	4
Gum, Maiden's	*Eucalyptus maidenii*	4
Gum, manna	*Eucalyptus viminalis*	4
Gum, mountain	*Eucalyptus dalrympleana*	4
Gum, pink	*Eucalyptus fasciculosa*	4
Gum, poplar	*Eucalyptus alba*	4
Gum, red, forest	*Eucalyptus blakelyi, Eucalyptus tereticornis*	2
Gum, red, river	*Eucalyptus camaldulensis*	2
Gum, rose	*Eucalyptus grandis*	4
Gum, round-leaved	*Eucalyptus deanei*	4
Gum, shining	*Eucalyptus nitens*	4
Gum, spotted	*Corymbia maculata,* incl. *Corymbia citriodora*	4
Gum, swamp	*Eucalyptus camphora*	4
Gum, white, Dunn's	*Eucalyptus dunnii*	4
Gum, yellow	*Eucalyptus leucoxylon*	4
Hardwood, Johnston River	*Backhousia bancroftii*	4
Hemlock, western	*Tsuga heterophylla*	4
Iroko	*Chlorophora excelsa*	1
Ironbark, grey	*Eucalyptus drepanophylla, Eucalyptus paniculata, Eucalyptus siderophloia*	3
Ironbark, red	*Eucalyptus sideroxylon*	2
Jam, raspberry	*Acacia acuminata*	2
Jarrah	*Eucalyptus marginata*	3
Jelutong	*Dyera costulata*	4
Kamarere	*Eucalyptus deglupta*	4
Kapur	*Dryobalanops* spp.	4
Karri	*Eucalyptus diversicolor*	4
Kauri, New Zealand	*Agathis australis*	4
Kauri, Queensland	*Agathis atropurpurea, Agathis microstachya Agathis robusta*	4
Kempas	*Koompassia malaccensis*	4
Keruing	*Dipterocarpus* spp.	4
Kwila (merbau)	*Intsia bijuga*	3
Lumbayau (mengkulang)	*Heritiera* spp.	4
Mahogany, African	*Khaya* spp.	4

Trade name	Botanical name	Marine borer resistance class
Mahogany, American	*Swietenia mahogani*	4
Mahogany, brush	*Geissois benthamii*	4
Mahogany, red	*Eucalyptus pellita, Eucalyptus resinifera*	2
Mahogany, red, Philippine,	*Shorea* spp.	4
Mahogany, southern	*Eucalyptus botryoides*	4
Mahogany, white	*Eucalyptus acmenoides, Eucalyptus tenuipes* *Eucalyptus umbra* subsp. *carnea*	2
Malas	*Homalium foetidum*	4
Mallet, brown	*Eucalyptus astringens*	4
Malletwood	*Rhodamnia argentea, Rhodamnia costata*	4
Malletwood, brown	*Rhodamnia rubescens*	4
Malletwood, silver	*Rhodamnia acuminata*	4
Mangrove, grey	*Avicennia marina*	4
Maple, Queensland	*Flindersia brayleyana*	4
Maple, rose	*Cryptocarya erythroxylon*	4
Maple, scented	*Flindersia laevicarpa*	4
Maple, sugar (rock)	*Acer saccharum*	4
Marri	*Corymbia calophylla*	4
Meranti, bakau	*Shorea* spp.	4
Meranti, dark-red	*Shorea* spp.	4
Meranti, light-red	*Shorea* spp.	4
Meranti, white	*Shorea* spp.	4
Meranti, yellow	*Shorea* spp.	4
Mersawa	*Anisoptera* spp.	4
Messmate	*Eucalyptus obliqua*	4
Nyatoh	*Palaquium* and *Payena* spp.	4
Oak, silky, northern	*Cardwellia sublimis*	4
Oak, tulip, blush	*Argyrodendron actinophyllum*	4
Oak, tulip, brown	*Argyrodendron polyandrum* *Argyrodendron trifoliolatum*	4
Oak, tulip, red	*Argyrodendron peralatum*	4
Oak, white, American	*Quercus alba*	4
Paulownia	*Paulownia* spp.	4
Penda, brown	*Xanthostemon chrysanthus*	2
Penda, red	*Xanthostemon whitei*	2
Penda, southern	*Xanthostemon, oppositifolius*	2
Penda, yellow	*Ristantia pachysperma*	2
Peppermint, black	*Eucalyptus amygdalina*	4
Peppermint, broad-leaved	*Eucalyptus dives*	4
Peppermint, narrow-leaved	*Eucalyptus radiata,* incl. *Eucalyptus australiana*	4
Peppermint, river	*Eucalyptus elata*	4
Peppermint, white	*Eucalyptus pulchella*	4
Pine, brown	*Podocarpus elatus*	3
Pine, bunya	*Araucaria bidwillii*	4
Pine, Canary Island	*Pinus canariensis*	4
Pine, Caribbean	*Pinus caribaea*	4
Pine, celery-top	*Phyllocladus aspleniifolius*	4
Pine, Corsican	*Pinus nigra*	4
Pine, hoop	*Araucaria cunninghamii*	4
Pine, Huon	*Lagarostrobos franklinii*	4

Trade name	Botanical name	Marine borer resistance class
Pine, King William	*Athrotaxis selaginoides*	4
Pine, klinki	*Araucaria hunsteinii*	4
Pine, loblolly	*Pinus taeda*	4
Pine, longleaf	*Pinus palustris*	4
Pine, maritime	*Pinus pinaster*	4
Pine, NZ white (kahikatea)	*Dacrycarpus dacrydioides*	4
Pine, patula	*Pinus patula*	4
Pine, ponderosa	*Pinus ponderosa*	4
Pine, radiata	*Pinus radiata*	4
Pine, Scots	*Pinus sylvestris*	4
Pine, slash	*Pinus elliottii*	4
Pine, white, western	*Pinus monticola*	4
Planchonella	*Planchonella chartacea*	4
Poplar, balsam	*Populus* spp.	4
Poplar, pink	*Euroschinus falcata*	4
Quandong, silver	*Elaeocarpus angustifolius, Elaeocarpus grandis*	4
Ramin	*Gonystylus* spp.	4
Redwood	*Sequoia sempervirens*	4
Rimu	*Dacrydium cupressinum*	4
Rosewood, New Guinea	*Pterocarpus indicus*	4
Sassafras	*Daphnandra dielsii, Daphnandra micrantha* *Daphnandra repandula, Doryphora aromatica* *Doryphora sassafras*	4
Satinash, grey	*Syzygium claviflorum, Syzygium gustavioides*	4
Satinash, rose	*Syzygium crebrinerve, Eugenia francisii*	4
Satinay	*Syncarpia hillii*	1
Sepetir	*Copaifera* spp., *Pseudosindora* spp., *Sindora* spp.	4
Sheoak, beach	*Allocasuarina equisetifolia*	4
Sheoak, black	*Allocasuarina littoralis*	4
Silkwood, maple	*Flindersia pimenteliana*	4
Spruce, Norway	*Picea abies*	4
Spruce, Sitka	*Picea sitchensis*	4
Stringybark, blue-leaved	*Eucalyptus agglomerata*	4
Stringybark, brown	*Eucalyptus baxteri, Eucalyptus blaxlandii* *Eucalyptus capitellata*	4
Stringybark, diehard	*Eucalyptus cameronii*	4
Stringybark, red	*Eucalyptus macrorhyncha*	3
Stringybark, silvertop	*Eucalyptus laevopinea*	4
Stringybark, white	*Eucalyptus eugenioides, Eucalyptus globoidea* *Eucalyptus phaeotricha*	3
Stringybark, yellow	*Eucalyptus muelleriana*	3
Sycamore, silver	*Cryptocarya glaucescens*	4
Tallowwood	*Eucalyptus microcorys*	3
Taun	*Pometia* spp.	4
Tea-tree, broad-leaved	*Melaleuca leucadendron,* *Melaleuca quinquenervia, Melaleuca viridiflora*	3
Tea-tree, river	*Melaleuca bracteata*	4
Tingle, red	*Eucalyptus jacksonii*	4
Touriga, red	*Calophyllum costatum*	4

Table 9.1 (continued): Timber marine borer resistance classification.

Trade name	Botanical name	Marine borer resistance class
Tuart	*Eucalyptus gomphocephala*	4
Turpentine	*Syncarpia glomulifera*	1
Walnut, New South Wales	*Endiandra virens*	4
Walnut, Queensland	*Endiandra palmerstonii*	4
Walnut, yellow	*Beilschmiedia bancroftii*	4
Wandoo	*Eucalyptus wandoo*	3
Yate, swamp	*Eucalyptus occidentalis*	4

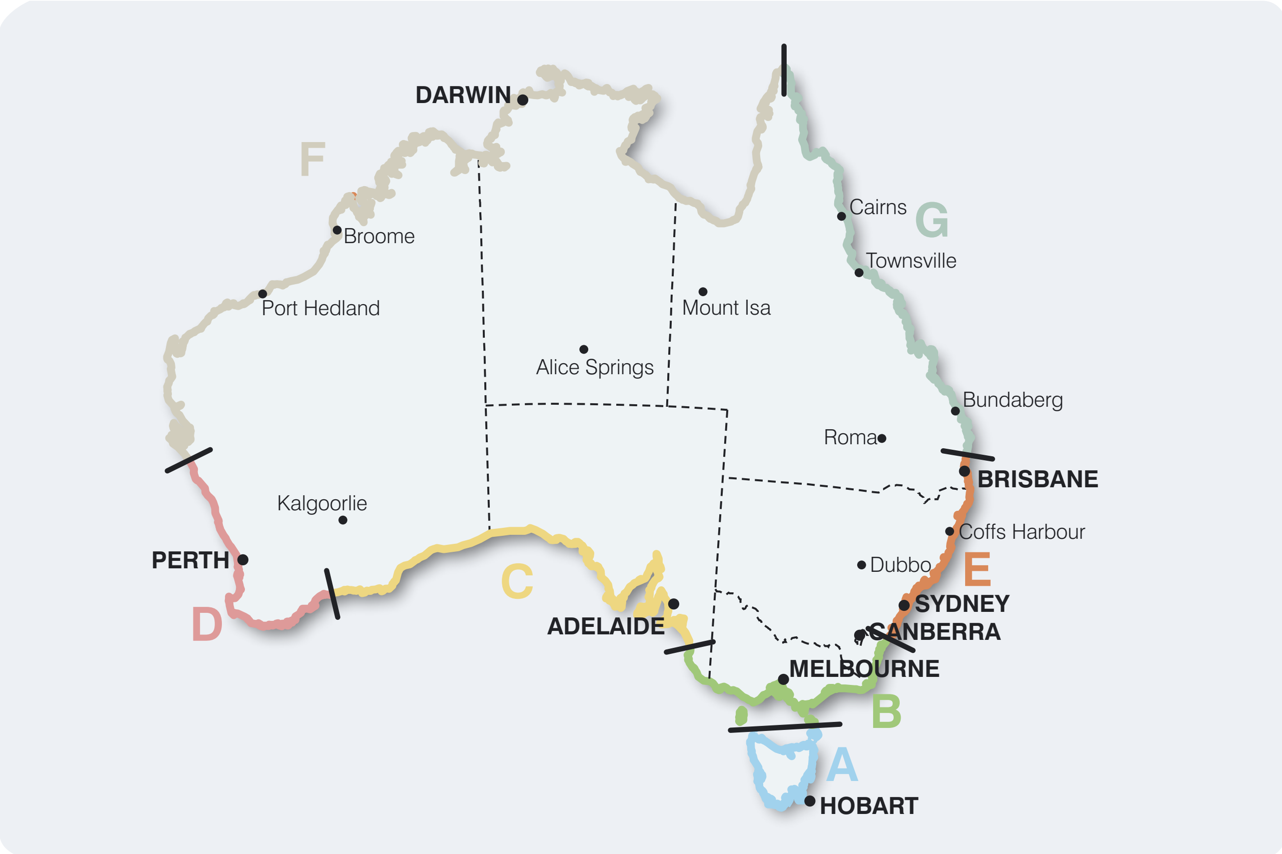


Figure 9.1: Marine borer hazard zones.

Table 9.2: Salinity classification.

Salinity class	Sea water salinity (parts per thousand)
1	1-10
2	11-25
3	26-35

Note: Sea water salinity can be measured with a hydrometer. Typically, salinity class 1 is water in rivers with a tidal influence, salinity class 2 is water in river mouth areas, and salinity class 3 is water in bays or open sea areas.

Table 9.3: Sheltering of piles.

Shelter	Shelter classification
Sheltered from strong current or surf (eg. Directly behind breakwaters)	Calm
Exposed to current and/or surf	Surf

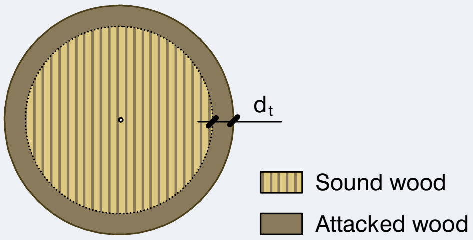


Figure 9.2: Assumed attack patterns for round piles.

Double treated marine piles at Couran Cove, Queensland.

Table 9.4: Typical service life of round piles in Hazard Zone A.

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
A	1	Calm	Untreated Hardwood	1	none	100	>100	>100	>100	50	100	100	>100
				2	none	60	>100	>100	>100	30	60	60	>100
			Treated Hardwood	1	H6 (CCA)	100	>100	>100	>100	50	100	100	>100
					H6 (creosote)	>100	>100	>100	>100	70	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	>100	>100	>100
				2	H6 (CCA)	80	>100	>100	>100	40	70	80	>100
					H6 (creosote)	>100	>100	>100	>100	60	90	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	90	>100	>100
				3	H6 (CCA)	60	90	>100	>100	30	45	60	90
					H6 (creosote)	90	>100	>100	>100	45	60	90	>100
					H6 (DBT)	>100	>100	>100	>100	50	70	>100	>100
				4	H6 (CCA)	45	50	90	100	25	25	45	50
					H6 (creosote)	70	80	>100	>100	40	40	70	80
					H6 (DBT)	90	90	>100	>100	45	50	90	90
			Treated Softwood	4	H6 (CCA)	60	60	>100	>100	30	30	60	60
					H6 (creosote)	>100	>100	>100	>100	50	60	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	60	>100	>100
		Surf	Untreated Hardwood	1	none	>100	>100	>100	>100	80	>100	>100	>100
				2	none	>100	>100	>100	>100	50	>100	>100	>100
			Treated Hardwood	1	H6 (CCA)	>100	>100	>100	>100	80	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	>100	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	>100	>100	>100	>100
				2	H6 (CCA)	>100	>100	>100	>100	70	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	90	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	>100	>100	>100	>100
				3	H6 (CCA)	100	>100	>100	>100	50	80	100	>100
					H6 (creosote)	>100	>100	>100	>100	80	100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	90	>100	>100	>100
				4	H6 (CCA)	70	80	>100	>100	35	40	70	80
					H6 (creosote)	>100	>100	>100	>100	60	70	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	80	>100	>100
			Treated Softwood	4	H6 (CCA)	90	>100	>100	>100	50	50	90	>100
					H6 (creosote)	>100	>100	>100	>100	90	90	>100	>100
					H6 (DBT)	>100	>100	>100	>100	100	>100	>100	>100
	2	Calm	Untreated Hardwood	1	none	80	>100	>100	>100	40	80	80	>100
				2	none	60	>100	>100	>100	30	50	60	>100
			Treated Hardwood	1	H6 (CCA)	90	>100	>100	>100	45	90	90	>100
					H6 (creosote)	>100	>100	>100	>100	60	100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	>100	>100	>100
				2	H6 (CCA)	70	>100	>100	>100	35	60	70	>100
					H6 (creosote)	100	>100	>100	>100	50	80	100	>100
					H6 (DBT)	>100	>100	>100	>100	60	80	>100	>100
				3	H6 (CCA)	50	80	>100	>100	30	40	50	80
					H6 (creosote)	80	>100	>100	>100	40	50	80	>100
					H6 (DBT)	90	>100	>100	>100	45	60	90	>100
				4	H6 (CCA)	40	45	80	90	20	25	40	45
					H6 (creosote)	70	70	>100	>100	35	35	70	70
					H6 (DBT)	80	80	>100	>100	40	40	80	80
			Treated Softwood	4	H6 (CCA)	50	60	100	>100	25	30	50	60
					H6 (creosote)	90	100	>100	>100	45	50	90	100
					H6 (DBT)	>100	>100	>100	>100	50	50	>100	>100

Table 9.4** (continued)**: Typical service life of round piles in Hazard Zone A.

Hazard zone[1]	Salinity class[2]	Shelter class[3]	Timber	Marine borer resistance class[4]	Treatment[5]	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
A	2	Surf	Untreated Hardwood	1	none	>100	>100	>100	>100	70	>100	>100	>100
				2	none	90	>100	>100	>100	45	90	90	>100
			Treated Hardwood	1	H6 (CCA)	>100	>100	>100	>100	70	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	90	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	>100	>100	>100	>100
				2	H6 (CCA)	>100	>100	>100	>100	60	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	80	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	90	>100	>100	>100
				3	H6 (CCA)	90	>100	>100	>100	45	70	90	>100
					H6 (creosote)	>100	>100	>100	>100	70	90	>100	>100
					H6 (DBT)	>100	>100	>100	>100	80	100	>100	>100
				4	H6 (CCA)	60	70	>100	>100	35	35	60	70
					H6 (creosote)	>100	>100	>100	>100	60	60	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	70	>100	>100
			Treated Softwood	4	H6 (CCA)	80	90	>100	>100	40	45	80	90
					H6 (creosote)	>100	>100	>100	>100	80	80	>100	>100
					H6 (DBT)	>100	>100	>100	>100	90	90	>100	>100
	3	Calm	Untreated Hardwood	1	none	70	>100	>100	>100	35	70	70	>100
				2	none	45	90	90	>100	25	45	45	90
			Treated Hardwood	1	H6 (CCA)	70	>100	>100	>100	35	70	70	>100
					H6 (creosote)	90	>100	>100	>100	45	80	90	>100
					H6 (DBT)	100	>100	>100	>100	50	80	100	>100
				2	H6 (CCA)	60	100	>100	>100	30	50	60	100
					H6 (creosote)	80	>100	>100	>100	40	60	80	>100
					H6 (DBT)	90	>100	>100	>100	45	70	90	>100
				3	H6 (CCA)	45	60	80	>100	25	35	45	60
					H6 (creosote)	60	90	>100	>100	35	45	60	90
					H6 (DBT)	70	90	>100	>100	40	50	70	90
				4	H6 (CCA)	30	35	60	70	15	20	30	35
					H6 (creosote)	50	60	>100	>100	25	30	50	60
					H6 (DBT)	60	70	>100	>100	30	35	60	70
			Treated Softwood	4	H6 (CCA)	40	45	80	90	20	25	40	45
					H6 (creosote)	80	80	>100	>100	40	40	80	80
					H6 (DBT)	80	90	>100	>100	40	45	80	90
		Surf	Untreated Hardwood	1	none	>100	>100	>100	>100	60	>100	>100	>100
				2	none	70	>100	>100	>100	35	70	70	>100
			Treated Hardwood	1	H6 (CCA)	>100	>100	>100	>100	60	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	80	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	80	>100	>100	>100
				2	H6 (CCA)	90	>100	>100	>100	45	80	90	>100
					H6 (creosote)	>100	>100	>100	>100	60	100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	>100	>100	>100
				3	H6 (CCA)	70	>100	>100	>100	35	50	70	>100
					H6 (creosote)	>100	>100	>100	>100	50	70	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	80	>100	>100
				4	H6 (CCA)	50	60	100	>100	25	30	50	60
					H6 (creosote)	90	90	>100	>100	45	50	90	90
					H6 (DBT)	>100	>100	>100	>100	50	60	>100	>100
			Treated Softwood	4	H6 (CCA)	70	70	>100	>100	35	40	70	70
					H6 (creosote)	>100	>100	>100	>100	60	70	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	70	>100	>100

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1. DBT stands for double-treatment.

Table 9.5: Typical service life of round piles in Hazard Zone B.

Hazard zone[1]	Salinity class[2]	Shelter class[3]	Timber	Marine borer resistance class[4]	Treatment[5]	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
B	1	Calm	Untreated Hardwood	1	none	80	>100	>100	>100	40	70	80	>100
				2	none	50	100	100	>100	25	50	50	100
			Treated Hardwood	1	H6 (CCA)	80	>100	>100	>100	40	80	80	>100
					H6 (creosote)	100	>100	>100	>100	50	90	100	>100
					H6 (DBT)	>100	>100	>100	>100	60	90	>100	>100
				2	H6 (CCA)	60	>100	>100	>100	30	60	60	>100
					H6 (creosote)	90	>100	>100	>100	45	70	90	>100
					H6 (DBT)	100	>100	>100	>100	50	70	100	>100
				3	H6 (CCA)	45	70	90	>100	25	35	45	70
					H6 (creosote)	70	90	>100	>100	35	50	70	90
					H6 (DBT)	80	>100	>100	>100	40	50	80	>100
				4	H6 (CCA)	35	40	70	80	20	20	35	40
					H6 (creosote)	60	60	>100	>100	30	30	60	60
					H6 (DBT)	70	70	>100	>100	35	35	70	70
			Treated Softwood	4	H6 (CCA)	45	50	90	100	25	25	45	50
					H6 (creosote)	80	90	>100	>100	40	45	80	90
					H6 (DBT)	90	100	>100	>100	45	50	90	100
		Surf	Untreated Hardwood	1	none	>100	>100	>100	>100	60	>100	>100	>100
				2	none	80	>100	>100	>100	40	80	80	>100
			Treated Hardwood	1	H6 (CCA)	>100	>100	>100	>100	60	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	80	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	90	>100	>100	>100
				2	H6 (CCA)	100	>100	>100	>100	50	90	100	>100
					H6 (creosote)	>100	>100	>100	>100	70	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	80	>100	>100	>100
				3	H6 (CCA)	80	>100	>100	>100	40	60	80	>100
					H6 (creosote)	>100	>100	>100	>100	60	80	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	90	>100	>100
				4	H6 (CCA)	60	70	>100	>100	30	35	60	70
					H6 (creosote)	100	>100	>100	>100	50	50	100	>100
					H6 (DBT)	>100	>100	>100	>100	60	60	>100	>100
			Treated Softwood	4	H6 (CCA)	70	80	>100	>100	40	40	70	80
					H6 (creosote)	>100	>100	>100	>100	70	70	>100	>100
					H6 (DBT)	>100	>100	>100	>100	80	80	>100	>100
	2	Calm	Untreated Hardwood	1	none	70	>100	>100	>100	35	70	70	>100
				2	none	45	80	90	>100	20	45	45	80
			Treated Hardwood	1	H6 (CCA)	70	>100	>100	>100	35	70	70	>100
					H6 (creosote)	90	>100	>100	>100	45	80	90	>100
					H6 (DBT)	100	>100	>100	>100	50	80	100	>100
				2	H6 (CCA)	50	100	>100	>100	30	50	50	100
					H6 (creosote)	70	>100	>100	>100	40	60	70	>100
					H6 (DBT)	80	>100	>100	>100	45	60	80	>100
				3	H6 (CCA)	40	60	80	>100	20	35	40	60
					H6 (creosote)	60	80	>100	>100	35	45	60	80
					H6 (DBT)	70	90	>100	>100	35	50	70	90
				4	H6 (CCA)	30	35	60	70	15	20	30	35
					H6 (creosote)	50	60	100	>100	25	30	50	60
					H6 (DBT)	60	70	>100	>100	30	35	60	70
			Treated Softwood	4	H6 (CCA)	40	45	80	90	20	20	40	45
					H6 (creosote)	70	80	>100	>100	35	40	70	80
					H6 (DBT)	80	80	>100	>100	40	40	80	80

Table 9.5** (continued)**: Typical service life of round piles in Hazard Zone B.

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
B	2	Surf	Untreated Hardwood	1	none	>100	>100	>100	>100	60	>100	>100	>100
				2	none	70	>100	>100	>100	35	70	70	>100
			Treated Hardwood	1	H6 (CCA)	>100	>100	>100	>100	60	>100	>100	>100
					H6 (creosote)	>100	>100	>100	>100	70	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	80	>100	>100	>100
				2	H6 (CCA)	90	>100	>100	>100	45	80	90	>100
					H6 (creosote)	>100	>100	>100	>100	60	100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	>100	>100	>100
				3	H6 (CCA)	70	>100	>100	>100	35	50	70	>100
					H6 (creosote)	>100	>100	>100	>100	50	70	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	80	>100	>100
				4	H6 (CCA)	50	60	100	>100	25	30	50	60
					H6 (creosote)	80	90	>100	>100	45	45	80	90
					H6 (DBT)	100	>100	>100	>100	50	50	100	>100
			Treated Softwood	4	H6 (CCA)	70	70	>100	>100	35	35	70	70
					H6 (creosote)	>100	>100	>100	>100	60	60	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	70	>100	>100
	3	Calm	Untreated Hardwood	1	none	50	>100	>100	>100	25	50	50	>100
				2	none	35	70	70	>100	20	35	35	70
			Treated Hardwood	1	H6 (CCA)	60	>100	>100	>100	30	50	60	>100
					H6 (creosote)	70	>100	>100	>100	35	60	70	>100
					H6 (DBT)	80	>100	>100	>100	40	70	80	>100
				2	H6 (CCA)	45	80	80	>100	25	40	45	80
					H6 (creosote)	60	90	>100	>100	30	50	60	90
					H6 (DBT)	70	>100	>100	>100	35	50	70	>100
				3	H6 (CCA)	35	50	60	100	20	25	35	50
					H6 (creosote)	50	70	100	>100	25	35	50	70
					H6 (DBT)	60	70	>100	>100	30	40	60	70
				4	H6 (CCA)	25	30	50	60	15	15	25	30
					H6 (creosote)	40	45	80	90	20	25	40	45
					H6 (DBT)	50	50	100	>100	25	25	50	50
			Treated Softwood	4	H6 (CCA)	30	35	60	70	15	20	30	35
					H6 (creosote)	60	60	>100	>100	30	30	60	60
					H6 (DBT)	60	70	>100	>100	35	35	60	70
		Surf	Untreated Hardwood	1	none	90	>100	>100	>100	45	90	90	>100
				2	none	60	>100	>100	>100	30	60	60	>100
			Treated Hardwood	1	H6 (CCA)	90	>100	>100	>100	45	90	90	>100
					H6 (creosote)	>100	>100	>100	>100	60	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	>100	>100	>100
				2	H6 (CCA)	70	>100	>100	>100	35	60	70	>100
					H6 (creosote)	100	>100	>100	>100	50	80	100	>100
					H6 (DBT)	>100	>100	>100	>100	60	80	>100	>100
				3	H6 (CCA)	50	80	>100	>100	30	40	50	80
					H6 (creosote)	80	>100	>100	>100	40	60	80	>100
					H6 (DBT)	90	>100	>100	>100	50	60	90	>100
				4	H6 (CCA)	40	45	80	90	20	25	40	45
					H6 (creosote)	70	70	>100	>100	35	35	70	70
					H6 (DBT)	80	90	>100	>100	40	45	80	90
			Treated Softwood	4	H6 (CCA)	50	60	>100	>100	25	30	50	60
					H6 (creosote)	100	>100	>100	>100	50	50	100	>100
					H6 (DBT)	>100	>100	>100	>100	50	60	>100	>100

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1. DBT stands for double-treatment.

Table 9.6: Typical service life of round piles in Hazard Zone C.

Hazard zone[1]	Salinity class[2]	Shelter class[3]	Timber	Marine borer resistance class[4]	Treatment[5]	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
C	1	Calm	Untreated Hardwood	1	none	60	>100	>100	>100	30	60	60	>100
				2	none	35	70	70	>100	20	35	35	70
			Treated Hardwood	1	H6 (CCA)	60	>100	>100	>100	30	60	60	>100
					H6 (creosote)	80	>100	>100	>100	40	70	80	>100
					H6 (DBT)	80	>100	>100	>100	45	70	80	>100
				2	H6 (CCA)	45	80	90	>100	25	45	45	80
					H6 (creosote)	60	100	>100	>100	35	50	60	100
					H6 (DBT)	70	>100	>100	>100	40	60	70	>100
				3	H6 (CCA)	35	50	70	>100	20	30	35	50
					H6 (creosote)	50	70	>100	>100	30	35	50	70
					H6 (DBT)	60	80	>100	>100	30	40	60	80
				4	H6 (CCA)	25	30	50	60	15	15	25	30
					H6 (creosote)	45	50	90	90	25	25	45	50
					H6 (DBT)	50	60	>100	>100	25	30	50	60
			Treated Softwood	4	H6 (CCA)	35	40	70	70	15	20	35	40
					H6 (creosote)	60	70	>100	>100	30	35	60	70
					H6 (DBT)	70	70	>100	>100	35	35	70	70
		Surf	Untreated Hardwood	1	none	90	>100	>100	>100	45	90	90	>100
				2	none	60	>100	>100	>100	30	60	60	>100
			Treated Hardwood	1	H6 (CCA)	100	>100	>100	>100	50	90	100	>100
					H6 (creosote)	>100	>100	>100	>100	60	>100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	70	>100	>100	>100
				2	H6 (CCA)	80	>100	>100	>100	40	70	80	>100
					H6 (creosote)	>100	>100	>100	>100	50	80	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	90	>100	>100
				3	H6 (CCA)	60	90	>100	>100	30	45	60	90
					H6 (creosote)	90	>100	>100	>100	45	60	90	>100
					H6 (DBT)	>100	>100	>100	>100	50	70	>100	>100
				4	H6 (CCA)	45	50	80	100	20	25	45	50
					H6 (creosote)	70	80	>100	>100	35	40	70	80
					H6 (DBT)	90	90	>100	>100	45	45	90	90
			Treated Softwood	4	H6 (CCA)	60	60	>100	>100	30	30	60	60
					H6 (creosote)	>100	>100	>100	>100	50	60	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	60	>100	>100
	2	Calm	Untreated Hardwood	1	none	50	100	100	>100	25	50	50	100
				2	none	30	60	60	>100	15	30	30	60
			Treated Hardwood	1	H6 (CCA)	50	100	100	>100	25	50	50	100
					H6 (creosote)	70	>100	>100	>100	35	60	70	>100
					H6 (DBT)	70	>100	>100	>100	40	60	70	>100
				2	H6 (CCA)	40	70	80	>100	20	40	40	70
					H6 (creosote)	60	90	>100	>100	30	45	60	90
					H6 (DBT)	60	90	>100	>100	35	50	60	90
				3	H6 (CCA)	30	45	60	90	15	25	30	45
					H6 (creosote)	45	60	90	>100	25	35	45	60
					H6 (DBT)	50	70	>100	>100	30	35	50	70
				4	H6 (CCA)	25	25	45	50	10	15	25	25
					H6 (creosote)	40	40	80	80	20	20	40	40
					H6 (DBT)	45	50	90	100	25	25	45	50
			Treated Softwood	4	H6 (CCA)	30	35	60	70	15	15	30	35
					H6 (creosote)	60	60	>100	>100	30	30	60	60
					H6 (DBT)	60	60	>100	>100	30	30	60	60

Table 9.6 *(continued)*: ***Typical service life of round piles in Hazard Zone C.***

Hazard zone[1]	Salinity class[2]	Shelter class[3]	Timber	Marine borer resistance class[4]	Treatment[5]	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
C	2	Surf	Untreated Hardwood	1	none	80	>100	>100	>100	40	80	80	>100
				2	none	50	>100	>100	>100	25	50	50	>100
			Treated Hardwood	1	H6 (CCA)	80	>100	>100	>100	45	80	80	>100
					H6 (creosote)	>100	>100	>100	>100	60	100	>100	>100
					H6 (DBT)	>100	>100	>100	>100	60	>100	>100	>100
				2	H6 (CCA)	70	>100	>100	>100	35	60	70	>100
					H6 (creosote)	90	>100	>100	>100	50	70	90	>100
					H6 (DBT)	>100	>100	>100	>100	50	80	>100	>100
				3	H6 (CCA)	50	80	100	>100	25	40	50	80
					H6 (creosote)	80	>100	>100	>100	40	50	80	>100
					H6 (DBT)	90	>100	>100	>100	45	60	90	>100
				4	H6 (CCA)	40	45	70	80	20	20	40	45
					H6 (creosote)	60	70	>100	>100	30	35	60	70
					H6 (DBT)	80	80	>100	>100	40	40	80	80
			Treated Softwood	4	H6 (CCA)	50	50	100	>100	25	25	50	50
					H6 (creosote)	90	100	>100	>100	45	50	90	100
					H6 (DBT)	100	>100	>100	>100	50	50	100	>100
	3	Calm	Untreated Hardwood	1	none	40	80	80	>100	20	40	40	80
				2	none	25	50	50	100	15	25	25	50
			Treated Hardwood	1	H6 (CCA)	40	80	80	>100	25	40	40	80
					H6 (creosote)	50	90	>100	>100	30	50	50	90
					H6 (DBT)	60	100	>100	>100	30	50	60	100
				2	H6 (CCA)	35	60	60	>100	20	30	35	60
					H6 (creosote)	45	70	90	>100	25	35	45	70
					H6 (DBT)	50	80	100	>100	25	40	50	80
				3	H6 (CCA)	25	40	50	70	15	20	25	40
					H6 (creosote)	40	50	70	100	20	25	40	50
					H6 (DBT)	45	60	90	>100	25	30	45	60
				4	H6 (CCA)	20	20	35	40	10	10	20	20
					H6 (creosote)	30	35	60	70	15	20	30	35
					H6 (DBT)	35	40	70	80	20	20	35	40
			Treated Softwood	4	H6 (CCA)	25	25	45	50	15	15	25	25
					H6 (creosote)	45	45	90	90	25	25	45	45
					H6 (DBT)	50	50	100	100	25	25	50	50
		Surf	Untreated Hardwood	1	none	70	>100	>100	>100	35	70	70	>100
				2	none	45	80	90	>100	20	45	45	80
			Treated Hardwood	1	H6 (CCA)	70	>100	>100	>100	35	70	70	>100
					H6 (creosote)	90	>100	>100	>100	45	80	90	>100
					H6 (DBT)	100	>100	>100	>100	50	80	100	>100
				2	H6 (CCA)	50	100	>100	>100	30	50	50	100
					H6 (creosote)	70	>100	>100	>100	40	60	70	>100
					H6 (DBT)	80	>100	>100	>100	45	60	80	>100
				3	H6 (CCA)	40	60	80	>100	20	35	40	60
					H6 (creosote)	60	80	>100	>100	35	45	60	80
					H6 (DBT)	70	90	>100	>100	35	50	70	90
				4	H6 (CCA)	30	35	60	70	15	20	30	35
					H6 (creosote)	50	60	100	>100	25	30	50	60
					H6 (DBT)	60	70	>100	>100	30	35	60	70
			Treated Softwood	4	H6 (CCA)	40	45	80	90	20	20	40	45
					H6 (creosote)	70	80	>100	>100	35	40	70	80
					H6 (DBT)	80	80	>100	>100	40	40	80	80

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1. DBT stands for double-treatment.

Table 9.7: Typical service life of round piles in Hazard Zone D.

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
D	1	Calm	Untreated Hardwood	1	none	35	70	70	>100	20	35	35	70
				2	none	10	20	20	35	5	9	10	20
			Treated Hardwood	1	H6 (CCA)	40	80	80	>100	20	40	40	80
					H6 (creosote)	50	90	>100	>100	30	45	50	90
					H6 (DBT)	60	90	>100	>100	30	50	60	90
				2	H6 (CCA)	25	35	45	60	15	20	25	35
					H6 (creosote)	40	45	70	90	20	25	40	45
					H6 (DBT)	45	50	90	>100	25	25	45	50
				3	H6 (CCA)	20	25	45	50	10	15	20	25
					H6 (creosote)	35	40	70	80	20	20	35	40
					H6 (DBT)	40	45	80	90	20	25	40	45
				4	H6 (CCA)	20	20	40	40	10	10	20	20
					H6 (creosote)	35	35	60	70	15	20	35	35
					H6 (DBT)	40	40	80	80	20	20	40	40
			Treated Softwood	4	H6 (CCA)	25	25	50	50	15	15	25	25
					H6 (creosote)	45	50	90	100	25	25	45	50
					H6 (DBT)	50	50	>100	>100	25	25	50	50
		Surf	Untreated Hardwood	1	none	60	>100	>100	>100	30	60	60	>100
				2	none	15	30	30	60	8	15	15	30
			Treated Hardwood	1	H6 (CCA)	70	>100	>100	>100	35	60	70	>100
					H6 (creosote)	90	>100	>100	>100	45	70	90	>100
					H6 (DBT)	100	>100	>100	>100	50	80	100	>100
				2	H6 (CCA)	40	50	80	>100	20	30	40	50
					H6 (creosote)	60	80	>100	>100	30	40	60	80
					H6 (DBT)	70	90	>100	>100	35	45	70	90
				3	H6 (CCA)	35	45	70	90	20	25	35	45
					H6 (creosote)	60	70	>100	>100	30	35	60	70
					H6 (DBT)	70	80	>100	>100	35	40	70	80
				4	H6 (CCA)	30	35	60	70	15	20	30	35
					H6 (creosote)	50	60	>100	>100	25	30	50	60
					H6 (DBT)	60	70	>100	>100	35	35	60	70
			Treated Softwood	4	H6 (CCA)	40	45	80	90	20	25	40	45
					H6 (creosote)	80	80	>100	>100	40	40	80	80
					H6 (DBT)	90	90	>100	>100	45	45	90	90
	2	Calm	Untreated Hardwood	1	none	30	60	60	>100	15	30	30	60
				2	none	9	15	15	30	4	8	9	15
			Treated Hardwood	1	H6 (CCA)	35	70	70	>100	20	35	35	70
					H6 (creosote)	50	80	90	>100	25	40	50	80
					H6 (DBT)	50	80	>100	>100	30	45	50	80
				2	H6 (CCA)	20	30	40	60	10	15	20	30
					H6 (creosote)	35	40	60	80	20	20	35	40
					H6 (DBT)	40	45	80	90	20	25	40	45
				3	H6 (CCA)	20	25	40	45	10	10	20	25
					H6 (creosote)	30	35	60	70	15	20	30	35
					H6 (DBT)	35	40	70	80	20	20	35	40
				4	H6 (CCA)	15	20	35	35	9	10	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	70	70	20	20	35	35
			Treated Softwood	4	H6 (CCA)	25	25	45	45	10	15	25	25
					H6 (creosote)	40	45	80	80	20	20	40	45
					H6 (DBT)	45	45	90	90	25	25	45	45

Table 9.7** (continued)**: Typical service life of round piles in Hazard Zone D.

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
D	2	Surf	Untreated Hardwood	1	none	50	>100	>100	>100	25	50	50	>100
				2	none	15	25	30	50	7	15	15	25
			Treated Hardwood	1	H6 (CCA)	60	>100	>100	>100	30	60	60	>100
					H6 (creosote)	80	>100	>100	>100	40	70	80	>100
					H6 (DBT)	90	>100	>100	>100	45	70	90	>100
				2	H6 (CCA)	35	50	70	90	20	25	35	50
					H6 (creosote)	50	70	>100	>100	30	35	50	70
					H6 (DBT)	60	80	>100	>100	35	40	60	80
				3	H6 (CCA)	30	40	60	80	15	20	30	40
					H6 (creosote)	50	60	100	>100	25	30	50	60
					H6 (DBT)	60	70	>100	>100	30	35	60	70
				4	H6 (CCA)	30	30	50	60	15	15	30	30
					H6 (creosote)	45	50	90	100	25	25	45	50
					H6 (DBT)	60	60	>100	>100	30	30	60	60
			Treated Softwood	4	H6 (CCA)	35	40	70	80	20	20	35	40
					H6 (creosote)	70	70	>100	>100	35	35	70	70
					H6 (DBT)	70	80	>100	>100	40	40	70	80
	3	Calm	Untreated Hardwood	1	none	25	50	50	100	15	25	25	50
				2	none	7	15	15	25	3	6	7	15
			Treated Hardwood	1	H6 (CCA)	30	50	60	>100	15	30	30	50
					H6 (creosote)	40	60	70	>100	20	35	40	60
					H6 (DBT)	45	70	80	>100	25	35	45	70
				2	H6 (CCA)	20	25	35	45	10	15	20	25
					H6 (creosote)	25	35	50	60	15	15	25	35
					H6 (DBT)	30	40	60	70	15	20	30	40
				3	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	50	60	15	15	25	30
					H6 (DBT)	30	35	60	70	15	15	30	35
				4	H6 (CCA)	15	15	25	30	8	8	15	15
					H6 (creosote)	25	25	45	45	15	15	25	25
					H6 (DBT)	30	30	50	60	15	15	30	30
			Treated Softwood	4	H6 (CCA)	20	20	35	40	10	10	20	20
					H6 (creosote)	35	35	70	70	15	20	35	35
					H6 (DBT)	35	40	70	70	20	20	35	40
		Surf	Untreated Hardwood	1	none	40	80	80	>100	20	40	40	80
				2	none	10	20	25	45	6	10	10	20
			Treated Hardwood	1	H6 (CCA)	45	90	90	>100	25	45	45	90
					H6 (creosote)	60	>100	>100	>100	35	50	60	>100
					H6 (DBT)	70	>100	>100	>100	35	60	70	>100
				2	H6 (CCA)	30	40	50	70	15	20	30	40
					H6 (creosote)	45	50	90	>100	25	30	45	50
					H6 (DBT)	50	60	100	>100	25	30	50	60
				3	H6 (CCA)	25	30	50	60	15	15	25	30
					H6 (creosote)	40	45	80	90	20	25	40	45
					H6 (DBT)	50	50	90	>100	25	30	50	50
				4	H6 (CCA)	20	25	45	50	10	15	20	25
					H6 (creosote)	40	40	70	80	20	20	40	40
					H6 (DBT)	45	45	90	90	25	25	45	45
			Treated Softwood	4	H6 (CCA)	30	30	60	60	15	15	30	30
					H6 (creosote)	50	60	>100	>100	30	30	50	60
					H6 (DBT)	60	60	>100	>100	30	30	60	60

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1. DBT stands for double-treatment.

Table 9.8: Typical service life of round piles in Hazard Zone E.

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
E	1	Calm	Untreated Hardwood	1	none	20	40	40	80	10	20	20	40
				2	none	6	10	10	20	2	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	45	45	80	15	25	25	45
					H6 (creosote)	30	50	60	100	15	25	30	50
					H6 (DBT)	35	50	70	>100	20	30	35	50
				2	H6 (CCA)	15	20	30	35	8	10	15	20
					H6 (creosote)	20	25	40	50	10	15	20	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				3	H6 (CCA)	15	15	25	30	7	8	15	15
					H6 (creosote)	20	25	40	45	10	10	20	25
					H6 (DBT)	25	25	45	50	15	15	25	25
				4	H6 (CCA)	10	15	20	25	6	7	10	15
					H6 (creosote)	20	20	35	40	10	10	20	20
					H6 (DBT)	20	25	45	45	10	15	20	25
			Treated Softwood	4	H6 (CCA)	15	15	30	30	8	8	15	15
					H6 (creosote)	25	30	50	50	15	15	25	30
					H6 (DBT)	30	30	60	60	15	15	30	30
		Surf	Untreated Hardwood	1	none	35	70	70	>100	20	35	35	70
				2	none	9	15	20	35	5	9	9	15
			Treated Hardwood	1	H6 (CCA)	40	70	70	>100	20	35	40	70
					H6 (creosote)	50	80	100	>100	25	45	50	80
					H6 (DBT)	60	90	>100	>100	30	45	60	90
				2	H6 (CCA)	25	30	45	60	15	15	25	30
					H6 (creosote)	35	45	70	90	20	25	35	45
					H6 (DBT)	40	50	80	100	20	25	40	50
				3	H6 (CCA)	20	25	40	50	10	15	20	25
					H6 (creosote)	35	40	60	70	15	20	35	40
					H6 (DBT)	40	45	80	90	20	20	40	45
				4	H6 (CCA)	20	20	35	40	10	10	20	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	40	70	70	20	20	35	40
			Treated Softwood	4	H6 (CCA)	25	25	45	50	15	15	25	25
					H6 (creosote)	45	45	90	90	25	25	45	45
					H6 (DBT)	50	50	100	100	25	25	50	50
	2	Calm	Untreated Hardwood	1	none	20	40	40	80	10	20	20	40
				2	none	6	10	10	20	2	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	45	45	80	15	25	25	45
					H6 (creosote)	30	50	60	100	15	25	30	50
					H6 (DBT)	35	50	70	>100	20	30	35	50
				2	H6 (CCA)	15	20	30	35	8	10	15	20
					H6 (creosote)	20	25	40	50	10	15	20	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				3	H6 (CCA)	15	15	25	30	7	8	15	15
					H6 (creosote)	20	25	40	45	10	10	20	25
					H6 (DBT)	25	25	45	50	15	15	25	25
				4	H6 (CCA)	10	15	20	25	6	7	10	15
					H6 (creosote)	20	20	35	40	10	10	20	20
					H6 (DBT)	20	25	45	45	10	15	20	25
			Treated Softwood	4	H6 (CCA)	15	15	30	30	8	8	15	15
					H6 (creosote)	25	30	50	50	15	15	25	30
					H6 (DBT)	30	30	60	60	15	15	30	30

Table 9.8: Typical service life of round piles in Hazard Zone E.

Hazard zone[(1)]	Salinity class[(2)]	Shelter class[(3)]	Timber	Marine borer resistance class[(4)]	Treatment[(5)]	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
E	2	Surf	Untreated Hardwood	1	none	35	70	70	>100	20	35	35	70
				2	none	9	15	20	35	5	9	9	15
			Treated Hardwood	1	H6 (CCA)	40	70	70	>100	20	35	40	70
					H6 (creosote)	50	80	100	>100	25	45	50	80
					H6 (DBT)	60	90	>100	>100	30	45	60	90
				2	H6 (CCA)	25	30	45	60	15	15	25	30
					H6 (creosote)	35	45	70	90	20	25	35	45
					H6 (DBT)	40	50	80	100	20	25	40	50
				3	H6 (CCA)	20	25	40	50	10	15	20	25
					H6 (creosote)	35	40	60	70	15	20	35	40
					H6 (DBT)	40	45	80	90	20	20	40	45
				4	H6 (CCA)	20	20	35	40	10	10	20	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	40	70	70	20	20	35	40
			Treated Softwood	4	H6 (CCA)	25	25	45	50	15	15	25	25
					H6 (creosote)	45	45	90	90	25	25	45	45
					H6 (DBT)	50	50	100	100	25	25	50	50
	3	Calm	Untreated Hardwood	1	none	20	40	40	80	10	20	20	40
				2	none	6	10	10	20	2	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	45	45	80	15	25	25	45
					H6 (creosote)	30	50	60	100	15	25	30	50
					H6 (DBT)	35	50	70	>100	20	30	35	50
				2	H6 (CCA)	15	20	30	35	8	10	15	20
					H6 (creosote)	20	25	40	50	10	15	20	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				3	H6 (CCA)	15	15	25	30	7	8	15	15
					H6 (creosote)	20	25	40	45	10	10	20	25
					H6 (DBT)	25	25	45	50	15	15	25	25
				4	H6 (CCA)	10	15	20	25	6	7	10	15
					H6 (creosote)	20	20	35	40	10	10	20	20
					H6 (DBT)	20	25	45	45	10	15	20	25
			Treated Softwood	4	H6 (CCA)	15	15	30	30	8	8	15	15
					H6 (creosote)	25	30	50	50	15	15	25	30
					H6 (DBT)	30	30	60	60	15	15	30	30
		Surf	Untreated Hardwood	1	none	35	70	70	>100	20	35	35	70
				2	none	9	15	20	35	5	9	9	15
			Treated Hardwood	1	H6 (CCA)	40	70	70	>100	20	35	40	70
					H6 (creosote)	50	80	100	>100	25	45	50	80
					H6 (DBT)	60	90	>100	>100	30	45	60	90
				2	H6 (CCA)	25	30	45	60	15	15	25	30
					H6 (creosote)	35	45	70	90	20	25	35	45
					H6 (DBT)	40	50	80	100	20	25	40	50
				3	H6 (CCA)	20	25	40	50	10	15	20	25
					H6 (creosote)	35	40	60	70	15	20	35	40
					H6 (DBT)	40	45	80	90	20	20	40	45
				4	H6 (CCA)	20	20	35	40	10	10	20	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	40	70	70	20	20	35	40
			Treated Softwood	4	H6 (CCA)	25	25	45	50	15	15	25	25
					H6 (creosote)	45	45	90	90	25	25	45	45
					H6 (DBT)	50	50	100	100	25	25	50	50

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1. DBT stands for double-treatment.

Table 9.9: Typical service life of round piles in Hazard Zone F.

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
F	1	Calm	Untreated Hardwood	1	none	15	25	25	50	8	15	15	25
				2	none	4	7	8	15	2	3	4	7
			Treated Hardwood	1	H6 (CCA)	15	30	30	60	9	15	15	30
					H6 (creosote)	20	35	40	70	10	20	20	35
					H6 (DBT)	25	35	45	70	15	20	25	35
				2	H6 (CCA)	10	15	20	25	5	7	10	15
					H6 (creosote)	15	20	30	35	8	10	15	20
					H6 (DBT)	20	20	35	40	9	10	20	20
				3	H6 (CCA)	9	10	15	20	5	6	9	10
					H6 (creosote)	15	15	25	30	8	9	15	15
					H6 (DBT)	15	20	30	35	9	10	15	20
				4	H6 (CCA)	8	9	15	15	5	5	8	9
					H6 (creosote)	15	15	25	25	7	8	15	15
					H6 (DBT)	15	15	30	30	9	9	15	15
			Treated Soft-wood	4	H6 (CCA)	10	10	20	20	5	6	10	10
					H6 (creosote)	20	20	35	35	10	10	20	20
					H6 (DBT)	20	20	40	40	10	10	20	20
		Surf	Untreated Hardwood	1	none	25	45	45	90	10	25	25	45
				2	none	6	10	10	25	3	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	50	50	90	15	25	25	50
					H6 (creosote)	35	60	70	>100	20	30	35	60
					H6 (DBT)	40	60	70	>100	20	30	40	60
				2	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	45	60	15	15	25	30
					H6 (DBT)	30	35	50	70	15	15	30	35
				3	H6 (CCA)	15	20	25	35	8	9	15	20
					H6 (creosote)	25	25	45	50	10	15	25	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				4	H6 (CCA)	15	15	25	25	7	8	15	15
					H6 (creosote)	20	20	40	40	10	10	20	20
					H6 (DBT)	25	25	50	50	15	15	25	25
			Treated Soft-wood	4	H6 (CCA)	15	20	30	35	9	9	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	60	70	15	20	35	35
	2	Calm	Untreated Hardwood	1	none	15	25	25	50	8	15	15	25
				2	none	4	7	8	15	2	3	4	7
			Treated Hardwood	1	H6 (CCA)	15	30	30	60	9	15	15	30
					H6 (creosote)	20	35	40	70	10	20	20	35
					H6 (DBT)	25	35	45	70	15	20	25	35
				2	H6 (CCA)	10	15	20	25	5	7	10	15
					H6 (creosote)	15	20	30	35	8	10	15	20
					H6 (DBT)	20	20	35	40	9	10	20	20
				3	H6 (CCA)	9	10	15	20	5	6	9	10
					H6 (creosote)	15	15	25	30	8	9	15	15
					H6 (DBT)	15	20	30	35	9	10	15	20
				4	H6 (CCA)	8	9	15	15	5	5	8	9
					H6 (creosote)	15	15	25	25	7	8	15	15
					H6 (DBT)	15	15	30	30	9	9	15	15
			Treated Soft-wood	4	H6 (CCA)	10	10	20	20	5	6	10	10
					H6 (creosote)	20	20	35	35	10	10	20	20
					H6 (DBT)	20	20	40	40	10	10	20	20

Table 9.9** (continued)**: Typical service life of round piles in Hazard Zone F.

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
F	2	Surf	Untreated Hardwood	1	none	25	45	45	90	10	25	25	45
				2	none	6	10	10	25	3	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	50	50	90	15	25	25	50
					H6 (creosote)	35	60	70	>100	20	30	35	60
					H6 (DBT)	40	60	70	>100	20	30	40	60
				2	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	45	60	15	15	25	30
					H6 (DBT)	30	35	50	70	15	15	30	35
				3	H6 (CCA)	15	20	25	35	8	9	15	20
					H6 (creosote)	25	25	45	50	10	15	25	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				4	H6 (CCA)	15	15	25	25	7	8	15	15
					H6 (creosote)	20	20	40	40	10	10	20	20
					H6 (DBT)	25	25	50	50	15	15	25	25
			Treated Softwood	4	H6 (CCA)	15	20	30	35	9	9	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	60	70	15	20	35	35
	3	Calm	Untreated Hardwood	1	none	15	25	25	50	8	15	15	25
				2	none	4	7	8	15	2	3	4	7
			Treated Hardwood	1	H6 (CCA)	15	30	30	60	9	15	15	30
					H6 (creosote)	20	35	40	70	10	20	20	35
					H6 (DBT)	25	35	45	70	15	20	25	35
				2	H6 (CCA)	10	15	20	25	5	7	10	15
					H6 (creosote)	15	20	30	35	8	10	15	20
					H6 (DBT)	20	20	35	40	9	10	20	20
				3	H6 (CCA)	9	10	15	20	5	6	9	10
					H6 (creosote)	15	15	25	30	8	9	15	15
					H6 (DBT)	15	20	30	35	9	10	15	20
				4	H6 (CCA)	8	9	15	15	5	5	8	9
					H6 (creosote)	15	15	25	25	7	8	15	15
					H6 (DBT)	15	15	30	30	9	9	15	15
			Treated Softwood	4	H6 (CCA)	10	10	20	20	5	6	10	10
					H6 (creosote)	20	20	35	35	10	10	20	20
					H6 (DBT)	20	20	40	40	10	10	20	20
		Surf	Untreated Hardwood	1	none	25	45	45	90	10	25	25	45
				2	none	6	10	10	25	3	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	50	50	90	15	25	25	50
					H6 (creosote)	35	60	70	>100	20	30	35	60
					H6 (DBT)	40	60	70	>100	20	30	40	60
				2	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	45	60	15	15	25	30
					H6 (DBT)	30	35	50	70	15	15	30	35
				3	H6 (CCA)	15	20	25	35	8	9	15	20
					H6 (creosote)	25	25	45	50	10	15	25	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				4	H6 (CCA)	15	15	25	25	7	8	15	15
					H6 (creosote)	20	20	40	40	10	10	20	20
					H6 (DBT)	25	25	50	50	15	15	25	25
			Treated Softwood	4	H6 (CCA)	15	20	30	35	9	9	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	60	70	15	20	35	35

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1. DBT stands for double-treatment.

Table 9.10: Typical service life of round piles in Hazard Zone G.

Hazard zone[1]	Salinity class[2]	Shelter class[3]	Timber	Marine borer resistance class[4]	Treatment[5]	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
G	1	Calm	Untreated Hardwood	1	none	15	25	25	50	8	15	15	25
				2	none	4	7	8	15	2	3	4	7
			Treated Hardwood	1	H6 (CCA)	15	30	30	60	9	15	15	30
					H6 (creosote)	20	35	40	70	10	20	20	35
					H6 (DBT)	25	35	45	70	15	20	25	35
				2	H6 (CCA)	10	15	20	25	5	7	10	15
					H6 (creosote)	15	20	30	35	8	10	15	20
					H6 (DBT)	20	20	35	40	9	10	20	20
				3	H6 (CCA)	9	10	15	20	5	6	9	10
					H6 (creosote)	15	15	25	30	8	9	15	15
					H6 (DBT)	15	20	30	35	9	10	15	20
				4	H6 (CCA)	8	9	15	15	5	5	8	9
					H6 (creosote)	15	15	25	25	7	8	15	15
					H6 (DBT)	15	15	30	30	9	9	15	15
			Treated Soft-wood	4	H6 (CCA)	10	10	20	20	5	6	10	10
					H6 (creosote)	20	20	35	35	10	10	20	20
					H6 (DBT)	20	20	40	40	10	10	20	20
		Surf	Untreated Hardwood	1	none	25	45	45	90	10	25	25	45
				2	none	6	10	10	25	3	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	50	50	90	15	25	25	50
					H6 (creosote)	35	60	70	>100	20	30	35	60
					H6 (DBT)	40	60	70	>100	20	30	40	60
				2	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	45	60	15	15	25	30
					H6 (DBT)	30	35	50	70	15	15	30	35
				3	H6 (CCA)	15	20	25	35	8	9	15	20
					H6 (creosote)	25	25	45	50	10	15	25	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				4	H6 (CCA)	15	15	25	25	7	8	15	15
					H6 (creosote)	20	20	40	40	10	10	20	20
					H6 (DBT)	25	25	50	50	15	15	25	25
			Treated Soft-wood	4	H6 (CCA)	15	20	30	35	9	9	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	60	70	15	20	35	35
	2	Calm	Untreated Hardwood	1	none	15	25	25	50	8	15	15	25
				2	none	4	7	8	15	2	3	4	7
			Treated Hardwood	1	H6 (CCA)	15	30	30	60	9	15	15	30
					H6 (creosote)	20	35	40	70	10	20	20	35
					H6 (DBT)	25	35	45	70	15	20	25	35
				2	H6 (CCA)	10	15	20	25	5	7	10	15
					H6 (creosote)	15	20	30	35	8	10	15	20
					H6 (DBT)	20	20	35	40	9	10	20	20
				3	H6 (CCA)	9	10	15	20	5	6	9	10
					H6 (creosote)	15	15	25	30	8	9	15	15
					H6 (DBT)	15	20	30	35	9	10	15	20
				4	H6 (CCA)	8	9	15	15	5	5	8	9
					H6 (creosote)	15	15	25	25	7	8	15	15
					H6 (DBT)	15	15	30	30	9	9	15	15
			Treated Soft-wood	4	H6 (CCA)	10	10	20	20	5	6	10	10
					H6 (creosote)	20	20	35	35	10	10	20	20
					H6 (DBT)	20	20	40	40	10	10	20	20

Table 9.10** (continued)**: Typical service life of round piles in Hazard Zone G.

Hazard zone(1)	Salinity class(2)	Shelter class(3)	Timber	Marine borer resistance class(4)	Treatment(5)	Typical service life (years)							
						Construction type A*		Construction type B*		Construction type C*		Construction type D*	
						300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia	300mm dia	400mm dia
G	2	Surf	Untreated Hardwood	1	none	25	45	45	90	10	25	25	45
				2	none	6	10	10	25	3	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	50	50	90	15	25	25	50
					H6 (creosote)	35	60	70	>100	20	30	35	60
					H6 (DBT)	40	60	70	>100	20	30	40	60
				2	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	45	60	15	15	25	30
					H6 (DBT)	30	35	50	70	15	15	30	35
				3	H6 (CCA)	15	20	25	35	8	9	15	20
					H6 (creosote)	25	25	45	50	10	15	25	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				4	H6 (CCA)	15	15	25	25	7	8	15	15
					H6 (creosote)	20	20	40	40	10	10	20	20
					H6 (DBT)	25	25	50	50	15	15	25	25
			Treated Soft-wood	4	H6 (CCA)	15	20	30	35	9	9	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	60	70	15	20	35	35
	3	Calm	Untreated Hardwood	1	none	15	25	25	50	8	15	15	25
				2	none	4	7	8	15	2	3	4	7
			Treated Hardwood	1	H6 (CCA)	15	30	30	60	9	15	15	30
					H6 (creosote)	20	35	40	70	10	20	20	35
					H6 (DBT)	25	35	45	70	15	20	25	35
				2	H6 (CCA)	10	15	20	25	5	7	10	15
					H6 (creosote)	15	20	30	35	8	10	15	20
					H6 (DBT)	20	20	35	40	9	10	20	20
				3	H6 (CCA)	9	10	15	20	5	6	9	10
					H6 (creosote)	15	15	25	30	8	9	15	15
					H6 (DBT)	15	20	30	35	9	10	15	20
				4	H6 (CCA)	8	9	15	15	5	5	8	9
					H6 (creosote)	15	15	25	25	7	8	15	15
					H6 (DBT)	15	15	30	30	9	9	15	15
			Treated Soft-wood	4	H6 (CCA)	10	10	20	20	5	6	10	10
					H6 (creosote)	20	20	35	35	10	10	20	20
					H6 (DBT)	20	20	40	40	10	10	20	20
		Surf	Untreated Hardwood	1	none	25	45	45	90	10	25	25	45
				2	none	6	10	10	25	3	5	6	10
			Treated Hardwood	1	H6 (CCA)	25	50	50	90	15	25	25	50
					H6 (creosote)	35	60	70	>100	20	30	35	60
					H6 (DBT)	40	60	70	>100	20	30	40	60
				2	H6 (CCA)	15	20	30	40	8	10	15	20
					H6 (creosote)	25	30	45	60	15	15	25	30
					H6 (DBT)	30	35	50	70	15	15	30	35
				3	H6 (CCA)	15	20	25	35	8	9	15	20
					H6 (creosote)	25	25	45	50	10	15	25	25
					H6 (DBT)	25	30	50	60	15	15	25	30
				4	H6 (CCA)	15	15	25	25	7	8	15	15
					H6 (creosote)	20	20	40	40	10	10	20	20
					H6 (DBT)	25	25	50	50	15	15	25	25
			Treated Soft-wood	4	H6 (CCA)	15	20	30	35	9	9	15	20
					H6 (creosote)	30	30	60	60	15	15	30	30
					H6 (DBT)	35	35	60	70	15	20	35	35

** Construction types A, B, C, and D indicate the construction features of the piles, defined as follows:*
A refers to piles stand-alone without contact with other structure element, having no maintenance measure applied.
B refers to piles stand-alone, having plastic wrap or floating collar as maintenance measure applied.
C refers to piles in contact with other element (e.g. X-brace), having no maintenance measure applied.
D refers to piles in contact with other element (e.g. X-brace) , having plastic wrap or floating collar as maintenance measure applied.
1. Hazard zone is defined in Figure 9.1.
2. Salinity class is defined in Table 9.2.
3. Shelter class is defined in Table 9.3.
4. Durability class is defined in Table 9.1.
5. H6 treatment levels are in accordance with AS 1604.1. DBT stands for double-treatment.

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- Drs John Thornton and Gary Johnson – in and above ground decay, pathology and field calibration
- Dr Laurie Cookson – marine borer and termite research
- Dr John French and Mr Jim Creffield – termite studies
- Mr Craig Seath – field calibration, laboratory studies and logistics
- Ms Sandra Roberts – administration and preparation of technical reports

Images:

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References

L. J. Cookson, CSIRO-DFFP, Marine Borers and Timber Piling Options.

Leicester, R.H., Wang, C-H. and Nguyen, M.N. "Manual No. 8: Termite attack."

National Association of Forest Industries, Timber Manual – Timber Datafile P4 'Timber – Design for Durability' NAFI, Canberra, 1989.

Nguyen, M.N., Leicester, R.H. and Wang, C-H. "Manual No. 5: Atmospheric corrosion of fasteners in timber structures."

Nguyen, M.N., Leicester, R.H. and Wang, C-H. "Manual No. 6: Embedded corrosion of fasteners in timber structures."

Nguyen, M.N., Leicester, R.H. and Wang, C-H. "Manual No. 7: Marine borer attack."

Nguyen, M.N., Leicester, R.H. and Wang, C-H. "Manual No. 9: Service Life Models for timber structures protected by a building envelope."

Standards Australia AS 1720.1 – Timber Structures – Design Methods. SAI Global Sydney, 1997.

Standards Australia AS 1720.2 – Timber Structures – Timber Properties. SAI Global Sydney, 1990.

Standards Australia AS 1720.4 – Timber Structures – Fire Resistance of Structural Timber Members. SAI Global Sydney, 1990

Standards Australia AS 1604.1 – Specification for Preservative Treatment – Sawn and Round Timber. SAI Global, Sydney, 2005.

Standards Australia AS/NZS 2312 – Guide to the Protection of Structural Steel against Atmospheric Corrosion by the use of Protective Coatings. SAI Global, Sydney, 2002.

Standards Australia AS 5604 – Timber – Natural Durability Ratings. SAI Global, Sydney, 2005.

Wang, C-H., Leicester, R.H. and Nguyen, M.N. "Manual No. 3: Decay in ground contact."

Wang, C-H., Leicester, R.H. and Nguyen, M.N. "Manual No. 4: Decay above ground."

Wang, C-H., Leicester, R.H. and Nguyen, M.N. "Manual No. 11: Equations for use in a service life design guide."

Appendix 1
Definitions – Exposed Corrosion

The coastal exposure condition is defined by the opening angle, θ (degrees), and radius, R (km), of a bay as shown in Figure A.1.1. The exposure factor for the idealised bay, abay , is calculated as follows:

$$\alpha_{bay}^2 = \left(\frac{\theta}{85}\right)^2 + \left(\frac{R}{20}\right)^2$$

The coastal exposure condition is then defined as follows:

For $\alpha_{bay} < 1$	CLOSED BAY
For $1 < \alpha_{bay} < 1.5$	PARTIALLY CLOSED BAY
For $1.5 < \alpha_{bay} < 2.5$	OPEN BAY
For $\alpha_{bay} > 2.5$	OPEN SURF

These coastal exposure factors, and associated exposure conditions are shown plotted in Figure A.1.1.

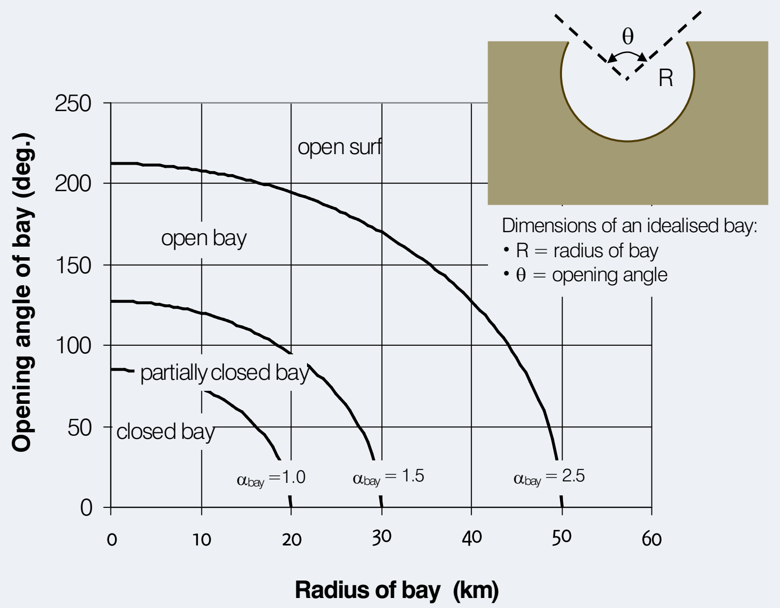

Figure A.1.1: Coastal exposure condition.

Appendix 2
Termites

Description of hazard parameters

Table A.2.1 shows in quantitative terms some typical distributions of wood corresponding to low, medium and high hazard levels of termite attack. For other distributions of wood, suitable estimates may be made through interpolation of these values.

Table A.2.1: Definition of hazard assessment due to occurrence of wood in the garden and under the house.

Hazard class	Number of potential nesting sites(1)	Typical distance between substantial food source (m)(2)
Low	<2	>20
Medium	2-5	5-20
High	>5	<5

(1) Examples of potential nesting sites

The following refers to potential nest sites for harbouring mature colonies which are not more than 50 m from the building.

- Tree (diameter larger than 300 mm)
- Tree stump or untreated pole (diameter larger than 200 mm)
- Untreated landscape timber (e.g., sleepers, retaining walls, length >1.0 m, height >0.5 m)
- Woodheap (height >0.5 m, ground contact area 0.5 x 0.5 m, length of periods that bottom layer woodheap is untouched >1 year)
- Compost heap
- Wood "stepping stones"
- Subfloor storage (height >0.5 m, ground contact area >0.5 x 0.5 m, length of period which it is untouched >1 year).
- Solid infill under a verandah
- Any part of a building with water leaking under it

(2) Example of a substantial food source

A typical example of a substantial food source would be a piece of timber non termite resistant timber equal to or greater than 200 × 50 mm lying in ground contact.

Table A.2.2 gives examples of building construction that leads to high, medium and low hazard of termite attack related to ground contact characteristics.

Table A.2.2: Examples of hazard assessment due to the nature of the ground contact of a house.

Hazard class	Ground contact elements
Low	• House supported by exposed concrete piers or steel stumps more than 2 m high
Medium	• Intact concrete slab on ground with slab edge exposure for visual inspection; • House on stumps less than 600 mm high with ant caps and made of concrete or treated timber(1) or heartwood of termite and decay resistant timber(2)
High	• Construction does not comply with AS 3660.1 • Building not inspective according to AS 3660.2 • Concealed entry zones of any type • Floor connected to ground by stair cases of untreated softwood, untreated non-durable timber(3), untreated sapwood of durable timber; • Attached patio with solid infill • Concrete slab-on-ground with large cracks and/or unprotected pipe penetrations • Floors connected to ground by elements containing hidden cavities (e.g. masonry construction, deeply grooved elements, members in imperfect contact). • Brick veneer house with non slab edge exposure • Leakage of moisture to ground • Suspended floor less than 600 mm off the ground and no chemical or physical barriers installed under floor.

Notes:
1. Treated timber refers to timber treated according to AS 1604.1-2005 [7].
2. For a listing of timber durability classes 1 and 2, see AS 5604-2005 [9].
3. For a listing of non-durable timber of classes 3 and 4 see AS 5604-2005 [9].

Table A.2.3 gives examples of high, medium and low hazard of termite attack related to the type of material used for construction.

Table A.2.3: Examples of hazard assessment related to the type of construction material used.

Hazard class	Type of construction material attacked
Low	• Treated timber(1) • Untreated heartwood of Termite Resistant timber(2)
Medium	• Untreated heartwood of other timber with in-ground durability class 1 or 2(2)
High	• Untreated timber of durability classes 3 and 4(2) • Untreated sapwood of all species • Composite wood boards

Notes:
1. Treated timber refers to timber treated in accordance AS 1604.1-2005 to H2 level or higher [7].
2. For durability classes, see AS 5604-2005 [9].

Table A.2.4 gives a method for assessing the hazard due to the nature of exposure of timber.

Table A.2.4: Examples of hazard related to environment favourable to termites.

Hazard class	Environment favourable to termites
Low	• High human activity • High up a building • Humidity $<$30%
Medium	• Exposed to rain
High	• No disturbance and dark (e.g. wall stud, double leaf masonry wall, roof member.) • Exposed to sources of moisture so as to be periodically wet • Abandoned houses or mostly vacant holiday houses • Humidity $>$90%

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Notes

Notes

06

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Timber-framed Construction

Sacrificial Timber Construction Joint

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Table of Contents

1 Introduction

In lightweight timber-framed buildings, fire protection is generally achieved by the use of fire-resistant linings. Due to the sequencing of trades in constructing fire and sound-rated timber-framed buildings, it is not always possible to provide complete coverage with fire-resistant linings, as framing elements often get in the way.

The National Construction Code – Building Code of Australia also has a requirement that a construction joint, which is what is being described here (Provision C3.16, Volume 1) is required to be fire-resisting with respect to integrity and insulation.

Solid timber has been researched and tested and has been shown in some cases to provide equivalent or better performance than fire-resistant linings. It is mainly used where linings stop at junctions between walls, roofs, ceilings and floor elements, or where walls abut other walls.

This Guide provides standard details for common locations where timber sacrificial blocks can be used to form these construction joints in walls and floors for Fire Resistance Levels of 60/60/60 and 90/90/90.

2 Scope

The Guide provides typical details where sacrificial-timber blocks are commonly used to maintain Fire Resistance Levels. This Guide provides typical thickness details and locations for sacrificial-timber blocks as well as any other associated construction needs to support nearby linings or to fill-related voids.

3 Assessment and Testing

Appendix A lists the assessments and tests that have been used to support the details in this Guide. The critical assessment that is used to draw together all the various research reports is Warringtonfire Aust report 22221A – Performance of various MRTFC roof, wall or floor junctions if tested in accordance with AS1530.4-2014.

4 How to Use This Guide

The Guide contains details that are illustrations only. Each illustration's detail has either been through a test or an assessment that supports its use has been made. Refer to Appendix A for reference to reports and assessments used to support these details.

The purpose of this Guide is to provide the foundation to the details used in WoodSolutions Technical Design Guide #1 – Timber-Framed Constructions for Townhouse Buildings Class 1a and #2 – Timber-Framed Constructions for Multi-Residential Buildings Class 2 and 3.

The details contained in each illustration have three essential elements:

- what it is protecting
- thickness and location of timber blocks required
- any associated construction such as metal angle or fire-grade mineral wool.

5 Junctions between Building Elements

Due to the number of building classifications and types of construction covered by this Guide, there is a variety of situations when the wall, ceiling, roof and floor elements may require the maintenance of the fire and sound rating.

In these cases, solid-timber blocking is used as an equivalent to fire-protective linings; the thicker the blocks, the greater the Fire Resistance Level achieved. In timber-framed construction, this is an important means of making fire-resisting joints between walls and roof, ceiling and floor elements as well as junctions of walls with walls. Refer to Figure 1 for general locations where timber blocks can be used.

Such joints are generally only required where there is a break in the fire-protective lining, and this generally excludes situations where two elements with the same Fire Resistance Level (FRL) intersect. Instead, the emphasis is on junctions between non-fire-rated elements and fire-rated elements, or elements of lower fire rating meeting elements with a higher fire rating.

The following details show typical construction practices that can be used to provide fire resistance continuity. The principles described in this Guide can be used for situations not covered by this Guide but which are consistent with the Guide's intent.

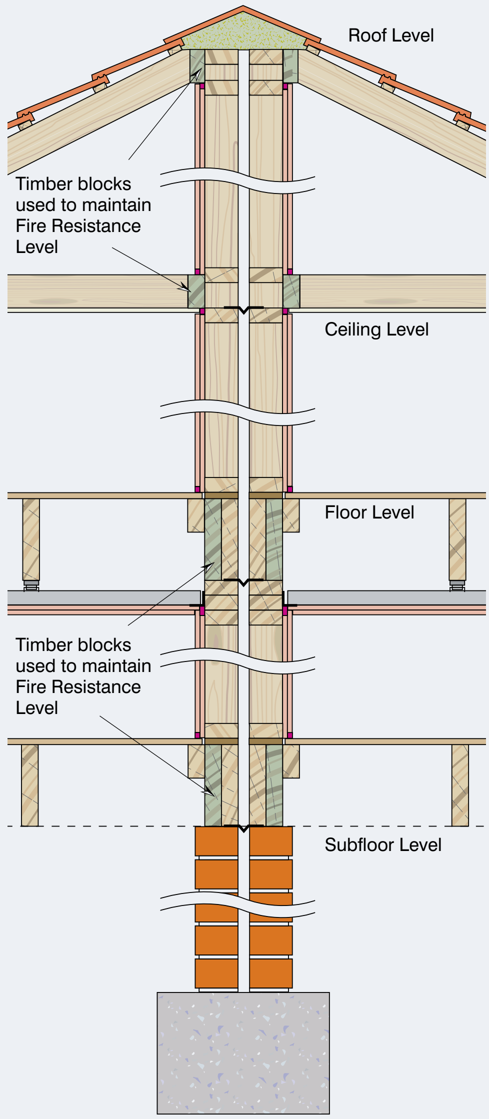


Figure 1: Common locations of sacrificial-timber blocking – elevation view.

6 The Intersection of Building Elements with Equivalent Fire Resistance Levels

Where building elements have equivalent Fire Resistance Levels, there is no requirement to continue the fire rating through the intersections. Often in these situations, a cavity barrier is required to limit the spread of fire, heat and smoke within a fire-rated cavity. The construction details on cavity barriers depend on the deemed-to-satisfy building regulation being followed. Refer to WoodSolutions Technical Design Guide #2 or #37 for details of cavity barriers that meet the deemed-to-satisfy building regulation being used.

6.1 Use of Sacrificial-Timber Blocking

The quantity and thickness of sacrificial-timber blocks depend on the difference in Fire Resistance Levels of the two elements that abut each other. The National Construction Code – Building Code of Australia requires different Fire Resistance Levels for various building elements, depending on their situation, such as:

- rise in storeys
- if sprinklers are included
- if contained within a specific area
- if the element is loadbearing or non-loadbearing
- location of the exterior wall from boundary or neighbouring building.

There may be places where non-fire-rated elements or lower-fire-rated elements will abut fire-rated elements.

This Guide details common locations where junctions are required to maintain a Fire Resistance Level of 60/60/60 and 90/90/90. Each detail will indicate the level of fire resistance it can achieve. In general terms only, a Fire Resistance Level of 60/60/60 requires the use of overlapping timber blocks having a minimum thickness of 45 mm. For a Fire Resistance Level of 90/90/90, the use of at least two overlapping timber blocks having a minimum thickness of 45 mm and the addition of metal angle of the minimum dimension of 35 x 35 x 0.75 mm is required. Each detail must be referred to for the specific requirements.

Timber blocks are to be arranged so that they are continuous. Where they are required to be joined, they must be arranged so that the joint is backed by a block of timber with similar thickness. Where two timber blocks are used for the 90 minutes Fire Resistant Level system, no joint is to occur within 100 mm.

Details presented in this Guide are applicable for double-stud as well as single stud construction, unless noted otherwise. For construction details of the fire-rated floor, wall and ceiling systems refer to appropriate lining manufacturers.

6.2 General Material Requirements

6.2.1 Timber Blocks

Wherever timber blocks are referred to within this Guide, they are to be a minimum size as nominated on the figure and have a density of no less than 470 kg/m^3. Joints in blocking pieces must be backed by a similar thickness piece of timber with at least 100 mm projection beyond the joint.

6.2.2 Metal Angle

Wherever metal angles are referred to within this Guide, they are to be made from galvanised steel and be a minimum size 35 x 35 x 0.7 BMT.

6.2.3 Mineral Wool

Wherever mineral wool is referred to within this Guide, the mineral wool must have a fusion temperature in excess of 1,120°C.

6.3 Roofs

6.3.1 Timber Rafter Roof Rafter and Ceiling Joist Elements Supported off Timber Blocks – FRL 60 Minutes

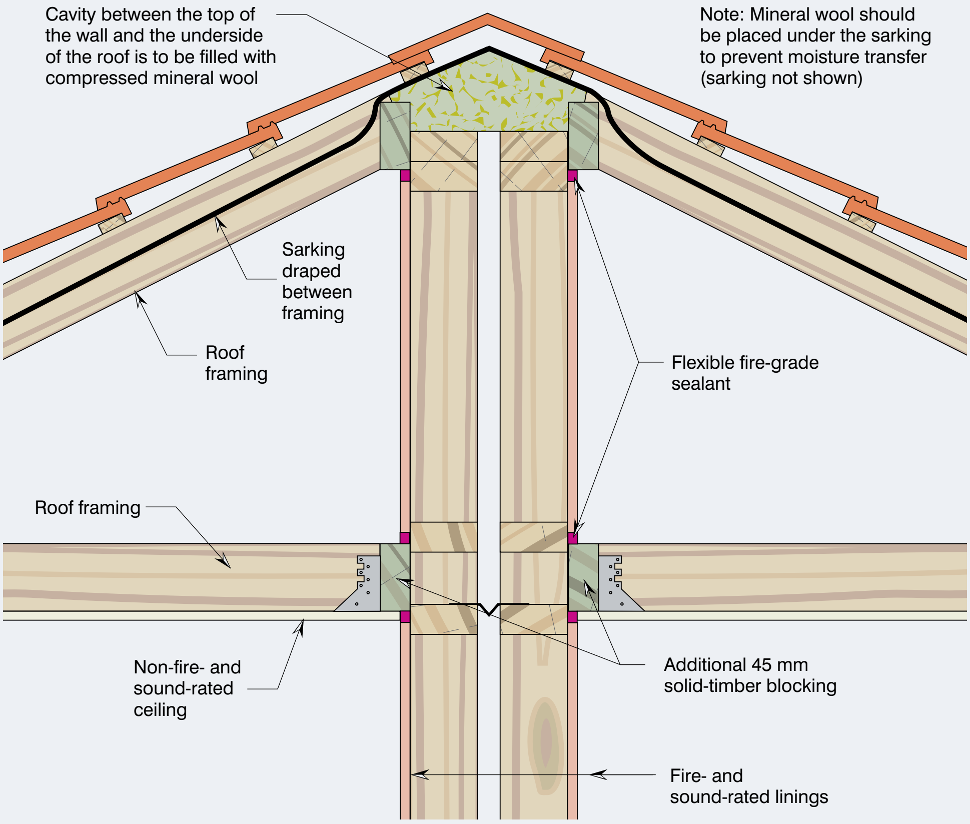


Figure 2: Timber roof rafter and ceiling joist supported off sacrificial-timber blocks – FRL 60 minutes – elevation view.

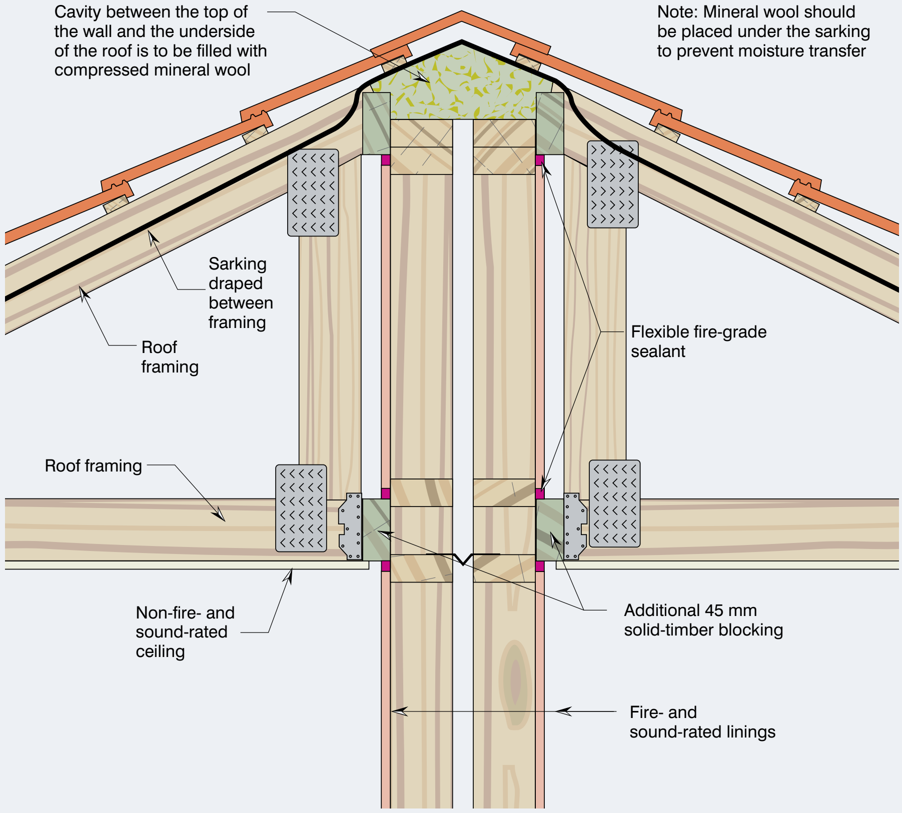


Figure 3: Timber trusses supported off sacrificial-timber blocks – FRL 60 minutes – elevation view.

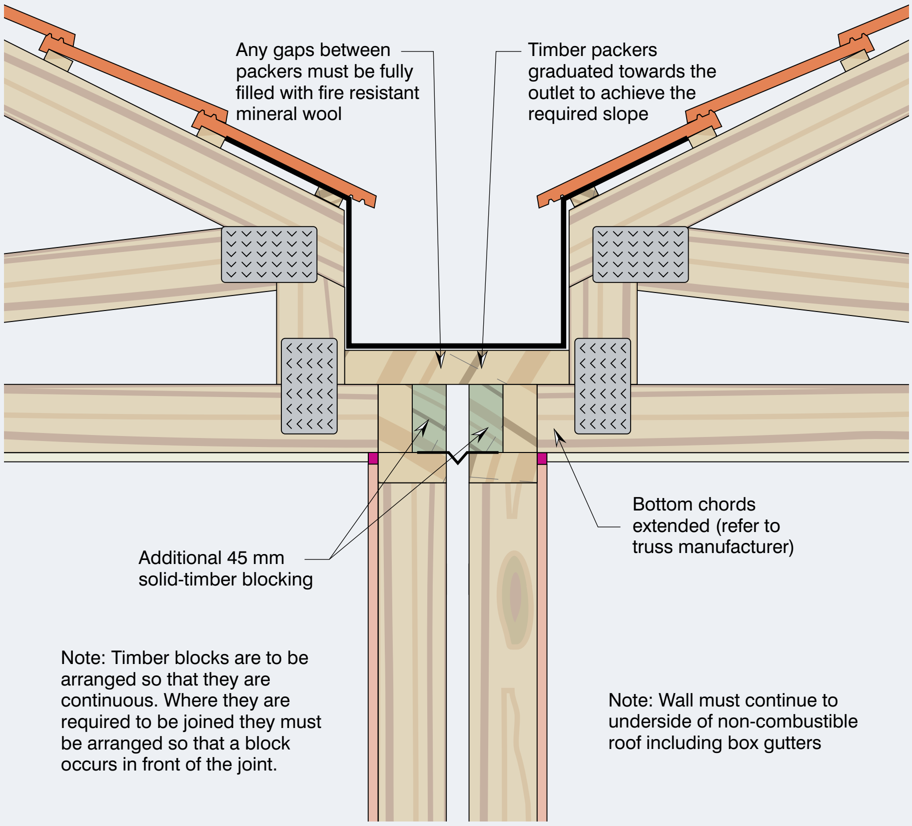


Figure 4: Timber trusses supported off sacrificial-timber blocks at box gutter – FRL 60 minutes – elevation view.

6.4 Interior Walls

6.4.1 Non-Fire-Rated Wall Abutting Fire- and Sound-Rated Wall – FRL 60 Minutes

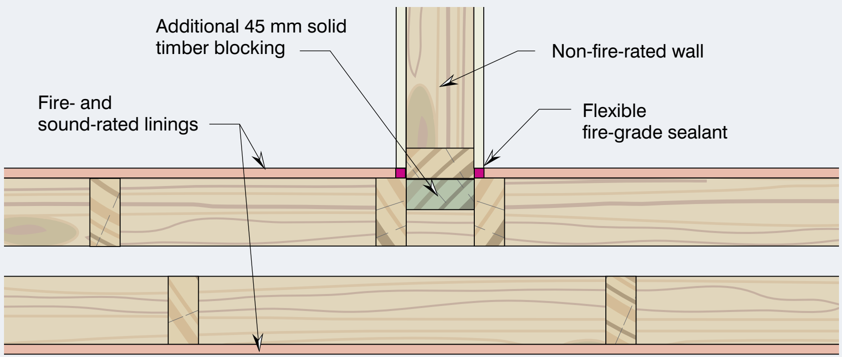


Figure 5: Non-fire-rated single stud wall abutting fire- and sound-rated double stud wall using timber blocks – FRL 60 minutes – plan view.

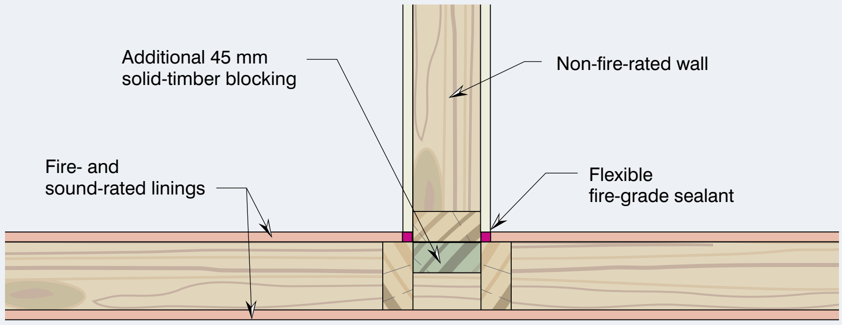


Figure 6: Non-fire-rated single stud wall abutting fire- and sound-rated single stud wall using timber blocks – FRL 60 minutes – plan view.

6.4.2 Non-Fire-Rated Wall Abutting Fire- and Sound-Rated Wall – FRL 90 Minutes

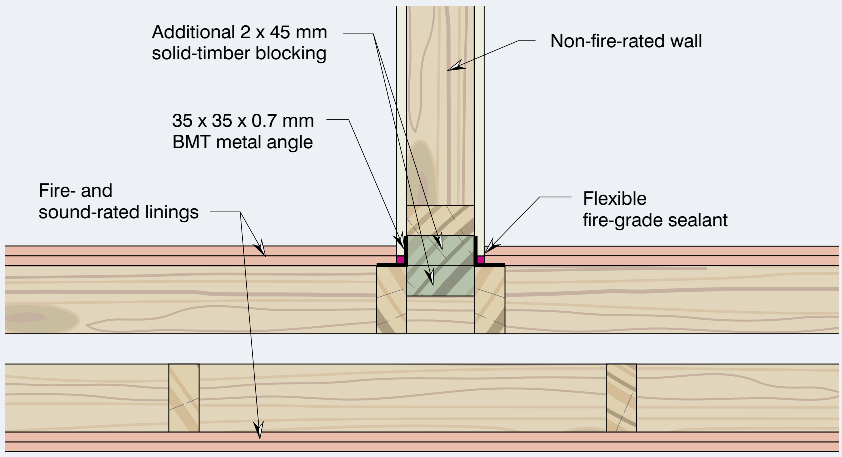


Figure 7: Non-fire-rated single stud wall abutting fire- and sound-rated double stud wall using timber blocks – FRL 90 minutes – plan view.

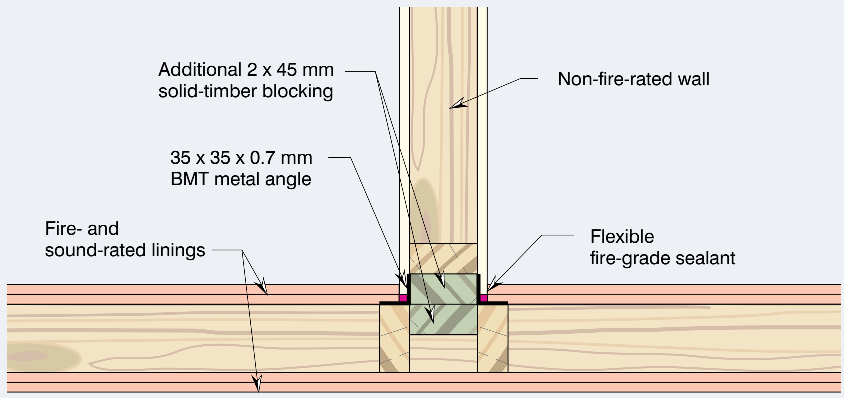


Figure 8: Non-fire-rated single stud wall abutting fire- and sound-rated single stud wall using timber blocks – FRL 90 minutes – plan view.

6.5 Exterior Walls

6.5.1 Sound- and Fire-Rated Wall Abutting Brick Veneer External Wall – FRL 60 Minutes

This detail is for the timber block element of this junction only. For detail on the fire-resistant mineral wool refer to manufacturers' requirements.

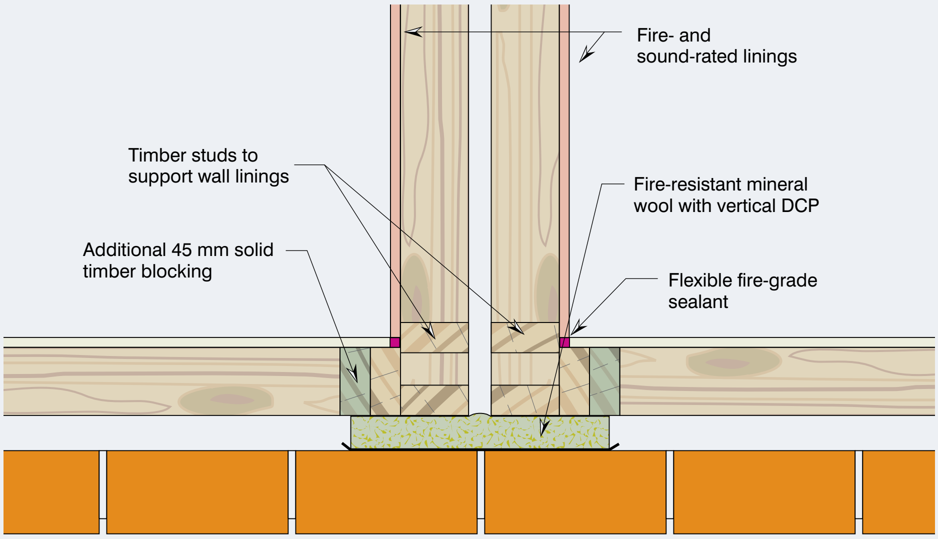


Figure 9: Fire- and sound- rated wall abutting a non-rated brick veneer cavity wall – FRL 60 minutes – plan view.

6.5.2 Sound- and Fire-Rated Wall Abutting Non-Fire-Rated Staggered Exterior Brick Veneer Wall – FRL 60 Minutes

This detail is for the timber block element of this junction only. For detail on the fire resistant mineral wool refer to manufacturers' requirements.

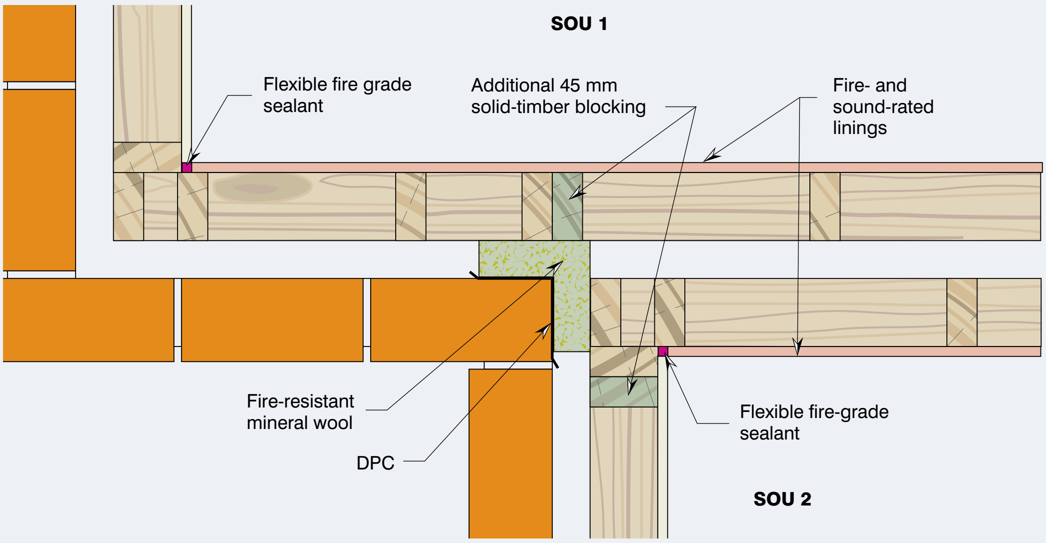


Figure 10: Fire- and sound-rated wall abutting a non-rated staggered brick veneer cavity wall – FRL 60 minutes – plan view.

6.5.3 Sound- and Fire-Rated Wall Abutting Non-Fire-Rated Exterior Lightweight Wall – FRL 60 Minutes

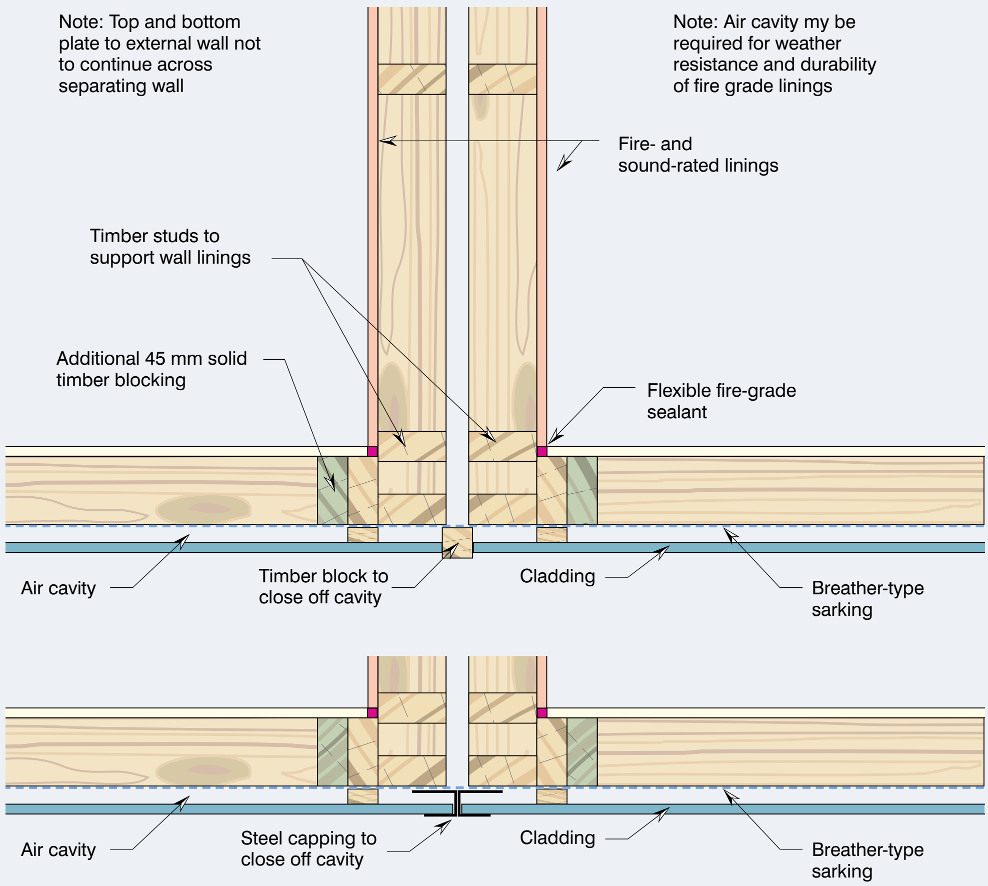


Figure 11: Fire- and sound-rated wall abutting a non-rated lightweight external wall – FRL 60 minutes – plan view.

6.6 Floors

6.6.1 Joist Parallel to Wall, Double Joist Detail – FRL 60 Minutes

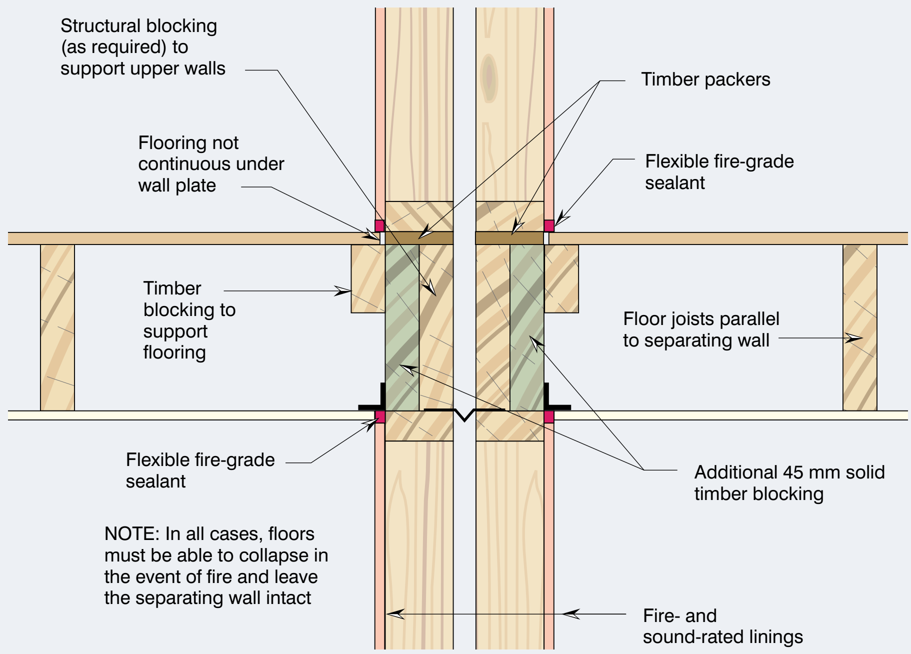


Figure 12: Joist parallel to wall – double joist detail – FRL 60 minutes – elevation view.

6.6.2 Joist Parallel to Wall, Double Joist Detail – FRL 90 Minutes

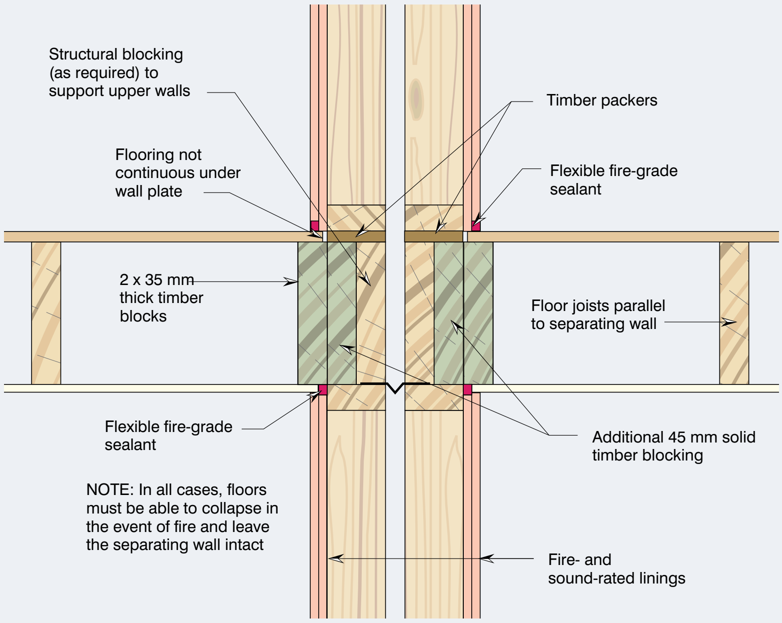


Figure 13: Joist parallel to wall, double joist detail – FRL 90 minutes – elevation view.

6.6.3 Joist Parallel to Wall, Wall Stud Through Junction – FRL 60 Minutes

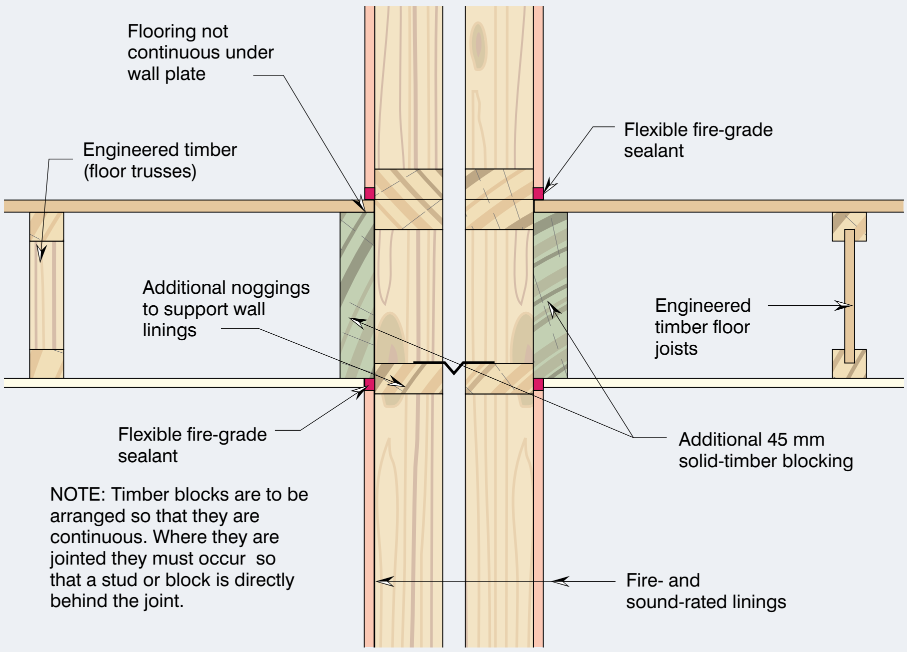


Figure 14: Joist parallel to wall, wall studs continuous through junction with timber blocks – FRL 60 minutes – elevation view.

6.6.4 Joist Parallel to Wall, Wall Stud Through Junction – FRL 90 Minutes

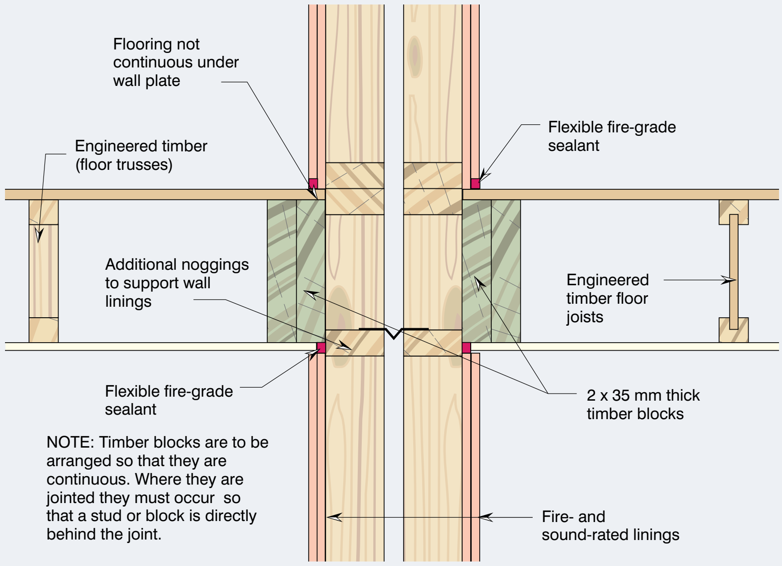


Figure 15: Joist parallel to the wall, wall studs continuous through the junction with timber blocks – FRL 90 minutes – elevation view.

6.6.5 Joist Perpendicular to Wall – FRL 60 Minutes

Detail for joist parallel to wall the same, except joists not supported off timber blocking.

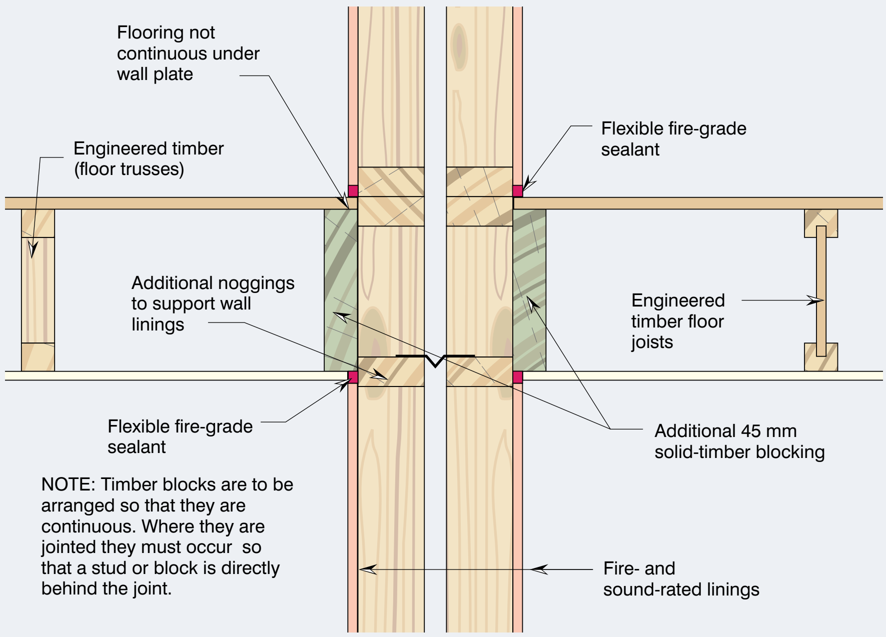


Figure 16: Joist perpendicular to the wall and supported off timber blocks – FRL 60 minutes – elevation view.

6.6.6 Joist Perpendicular to Wall – FRL 90 Minutes

Detail for joist parallel to wall the same, except joists not supported off timber blocking.

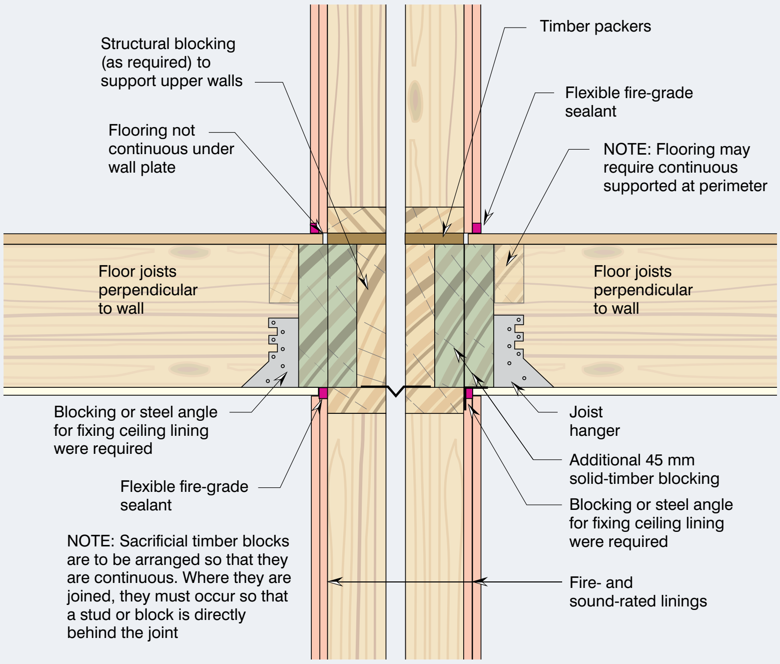


Figure 17: Joist perpendicular to wall and supported off timber blocks – FRL 90 minutes – elevation view.

6.6.7 Fire Pockets in Fire-Rated Walls – FRL 60 Minutes

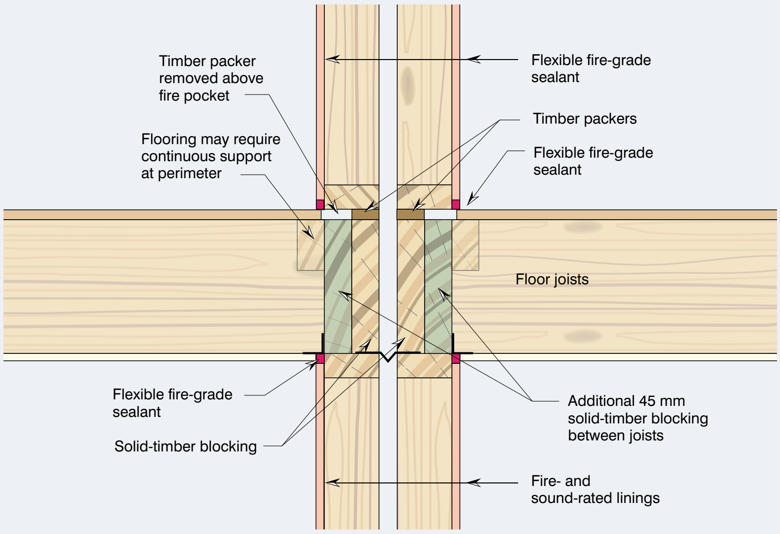


Figure 18: Joist supported by fire pockets in fire- and sound-rated wall – FRL 60 minutes – elevation view.

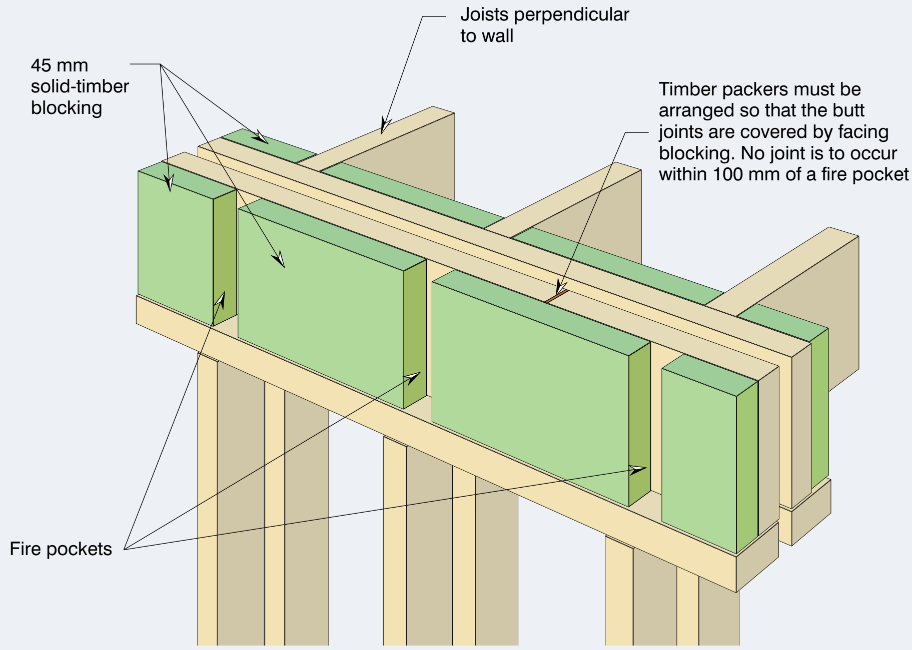


Figure 19: Fire pockets in fire- and sound-rated wall – FRL 60 minutes – elevation view.

6.6.8 Fire Pockets in Fire-Rated Walls – FRL 90 Minutes

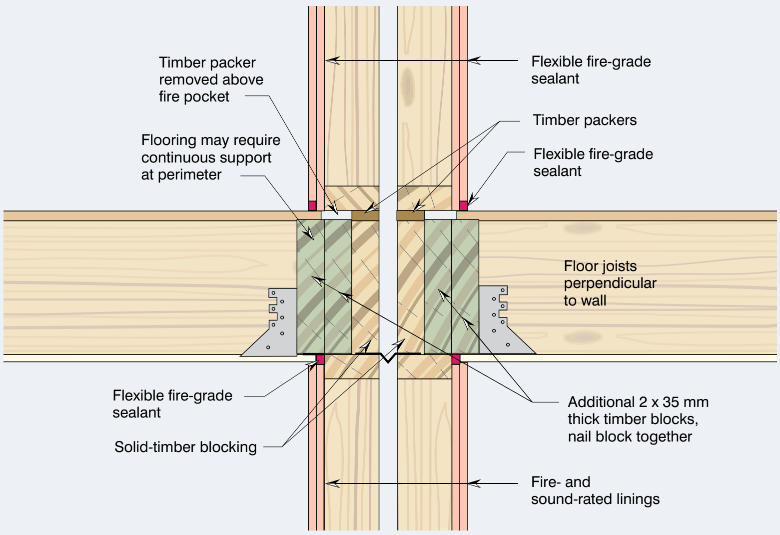


Figure 20: Joist supported by fire pockets in fire- and sound-rated wall – FRL 90 minutes – elevation view.

6.6.9 Fire Pocket Top Chord Support Detail for Floor Truss – FRL 60 Minutes

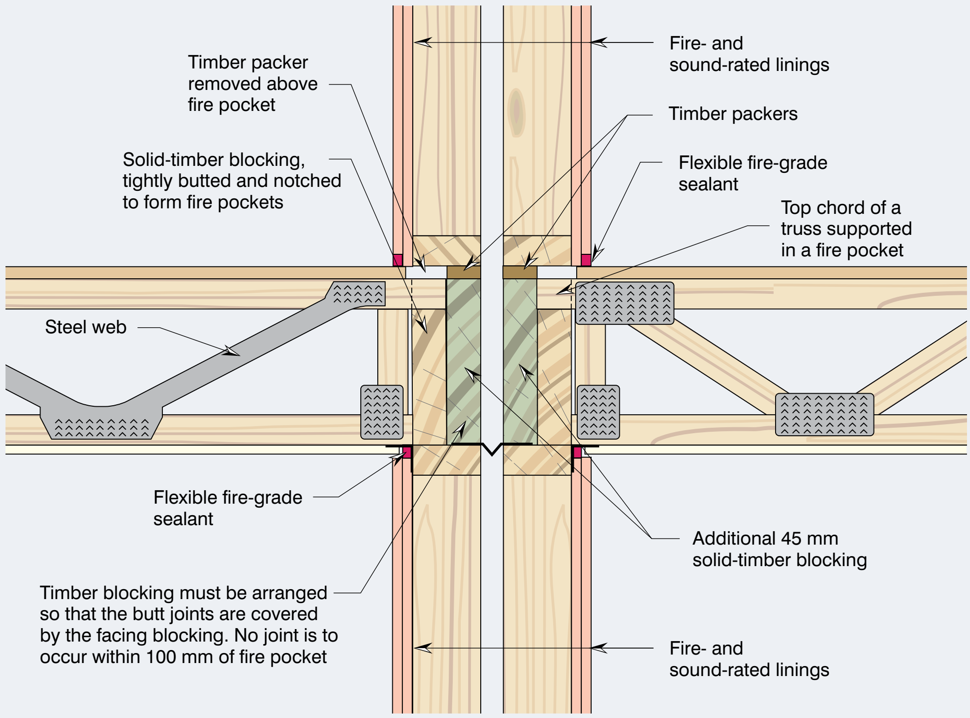


Figure 21: Floor truss supported by fire pockets in fire- and sound-rated wall – FRL 60 minutes – elevation view.

6.6.10 Fire Pocket Top Chord Support Detail for Floor Truss – FRL 90 Minutes

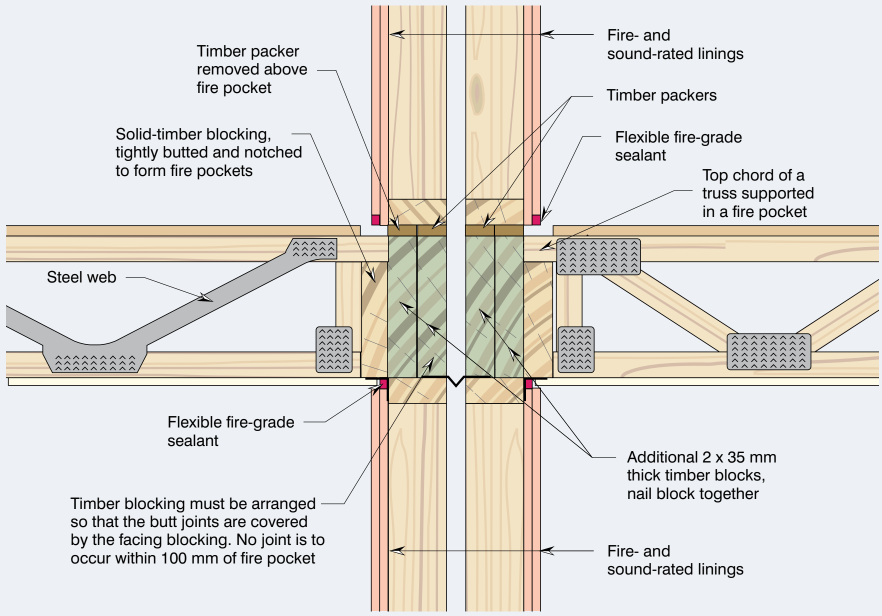


Figure 22: Floor truss supported by fire pockets in fire- and sound-rated wall – FRL 90 minutes – elevation view.

6.6.11 Floor Truss Top Chord Ledger Support Detail – FRL 60 Minutes

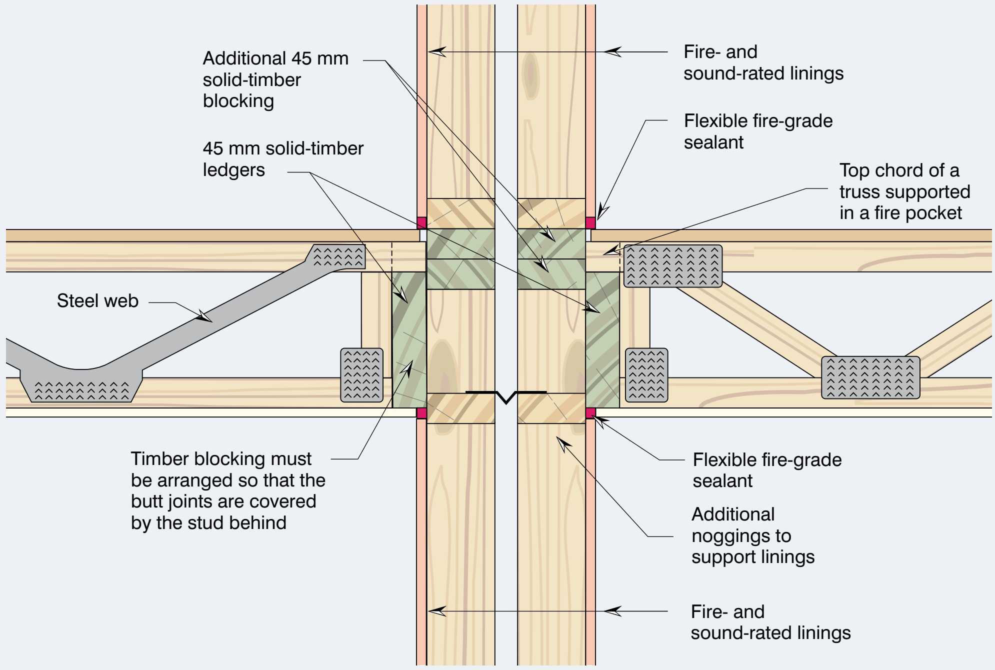


Figure 23: Floor truss supported on their top chords by ledger to the side of the fire- and sound-rated wall – FRL 60 minutes – elevation view.

6.6.12 Floor Truss Top Chord Ledger Support Detail – FRL 90 Minutes

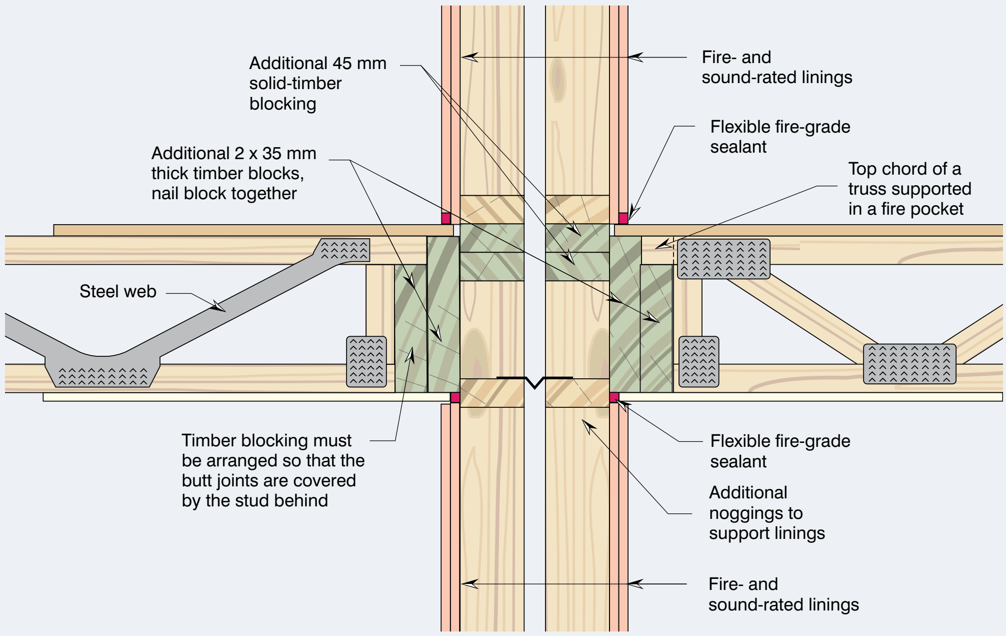
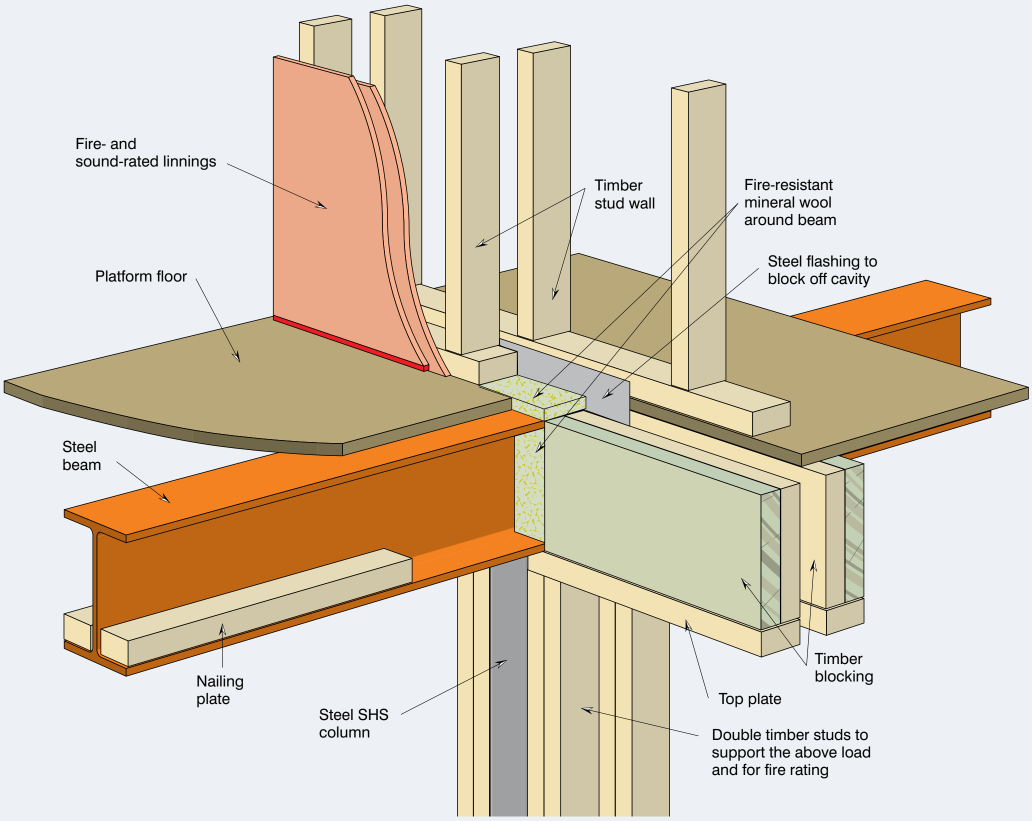
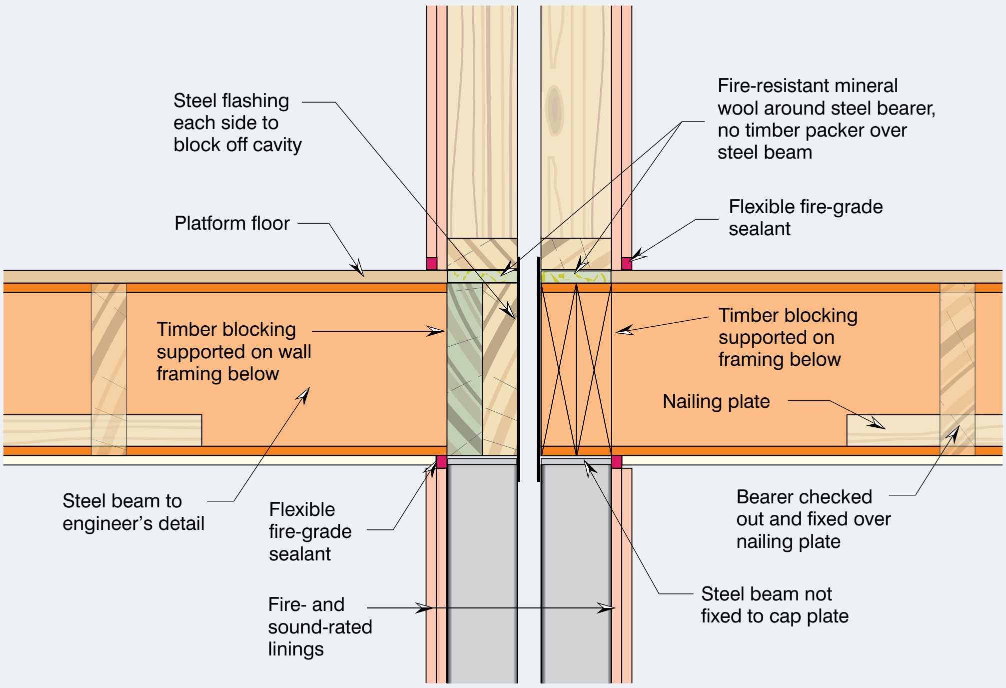


Figure 24: Floor truss supported on their top chords by ledger to the side of the fire- and sound-rated wall – FRL 90 minutes – elevation view.

6.7 Non-Fire-Rated Steel Beam Pocket Support



Cut-away view from above



Elevation view

Figure 25: Steel beam and column housed in fire- and sound-rated wall – FRL 60 minutes.

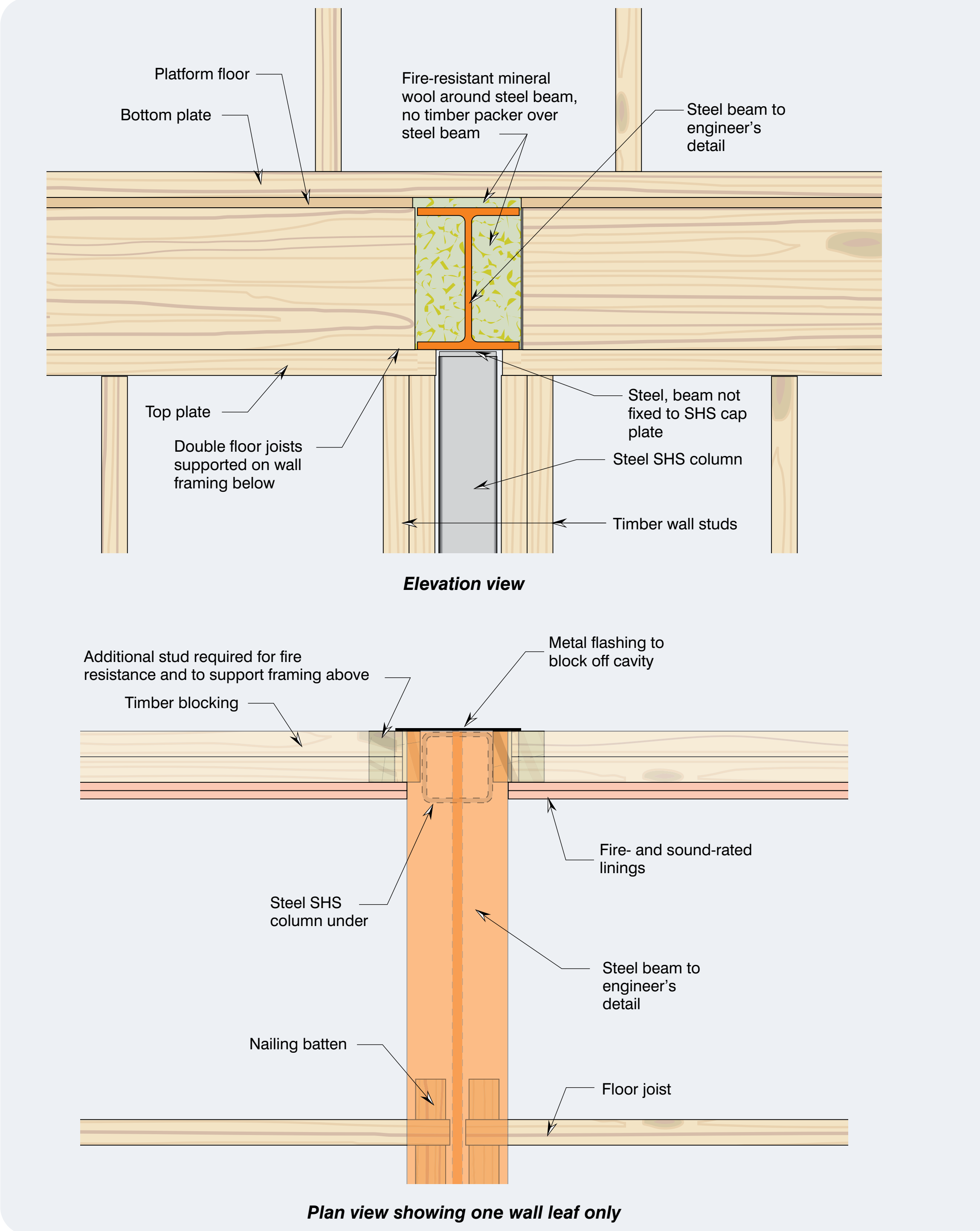


Figure 26: Detail of steel beam pocket in fire- and sound rated wall – FRL 60 minutes.

6.8 Timber Blocks Size of Alternative Thickness and/or Density

Generally, the 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 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 Timber Structures Part 4: Fire resistance of timber elements is the effective depth of char for a 75 minute period. The minimum thickness of timber allowed is 45 mm. Therefore, the effective depth of char is

$$d_c = c \,.\, t + 7.0 \text{ mm} \tag{1.1}$$

Where

C = notional char rate, found from AS/NZS 1720.4 or common species are repeated in Table 1.

t = 75 minutes

Table 1 provides minimum timber block thickness for common timber used in construction. The timber block thicknesses are represented in minimum dimension, and 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 should be used not the density of the engineered timber that includes the weight of the adhesive.

Table 1: 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.

A

Further Design Assistance Appendix A – Design References

Australian Building Codes Board

- Building Code of Australia – Volume 1 & 2.

Australian Standards

- AS/NZS 1720.4 - Timber Structures Part 4: Fire resistance of timber elements.
- ASAS 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 1267.1 Acoustics – Rating of sound insulation in buildings and building elements.
- 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 Technical Design Guides

- Guide #1: Timber-Framed Construction for Townhouse Buildings Class 1 – Design and construction guide for BCA compliant sound- and fire-rated construction
- Guide #2: Timber-Framed Construction for Multi-Residential Buildings Class 2, and 3 – Design and construction guide for BCA compliant sound- and fire-rated construction
- Guide #37R: Mid-Rise Timber Buildings – Multi-residential Class 2 and 3

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 2005, April 2009.
- 22567B Assessment Report: The likely fire-resistance performance of MRTFC wall floor junctions if tested in accordance with AS 1530.4 2005, September 2008.
- RIR 22567B Regulatory Information Report: The likely fire-resistance performance of MRTFC wall floor junctions if tested in accordance with AS 1530.4 2005, September 2008.
- 2256701 Test Report: Fire-resistance test of a timber wall floor junction in general accordance with AS 1530.4 2005, September 2008.
- 2256702 Test Report: Fire-resistance test of a wall beam junction when tested in general accordance with AS 1530.4 2005, September 2008.

Exova Warringtonfire Australia

- 2365300 Test Report: Fire-resistance test of floor junctions incorporating timber and plasterboard in general accordance with AS 1530.4 2005, May 2009.
- 2365400 Test Report: Fire-resistance test of floor junctions incorporating timber and plasterboard in general accordance with AS 1530.4 2005, May 2009.
- 2365500 Test Report: Fire-resistance test of floor junctions incorporating timber and plasterboard in general accordance with AS 1530.4 2005, May 2009.

B

Appendix B – Glossary of Terms

BCA

Building Code of Australia – Volume 1 – Class 2 to 9 Buildings and Volume 2 – Class 1 and Class 10 Buildings.

Cavity barrier

A non-mandatory obstruction installed in concealed cavities within fire-rated wall or floor/ceiling systems.

Construction joint

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

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.

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 BCA
- a doorway opening to a road or open space.

Fire-grade lining

Either fire-grade 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 passageway

A corridor or hallway of fire-resisting construction which provides egress to a fire-isolated stairway or ramp.

Fire-isolated stair or ramp

A stair or ramp construction of non-combustible materials and within a fire-resisting shaft or enclosure.

Fire-protective covering

- 13 mm fire-grade plasterboard; or
- 12 mm cellulose fibre-reinforced cement sheeting complying with AS 2908.2; or
- 12 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-grade 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 determined in accordance with Specification A2.3 (of the BCA) for the following:

- structural adequacy
- integrity
- insulation.

Fire-resisting construction

Construction that satisfies Volume 2 of the BCA.

Fire-resisting (fire-rated)

As applied to a building element, means having the FRL required by the BCA for that element.

Fire-resisting junction

The intersection between a fire-rated wall or floor/ceiling system and/or another rated or non-rated system, which maintain the fire resistance at the intersection.

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 manual must be fire-resisting and therefore must have a fusion temperature in excess of 1,160°C.

Fire-resisting sealant

Fire-grade material used to fill gaps at joints and intersections in fire-grade 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: Fire walls 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.

Unit

Sole-occupancy unit.

Weighted sound reduction index (R_w)

The rating of sound insulation in a building or building element as described in AS/NZS 1267.11999.

Collect the full set of resources for your library

Over 50 technical guides cover aspects ranging from design to durability, specification to detailing. Including worked drawings, they are an invaluable resource for ensuring timber-related projects comply with the National Construction Code (NCC). Download them now from WoodSolutions.com.au, the website for wood.

- **1** Timber-framed Construction for Townhouse Buildings Class 1a
- **2** Timber-framed Construction for Multi-residential Buildings Class 2 & 3
- **3** Timber-framed Construction for Commercial Buildings Class 5, 6, 9a & 9b
- **4** Building with timber in bushfire-prone areas
- **5** Timber service life design - design guide for durability
- **6** Timber-framed Construction - sacrificial timber construction joint
- **7** Plywood box beam construction for detached housing
- **8** Stairs, balustrades and handrails Class 1 Buildings – construction
- **9** Timber flooring - design guide for installation
- **10** Timber windows and doors
- **11** Timber-framed systems for external noise
- **12** Impact and assessment of moisture-affected, timber-framed construction
- **13** Finishing timber externally
- **14** Timber in Internal Design
- **15** Fire Design
- **16** Massive Timber Construction Systems: Cross-Laminated Timber (CLT)
- **17** Alternative Solution Fire Compliance, Timber Structures
- **18** Alternative Solution Fire Compliance, Facades
- **19** Alternative Solution Fire Compliance, Internal Linings
- **20** Fire Precautions During Construction of Large Buildings
- **21** Domestic Timber Deck Design
- **22** Thermal Performance in Timber-framed Buildings
- **23** Using Thermal Mass in Timber-framed Buildings
- **24** Thermal Performance for Timber-framed Residential Construction
- **25** Rethinking Construction - Consider Timber
- **26** Rethinking Office Construction - Consider Timber
- **27** Rethinking Apartment Building Construction - Consider Timber
- **28** Rethinking Aged Care Construction - Consider Timber
- **29** Rethinking Industrial Shed Construction - Consider Timber
- **30** Timber Concrete Composite Floors
- **31** Timber Cassette Floors
- **32** EXPAN Long Span Roofs - LVL Portal Frames and Trusses
- **33** EXPAN Quick Connect Moment Connection
- **34** EXPAN Timber Rivet Connection
- **35** EXPAN Floor Diaphragms in Timber Buildings
- **36** EXPAN Engineered Woods and Fabrication Specification
- **37** Mid-rise Timber Buildings (Class 2, 3 and 5 Buildings)
- **37R** Mid-rise Timber Buildings, Multi-residential (Class 2 and 3)
- **37C** Mid-rise Timber Buildings, Commercial and Education Class 5, 6, 7, 8 and 9b (including Class 4 parts)
- **38** Fire Safety Design of Mid-rise Timber Buildings
- **39** Robustness in Structures
- **40** Building Timber-framed Houses to Resist Wind
- **41** Timber Garden Retaining Walls Up to 1m High
- **42** Building Code of Australia Deemed to Satisfy Solutions for Timber Aged Care Buildings (Class 9c)
- **43** Reimagining Wood-based Office Fitout Systems - Design Criteria and Concepts
- **44** CLT Acoustic Performance
- **45** Code of Practice - Fire Retardant Coatings
- **46** Wood Construction Systems
- **47** Timber Bollards
- **48** Slip Resistance & Pedestrian Surfaces
- **49** Long-span Timber Floor Solutions
- **50** Mid-rise Timber Building Structural Engineering
- **51** Cost Engineering of Mid-rise Timber Buildings

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07

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Plywood Box Beam Construction for Detached Housing

Technical Design Guide issued by Forest and Wood Products Australia

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Table of Contents

Introduction

Plywood box beams are lightweight, simple to fabricate, conventionally stable and, with good design, structurally efficient and economical. The options provided in the following span tables are designed according to limit state design theory and for winds speeds up to N3. The span tables open up new options for beams incorporated into walls, portal frames and other typical long span applications.

Plywood webbed beams consist of flanges, webs and web stiffeners as shown in Figure 1.

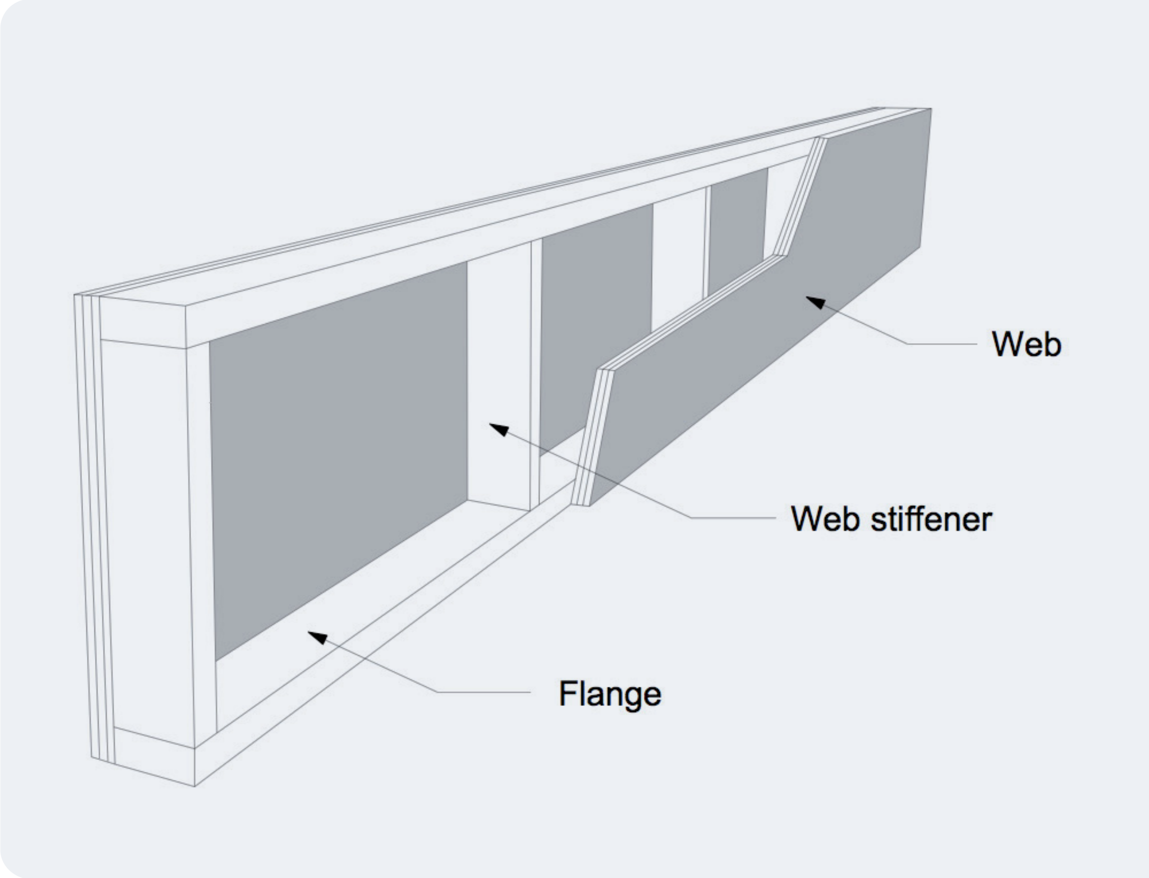

Figure 1: Cut-away view of a plywood box beam

1

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August 2008

STRUCTURAL CERTIFICATION OF REVISED PLYWOOD SHEATHED
BOX BEAM SPAN TABLES

Due to modifications to design data in various codes the contents of:

Plywood Box Beam Span Tables for Detached Housing Construction

has been revisited. Necessary adjustments have been made to effected box beam spans through applications of the requirements of AS1684.1: 1999 in conjunction with Wind Code and AS1720.1: 2010 updates.

The new tables have been independently checked by the writer through rigorous application of the fundamental principles of structural analysis and design procedures. Checks were performed on box beam candidates randomly chosen from the range of structural applications.

The checking procedure involved the application of actions obtained from AS/NZS1170 Parts 0, 1 and 2 and implementation of design procedures detailed in AS1720.1: 2010. The factored wind speed (non-cyclonic) used for checking purposes assumes structures to be confined to Category 3 regions, subjected to wind from any direction, a shielding multiplier of 1.0 and to not be influences by adverse topographical situations.

If the structure's exposure to wind conditions violates any of the preceding restrictions, in particular those pertaining to wind, terrain and topographical conditions, the box beam, if to be utilised, must be designed by an engineer.

As a professional engineer, competent in the engineering of timber structures and their components, I certify the box beams referred to in this Manual as being structurally adequate regarding the specific requirements of AS1684.1: 1999.

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CP Eng (1989-2010)

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2

Limitations and Beam Design Data

The criteria specified in this publication are specifically for conventional timber-framed buildings and applicable to single and two-storey constructions built within the limits or parameters below (Note: for any details not dealt with below assumptions and design conditions in AS1684 apply).

Wind classification
Beam spans in the Span Tables are for wind loads up to N3 as described in AS4055 Wind Loads for Houses. For this wind classification the maximum building height limitation of 8500 mm, as given in AS4055, shall apply.

Plan
Building shapes shall be essentially rectangular, square, L-shaped or a combination of essentially rectangular elements including splayed-end and boomerang-shaped buildings.

Number of storeys of timber framing
The maximum number of storeys of timber framing shall not exceed two.

Building Width
The maximum width of a building shall be 16000 mm excluding eaves.

Wall height
The maximum wall height shall be 3000 mm floor to ceiling as measured at common external walls i.e. not gable or skillion ends.

Roof pitch
The maximum roof pitch shall be 35° (70:100).

Roof type
Roof construction shall be hip, gable, skillion, cathedral, trussed or pitched, or in any combination of these.

Building masses
Building masses appropriate for the member being designed shall be determined prior to selecting and designing from the Span Tables in this publication. Where appropriate, the maximum building masses relevant to the use of each member span table are noted under the Table. The roof mass shall be determined for the various types of roof construction for input to the Span Tables. For further guidance refer AS1684 Part 2, Appendix B. For counter beams, strutting beams, combined hanging strutting beams, and the like, the mass of roof framing is also accounted for in the Span Tables. The mass of a member being considered has been accounted for in the design of that member.

Size Tolerances
When using the Span Tables no (0 mm) undersize tolerances on timber sizes shall be permitted.

Moisture content
A moisture content of 15% or lower applies.

Bearing
The minimum bearing for specific beam members (bearers, lintels, hanging beams, strutting beams, combined strutting/hanging beams, counter beams, combined counter/strutting beams etc.) shall be as given in the Notes to the Span Tables. Unless indicated otherwise, all beams shall bear on their supporting element, a minimum of 35 mm at their ends or 70 mm at the continuous part of the member, by their full breadth (thickness). Reduced bearing area shall only be used where additional fixings are provided to give equivalent support to the members. Where the bearing area is achieved using a non-rectangular area such as a splayed joint, the equivalent bearing area shall not be less than that required above.

Durability
All span tables assume that the beam is to be located in an interior environment.

Material Properties and Key Design Data

The minimum structural properties adopted for timber flange and web stiffener materials are in accordance with Table 2.4 (for timber) and Table 5.1 (for Plywood) of AS1720.1. Timber Joint groups for various species are in accordance with Table 2.1 of AS1720.1. In addition, properties for LVL are handled separately below.

Laminated veneer lumber (LVL 10):

- Bending (f'b) 42 N/mm^2
- Tension (f't) 27 N/mm^2
- Shear (f's) 5.3 N/mm^2
- Compression (f'c) 40 N/mm^2
- Modulus of Elasticity (e) 10 700 N/mm^2

Other assumptions

- All beams are simply supported single spans
- Applied loads are static and applied vertically
- Applied loads for lintel and bearer beams have generally been input as evenly distributed discrete loads.
- Lintels have also been designed to include concentrated loads from roofs.
- Applied loads for strutting beams spanning perpendicular to the rafters and combined strutting and hanging beams have been input as discrete loads at every second rafters spacing (Note" Web stiffeners should be added at point load application points).
- Applied loads for strutting beams spanning parallel to the rafters have been input as a single mid-span load.
- Rafter and joist spacings 600 mm centres, maximum.
- All beams are required to be laterally restrained at their supports. Intermediate lateral restraint to the top edge of lintel and bearer beams is provided by the rafters or joists. Additional lateral restraint is required to strutting and combined hanging and strutting beams. Specific requirements are adjacent to individual Span Tables and guidance is also provided in Figure 13.
- Roof Load Width (RLW) and Floor Load Width (FLW) are measures of the width of the load area being supported by the member. Examples are shown for each being type.
- Roof Load Area (RLA) for strutting beams spanning parallel to the rafters is a measure of the load area being supported by the member.
- Span is defined as the face-to-face distance between points capable of giving full support to structural members.

3

Load Terminology Used in the Span Tables

Roof load width (RLW)

RLW is used as a convenient indicator of the roof loads that are carried by some roof members and then by support structures such as lintels. Roof load width (RLW) is simply half the particular member's span, between support points, plus any overhang, and is measured on the rake of the roof.

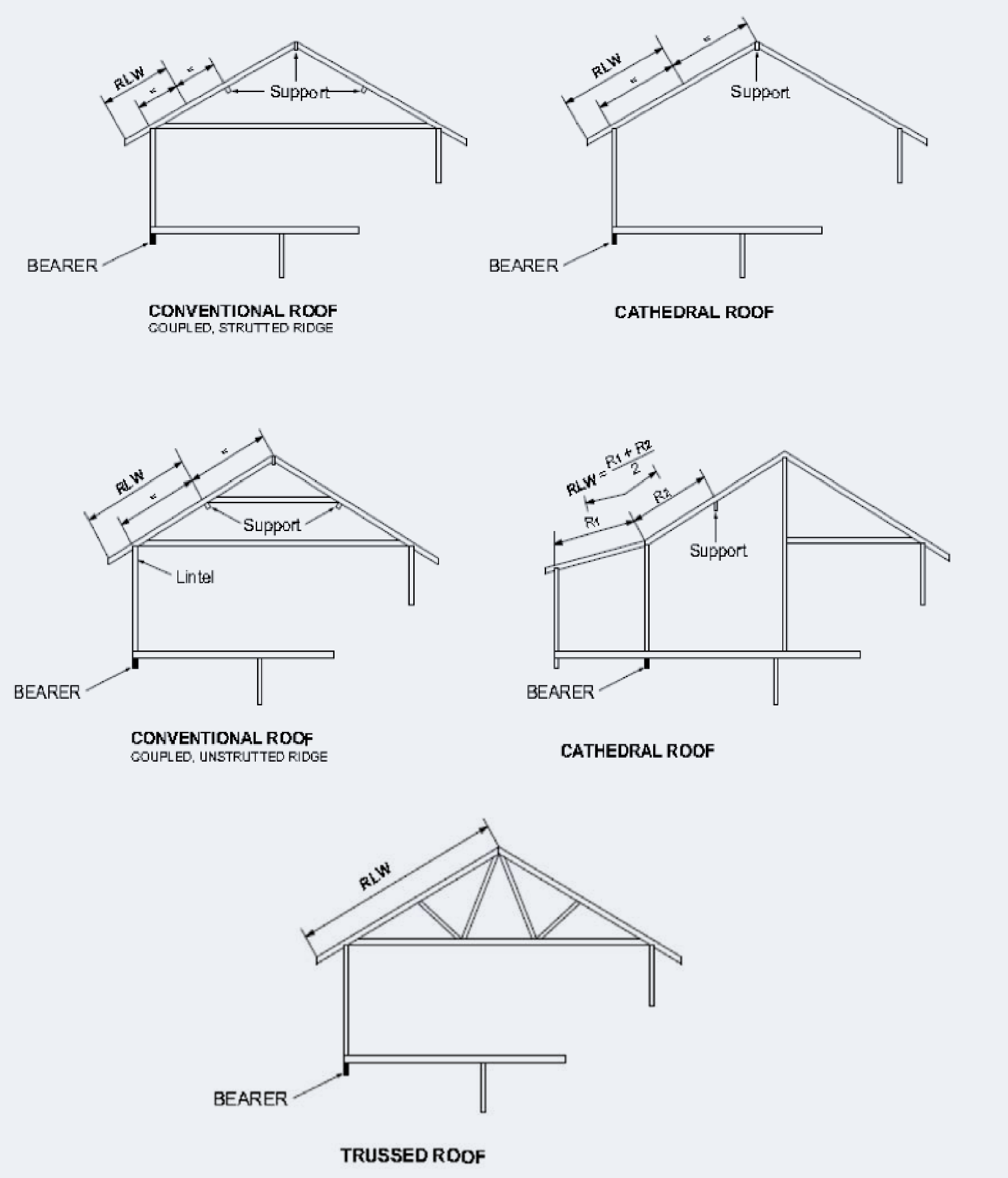


Figure 2: Method for Calculating Roof Load Width for Lintels

Roof load area (RLA)

The area supported by a member is the contributory area measured in the roof, that imparts load onto supporting members. The roof area shall be used as an input to Span Tables for strutting beams and combined strutting/hanging beams and combined strutting/counter beams. The typical roof area supported by strutting beams is shown in Figure 3.

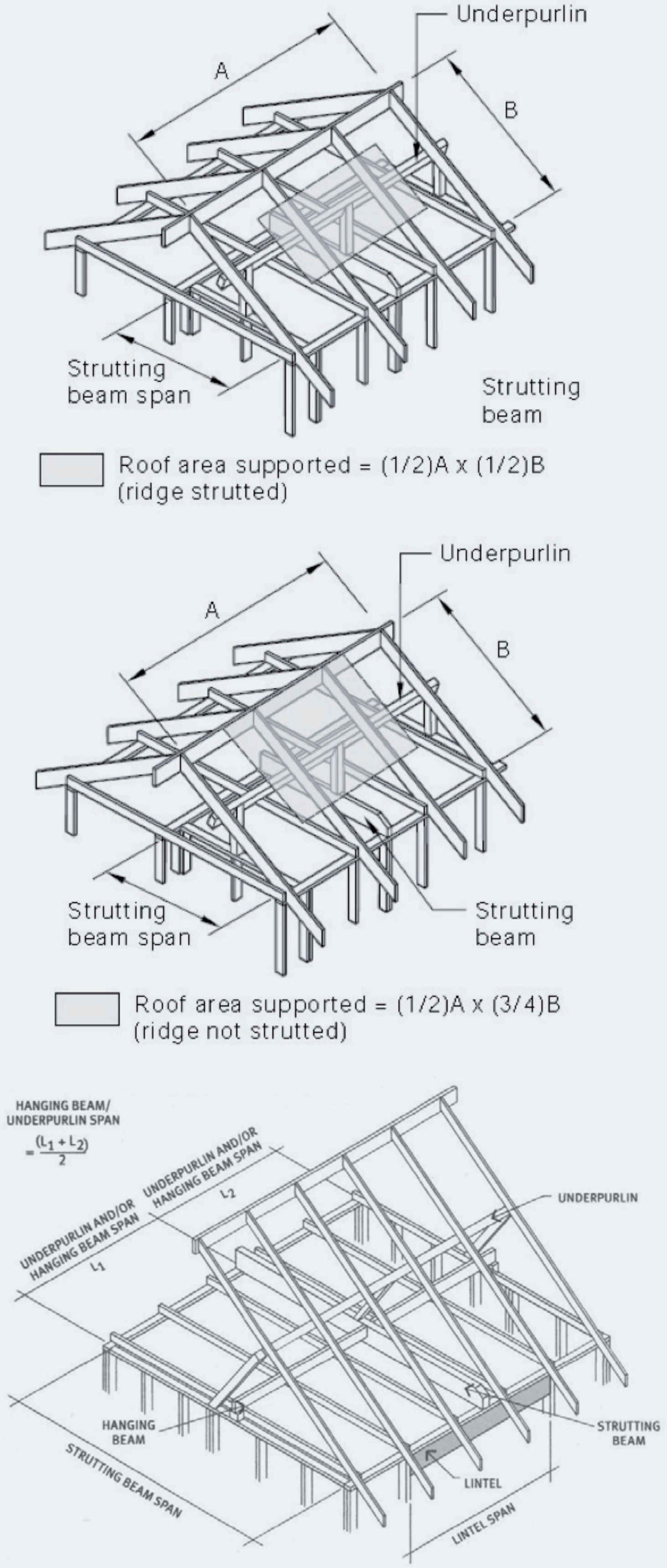
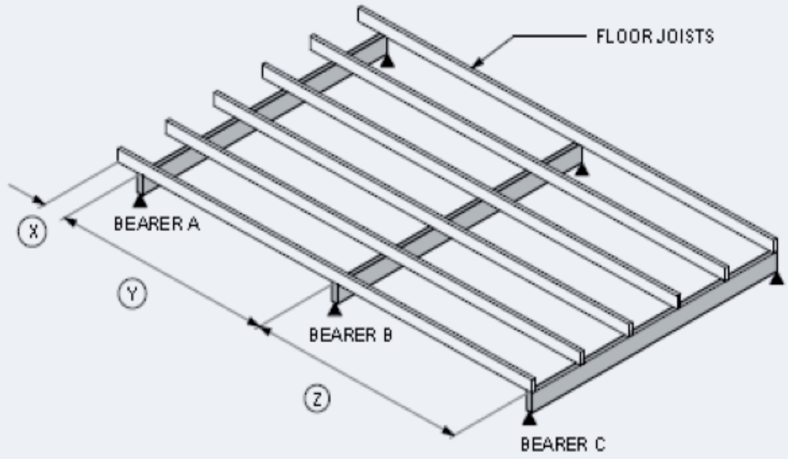


Figure 3: Roof load area for Strutting beams (and similar)

Floor load width (FLW)

FLW is the contributory width of floor, measured horizontally, that imparts floor load to a bearer or similar. So floor load width (FLW) is simply half the floor joist span on either side of the bearer, added together. The only exception is where there is a cantilever. In this situation, the total cantilever distance is included.



BEARER	FLOOR LOAD WIDTH 'FLW'
A	$FLW = X + \frac{Y}{2}$
B	$FLW = \frac{Y + Z}{2}$
C	$FLW = \frac{Y}{2}$

Figure 4: Method for Calculating Floor Load Width for Bearers

Ceiling load width (CLW)

Ceiling load width (CLW) is the contributory width of ceiling, usually measured horizontally, that imparts ceiling load to a supporting member. CLW shall be used as an input to Span Tables for counter beams and strutting/hanging beams. An example of its method of calculation is shown in Figure 5.

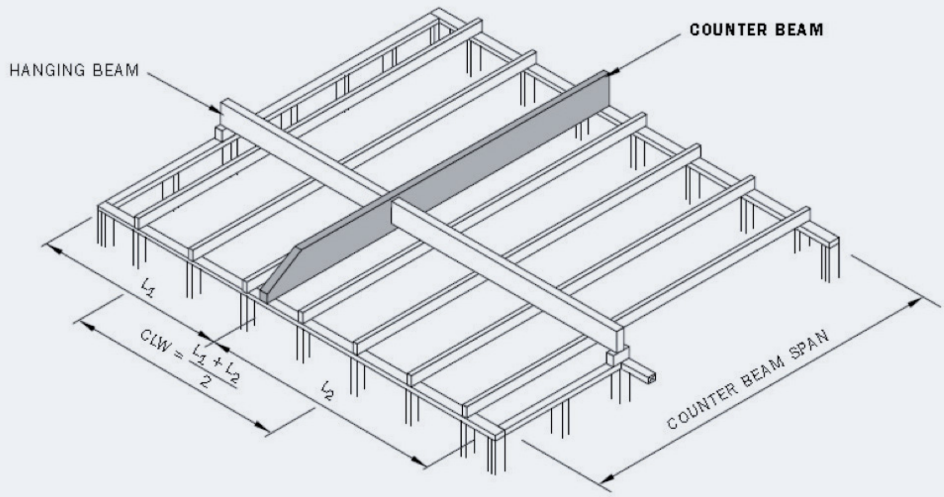


Figure 5: Method for Calculating Ceiling Load Width for Counter Beams

4 Beam Components and Fabrication

Flanges

Flange sizes in the following span tables utilise commonly available MGP and F-Grade seasoned softwood, seasoned hardwood and Laminated Veneer Lumber. Options include:

- MGP 10; 90 x 45 mm; JD 5
- MGP 12; 90 x 45 mm; JD 4
- F5; 90 x 45 mm; JD 5
- F17; 90 x 65 mm; JD 4
- Structural Grade LVL 10; 90 x 45mm; JD 5

A benefit of these timbers is that they are commonly available in all regions of Australia. The use of higher stress graded timber does not necessarily lead to higher beam spans as stress grade is not the governing feature of the beam design – nail holding between the web and flange is more important.

All timber used in conjunction with this span table should be stress graded in accordance with the relevant Australian Standards. Further to this, Structural Laminated Veneer Lumber (LVL) must be manufactured to AS/NZS 4357.0:2005 and in accordance with EWPAA branded structural LVL (see Figure 6 below). This ensures an engineered product of known and consistent physical and mechanical properties. Also note that that some chemical treatments may adversely affect structural properties and advice should be sought from the manufacturer prior to any treatment. The design properties of structural LVL as well as product dimensions are published by the individual manufacturers. In the span tables in this manual, LVL must attain a Modulus of Elasticity of 10 MPa. For further information on LVL go to www.paa.asn.au.

Figure 6: Branding for LVL and plywood products

Plywood Webs

Plywood webs for box beams called up in the span tables are according to the following specification:

- Thickness: 7 mm minimum thick
- Structural grade: F8 (minimum)
- Grain direction: must run parallel to the beam span
- Face Grade: D/D minimum (i.e. structural non-aesthetic grade)
- Branding: EWPAA structurally tested

Plywood must be manufactured to AS/NZS 2269. This is the only plywood suitable for use in plywood box beam applications in these span tables. Under this scenario, a permanent Type A phenolic resin is used to bond the individual timber veneers. The Type A bond is distinctly dark in colour and is durable and permanent under conditions of stress.

EWPAA branded structural plywood is manufactured under a rigorous product quality control and product certification system and should be branded with the “PAA Tested” stamp (see Figure 6).

For the faces of plywood sheets, five face veneer qualities are possible including A, S, B, C and D. Structural plywood can be economically specified with appropriate face and back veneer qualities to suit the specific application. Where appearance is not important and the prime consideration is structural performance, D/D grade is most appropriate. For further information on plywood go to www.paa.asn.au.

Web Stiffeners

Web stiffeners are made from the same material as flanges and are required to control buckling in plywood webs. Web stiffeners must be located at a maximum of 600 mm spacings and must be located at or in addition to positions of high load concentration to counter localised web buckling (e.g. at the ends of beams and under roof beam point loads). They must also be positioned to support plywood web butt joints.

Nailing

Plywood webs are to be fastened to flanges and web stiffeners using:

- 2.87 mm minimum diameter flathead nails
- 32 mm long if ring shanked; 35 mm long it straight shanked
- Nails spaced 50 mm apart (maximum)
- Nailing at the edge of plywood sheets should been no closer than 5 nail diameters from the edge (e.g.15 mm for 2.87mm diameter nails).
- To avoid splitting in flange and web stiffeners, nails should be staggered 6 mm about the centre line of the flange (or web stiffener) as shown in Figure 7.

Note: The requirements of AS1720 have been varied with respect to recommend the nail spacings. Nail spacings have been reduced and staggered along the flange as detailed in Figure 7.

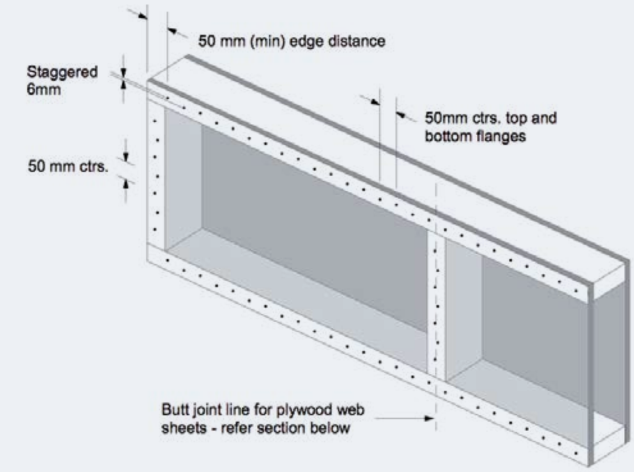


Figure 7: Staggered nailing pattern for webs

When specifying the type of nail to be used, the likelihood of corrosion should be considered. Hot dipped galvanised nail should be used in high humidity or mildly corrosive environments, or where treated plywood or timber is used. Stainless steel nails may be required in highly corrosive environments.

When fabricating flange and web stiffener framework, normal frame nailing techniques (in accordance with AS1684) may be used but care should be taken not to split the timber. Of note, this nailing is only required to assist fabrication of the framework as it is not structurally required once the plywood webs have been fixed i.e. using nailing requirements mentioned above.

Adhesive

Adhesive helps provide a stiffer beam but due to the difficulty in reliably achieving full adhesive bond onsite, the beams in the span tables are based on nail holding/shear capacity. Even so, it is strongly recommended that an appropriate construction adhesive be used as an additional measure. Run a continuous bead of adhesive between the structural timber and plywood.

Joints and Splices

Butt joints in plywood webs must be located on web stiffeners as shown in Figure 7. Joints must be alternated either side of the beam on alternative stiffeners. Here, webs must be nailed to stiffeners in the same manner as specified previously under "Nailing" but due to two sheets being joined over the same stiffener, care should be taken to angle nails towards the centre of the web stiffener to avoid splitting the edges of the stiffener.

Flange joints/splices should where practical be continuous length flanges which serves to avoid the need for splices. Where joints or splices are necessary, construct using timber splice plates as shown in Figure 8. Splices should be placed away from locations of high moment (e.g. away from the centre of simply supported beams) and where concentrated loads occur.

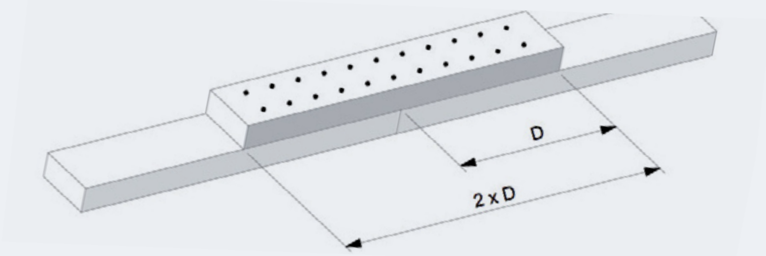


Figure 8: Timber splice plate

5

Installation

Lintels

Box beam lintels may be fabricated as separate units and then installed into a timber stud frame, or, lintels can be fabricated and installed as an integral part of a timber stud frame. In the latter, relevant parts of the wall frame must be constructed using flange and web stiffener sizes and spacings, taken from the span tables. The area is then sheathed as required on both sides with structural plywood, again taken from the span tables.

Where lintel box beams are built into the wall they must not include the top plate of the wall into the beam. Lintels assumptions require top plates in addition to the beam capacity and they also provide a function of continuity in the wall framing. Further construction requirements are shown in Figure 9 and Figure 10 below.

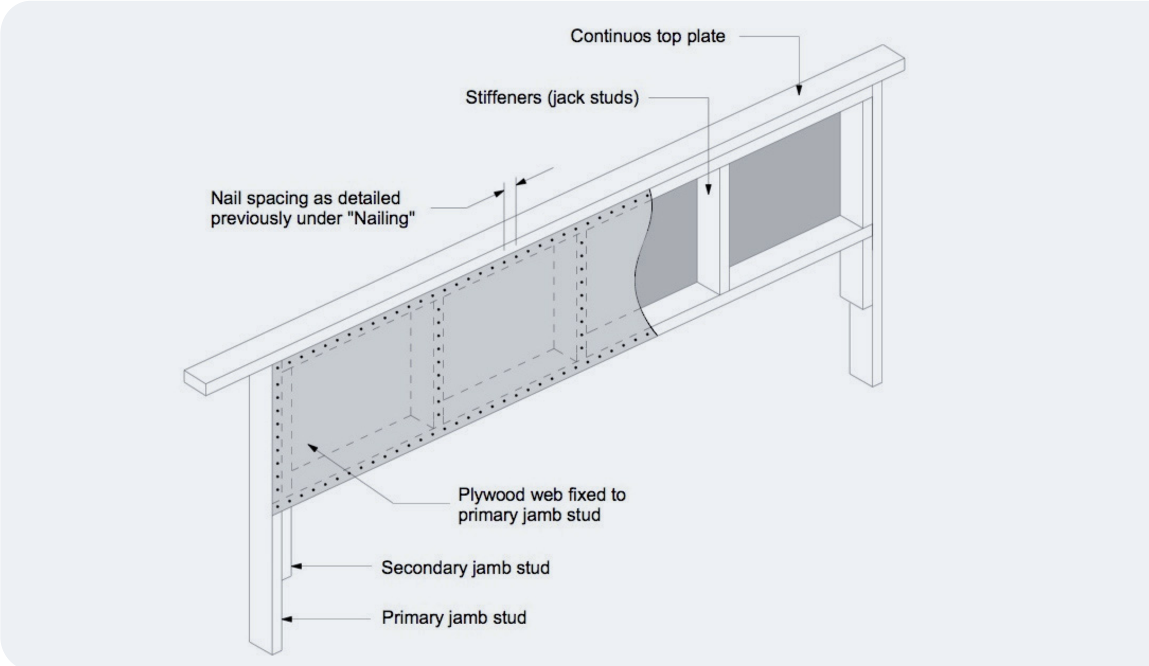


Figure 9: Beams fabricated as part of the wall frame

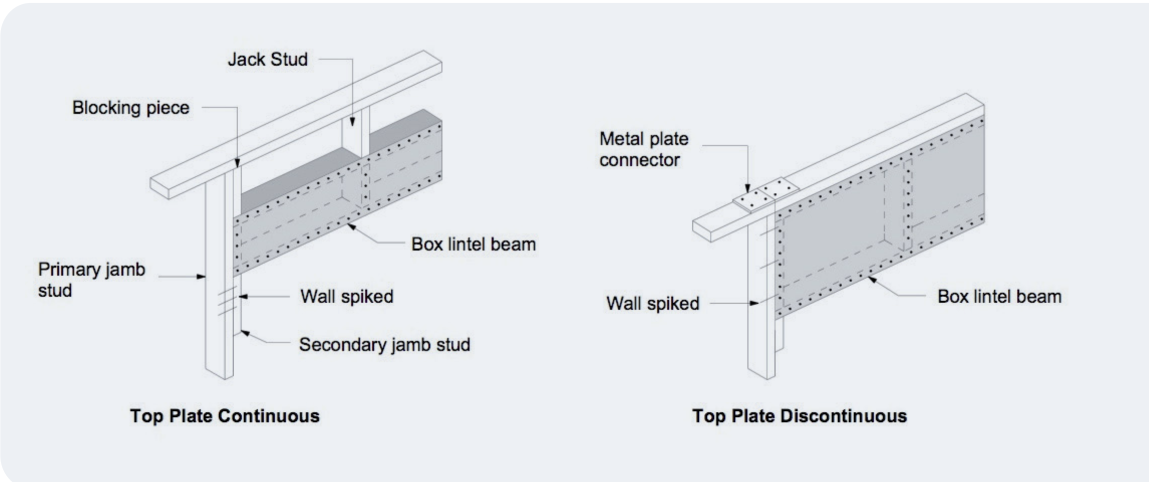


Figure 10: Beams fabricated separately

Strutting and combined strutting hanging beams

Installation requirements for plywood box beam, strutting and hanging beams are as detailed in AS1684. Figure 11 provides additional fabrication and installation details where box beams require tapered ends – as required for certain roof types.

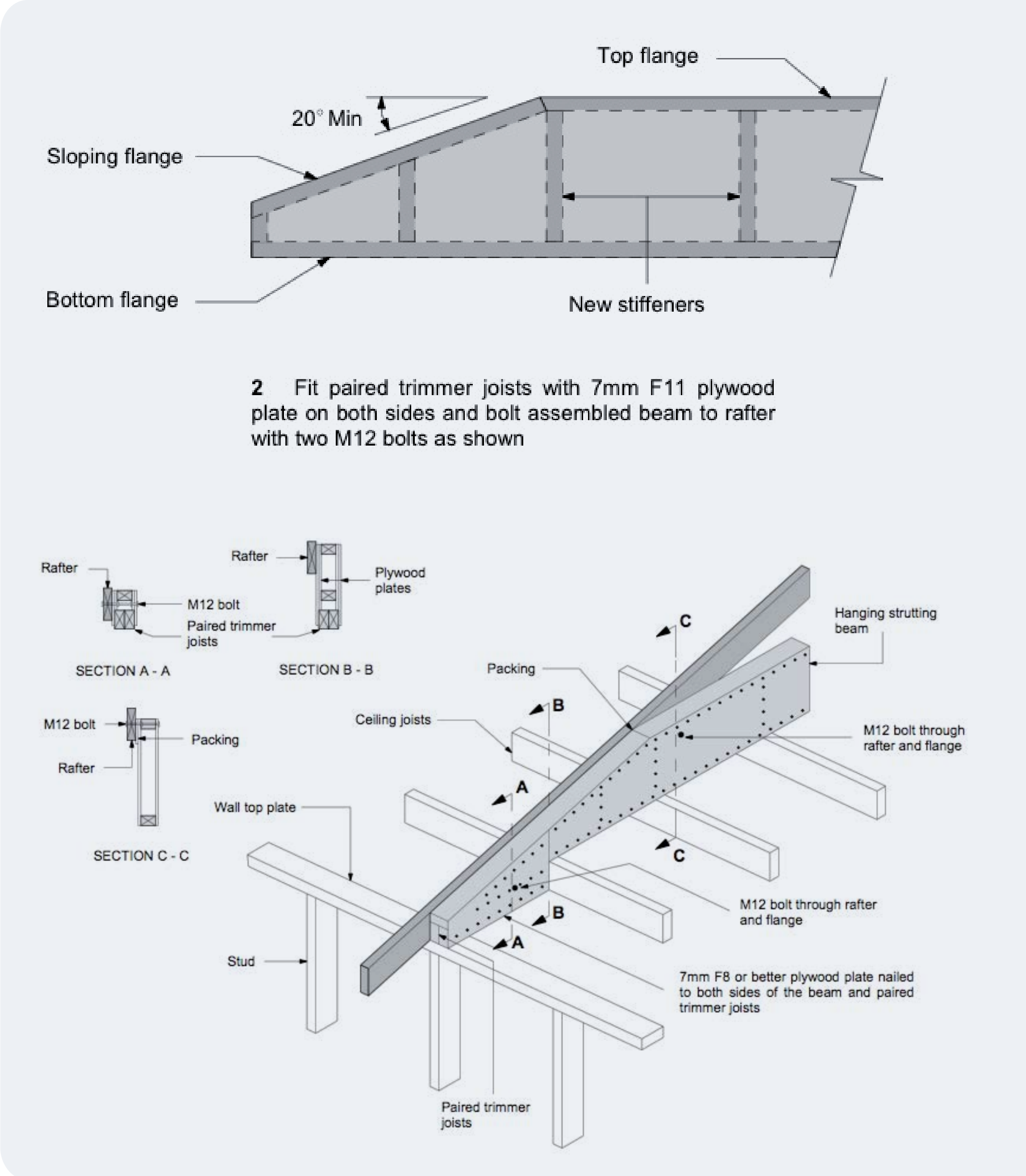


Figure 11: Treatment of tapered ends in strutting and hanging beams

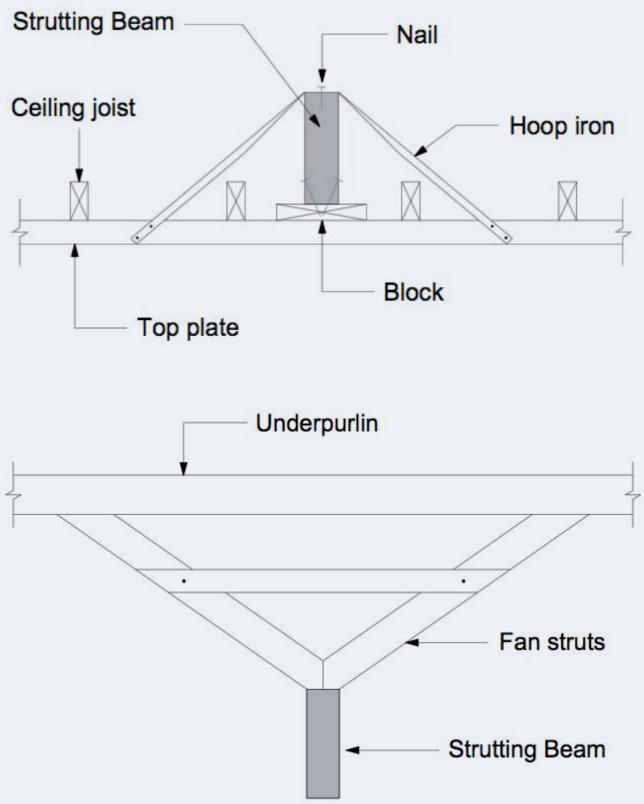


Figure 12: Possible end and intermediate restraint details

Referenced Documents

The following Australian and New Zealand standards have been applied:

- AS/NZS 2269: 2004 Plywood structural
- AS 4055: 2006 Wind loads for housing
- AS1720.1: 1997 Timber structure- Part 1 Design Method
- AS 1684: 2006 Residential timber framed construction
- AS/NZS 4357.0: 2005 Structural Laminated Veneer Lumber

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Span Tables

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23rd May, 2011

To Whom it May Concern

Plywood Box Beam Span Tables for Detached Housing Construction

The writer and Mick McDowell RPEQ 2463 NPER 404540 agree to the following assumptions in the revision of the current FWPA 'Plywood Box Beam Span Tables for Detatched Housing Construction':

That the revision will be in accordance with the latest provisions of AS 1720.1 - 2010; AS/NZS 2269.0 - 2008; AS 4055 - 2006; AS 1684.1 - 1999; AS/NZS 1170.1 - 2002; and AS/NZS 1170.2 - 2011.

That the significant revisions are the changes to the material characteristic properties, the changes to the capacity factors (including the new above 25 square metres supported provisions) and the AS/NZS 1170.1 - 2002 changes in load factors used in AS 1684.1 - 1999.

The other assumptions used in this revision remain as for the present N3 wind class span tables.

Yours Faithfully

James MacGregor

Mick McDowall

Span Tables - Lintel Beams

Table 1: Ply Box Single Span Lintel Beam Single/Upper Storey

Flanges: 90 x 45 mm, Ply webs: 7 mm F8, Wind Classification: N1, N2 & N3

Chord Stress Grade	Box Beam Depth (mm)	Lintels Single/Upper Storey Sheet Roof 600 mm Rafters Spacing									
		Roof Load Width (mm)									
		2700	3000	3300	3600	3900	4200	4500	4800	5100	5400
		Maximum Beam Span (mm)									
F5	400	4300	4000	3900	3700	3600	3400	3300	3200	3100	2800
F5	600	5500	5200	5000	4800	4600	4400	4300	4100	4000	3900
F5	800	6500	6200	6000	5700	5500	5300	5100	5000	4800	4600
F5	1200	7500	7200	6900	6600	6400	5900	5500	5300	5200	5100
MGP 10	400	4300	4100	3900	3700	3600	3500	3300	3200	3100	2900
MGP 10	600	5500	5300	5000	4800	4600	4400	4300	4100	4000	3900
MGP 10	800	6600	6200	6000	5700	5500	5300	5100	5000	4800	4600
MGP 10	1200	7500	7200	6900	6600	6400	5900	5500	5300	5100	5000
LVL 10	400	4700	4500	4400	4200	4200	4100	4000	3900	3700	3600
LVL 10	600	6100	5900	5700	5600	5400	5300	5100	5000	4900	4800
LVL 10	800	7200	7000	6800	6600	6400	6300	6100	6000	5900	5800
LVL 10	1200	8000	8000	8000	8000	8000	7900	7800	7600	7500	7300
MGP 12	400	4900	4700	4500	4300	4200	4200	4100	4000	3900	3800
MGP 12	600	6300	6100	5900	5700	5600	5400	5300	5100	4900	4600
MGP 12	800	7500	7200	7000	6800	6400	5900	5500	5400	5200	5100
MGP 12	1200	8000	8000	7500	7100	6800	6600	6400	6200	6100	5900
F17	400	4900	4700	4500	4400	4200	4200	4100	4000	3900	3800
F17	600	6400	6200	6000	5800	5600	5500	5300	5200	5100	4900
F17	800	7500	7300	7100	6900	6700	6500	6400	6200	6100	6000
F17	1200	8000	8000	8000	8000	8000	8000	8000	7900	7700	7600

Notes

i) Maximum spans are based on the support of a maximum sheet roof, framing and ceiling mass of 40 kg/m^2. For guidance on roof and ceiling mass refer to Appendix A of AS1684.2.

ii) Lintels to internal wall openings supporting ceiling joist only shall be sized as hanging beams.

iii) Lintels in gable or skillion end walls not supporting roof loads shall be determined as per Clause 6.3.6.3 of AS1684.2.

iv Minimum bearing length = 35 mm at end supports.

v) When lintels are used to their maximum design limits, deflections of up to 10 mm (deadload) or 15 mm (live load) may be expected.

vi) For Roof Load Width determination, refer to Figure 2.

Span Tables - Lintel Beams

Table 2: Ply Box Single Span Lintel Beam Single/Upper Storey											
Flanges: 90 x 45 mm, Ply webs: 7 mm F8, Wind Classification: N1, N2 & N3											
Chord Stress Grade	Box Beam Depth (mm)	Lintels Single/Upper Storey Sheet Roof 1200 mm Rafters Spacing									
		Roof Load Width (mm)									
		2700	3000	3300	3600	3900	4200	4500	4800	5100	5400
		Maximum Beam Span (mm)									
F5	400	4200	3900	3700	3500	3400	3300	3100	3000	3000	2900
F5	600	5600	5300	5100	4900	4800	4400	4100	3800	3600	3500
F5	800	6600	6200	5900	5600	5400	5300	5100	5000	4800	4600
F5	1200	8000	8000	7500	6900	6400	6100	5900	5700	5500	5400
MGP 10	400	4200	4000	3800	3600	3400	3300	3200	3100	3000	2300
MGP 10	600	5600	5300	5100	4900	4800	4400	4100	3900	3600	3500
MGP 10	800	6500	6200	5900	5600	5400	5200	5100	4900	4800	4600
MGP 10	1200	8000	8000	7500	6900	6400	6000	5800	5600	5500	5300
LVL 10	400	4700	4600	4400	4300	4100	3400	3300	3200	3000	2300
LVL 10	600	6000	5800	5600	5500	5400	5200	5100	5000	4900	4500
LVL 10	800	7200	6900	6700	6500	6300	6200	6000	5900	5800	5700
LVL 10	1200	8000	8000	8000	8000	8000	7900	7800	7600	7400	7300
MGP 12	400	4900	4700	4500	4400	4300	4200	4000	3800	3500	3400
MGP 12	600	6200	6000	5800	5600	5500	5400	5100	4900	4700	4400
MGP 12	800	7400	7200	6900	6700	6400	5900	5500	5200	5200	5000
MGP 12	1200	8000	8000	8000	7900	7600	7300	7100	6900	6600	6400
F17	400	4900	4700	4600	4400	4300	4200	4100	4000	3800	3700
F17	600	6300	6100	5900	5700	5500	5400	5300	5200	4900	4600
F17	800	7500	7300	7000	6800	6600	6400	6300	6100	6000	5900
F17	1200	8000	8000	8000	8000	8000	8000	8000	7900	7700	7500

Notes

i) Lintels to internal walls supporting ceiling joist only shall be sized as hanging beams. Lintels in gable or skillions end walls not supporting roof loads shall be determined as per Clause 6.3.6.3 of AS1684.2. Remember minimum bearing length = 35 mm at end supports. When lintels are used to their maximum design limits, deflections of up to 10 mm(deadload) or 15 mm (live load) may be expected.

ii) For Roof Load Width determination, refer to Figure 2.

Span Tables - Lintel Beams

Table 3: Ply Box Single Span Lintel Beam Single/Upper Storey

Flanges: 90 x 45 mm, Ply webs: 7 mm F8, Wind Classification: N1, N2 & N3

Chord Stress Grade	Box Beam Depth (mm)	Lintels Single/Upper Storey Tile Roof 600 mm Rafters Spacing									
		Roof Load Width (mm)									
		2700	3000	3300	3600	3900	4200	4500	4800	5100	5400
		Maximum Beam Span (mm)									
F5	400	3600	3400	3200	2900	2800	2600	2500	2400	2300	2300
F5	600	4400	4200	4200	4000	3800	3700	3600	3500	3400	3300
F5	800	5300	5100	4900	4700	4600	4400	4300	4200	4000	3900
F5	1200	6800	6600	6300	6200	6000	5800	5600	5400	5200	5100
MGP 10	400	3600	3400	3000	3000	2800	2600	2400	2400	2400	2300
MGP 10	600	4500	4400	4200	4000	3900	3700	3600	3500	3400	3300
MGP 10	800	5500	5200	5000	4800	4600	4400	4300	4100	4000	3900
MGP 10	1200	7000	6700	6400	6100	5900	5700	5500	5300	5200	5000
LVL 10	400	3600	3400	3000	3000	2800	2600	2400	2400	2400	2400
LVL 10	600	4500	4400	4200	4200	4000	3900	3800	3700	3600	3600
LVL 10	800	5500	5300	5100	4900	4800	4600	4500	4300	4200	4200
LVL 10	1200	7000	6800	6600	6400	6200	6000	5900	5700	5600	5400
MGP 12	400	3600	3600	3500	3300	3000	3000	2800	2600	2500	2400
MGP 12	600	4700	4500	4300	4200	4100	4000	3800	3700	3600	3600
MGP 12	800	5700	5400	5200	5000	4800	4700	4500	4400	4300	4200
MGP 12	1200	7200	6900	6700	6500	6300	6100	6000	5800	5700	5500
F17	400	3600	3600	3500	3300	3100	3000	2800	2600	2500	2400
F17	600	4700	4500	4300	4200	4100	4000	3900	3700	3600	3600
F17	800	5700	5500	5300	5100	4900	4700	4600	4400	4300	4200
F17	1200	7200	7000	6700	6500	6300	6000	5900	5700	5600	5400

Notes

i) Maximum spans are based on the support of a maximum total tile roof, framing and ceiling mass of 90 kg/m^2. For guidance on roof and ceiling mass refer to Appendix A, AS1684.2.

ii) Lintels to internal wall openings supporting ceiling joist only shall be sized as hanging beams. Lintels in gable or skillion end walls not supporting roof loads shall be determined as per Clause 6.3.6.3 of AS1684.2.

iii) Minimum bearing length = 35 mm at end supports.

v) When lintels are used to their maximum design limits, deflections of up to 10 mm (deadload) or 15 mm (live load) may be expected.

vi) For Roof Load Width determination, refer to Figure 2.

Span Tables - Lintel Beams

Table 4: Ply Box Single Span Lintel Beam Single/Upper Storey											
Flanges: 90 x 45 mm, Ply webs: 7 mm F8, Wind Classification: N1, N2 & N3											
Chord Stress Grade	Box Beam Depth (mm)	Lintels Single/Upper Storey Tile Roof 1200 mm Rafters Spacing									
		Roof Load Width (mm)									
		2700	3000	3300	3600	3900	4200	4500	4800	5100	5400
		Maximum Beam Span (mm)									
F5	400	3200	2200	2200	2100	2000	2000	1900	1800	1800	1800
F5	600	4400	4300	4100	3900	3700	3500	3400	3200	3000	2900
F5	800	5300	5100	4900	4800	4600	4400	4200	4100	3900	3800
F5	1200	6700	6500	6200	6100	5900	5700	5500	5200	4900	4600
MGP 10	400	3000	2200	2100	2000	1900	1900	1800	1800	1700	1600
MGP 10	600	4600	4300	4100	3900	3700	3600	3400	3200	3100	2900
MGP 10	800	5400	5200	5000	4800	4600	4400	4200	4000	3900	3800
MGP 10	1200	7000	6700	6300	6100	5800	5600	5400	5200	4900	4600
LVL 10	400	3000	2200	2100	2000	1900	1900	1800	1800	1700	1600
LVL 10	600	4600	4400	4300	4100	4000	3800	3700	3600	3500	3400
LVL 10	800	5500	5300	5100	4900	4800	4600	4500	4400	4300	4200
LVL 10	1200	7000	6700	6400	6200	6100	5900	5700	5600	5500	5400
MGP 12	400	3500	3200	3000	2300	2200	2100	2000	2000	1900	1900
MGP 12	600	4700	4500	4300	4200	4100	3900	3800	3700	3500	3300
MGP 12	800	5600	5400	5200	5000	4900	4700	4600	4500	4400	4300
MGP 12	1200	7100	6800	6600	6400	6200	6000	5800	5700	5500	5400
F17	400	3500	3400	3200	3100	3000	2800	2500	2300	2200	2100
F17	600	4700	4500	4400	4200	4100	3900	3800	3700	3600	3500
F17	800	5600	5400	5200	5100	4900	4800	4600	4500	4400	4300
F17	1200	7200	6900	6600	6400	6200	6000	5900	5700	5600	5500

Notes

i) Maximum Lintel Spans are based on the support of a maximum total tile roof, framing and ceiling mass of 90 kg/m^2.
For guidance on roof and ceiling mass refer to Appendix A of AS1684.2.

ii) Lintels to internal wall openings supporting ceiling joist only shall be sized as hanging beams.

iii) Lintels in gable or skillion end walls not supporting roof loads shall be determined as per Clause 6.3.6.3 of AS1684.2.

iv) Minimum bearing length = 35 mm at end supports.

v When lintels are used to their maximum design limits, deflections of up to 10 mm (deadload) or 15 mm (live load) may be expected.

vi) For Roof Load Width determination, refer to Figure 2.

Span Tables - Lintel Beams

Table 5: Ply Box Single Span Lintel Beam Single/Upper Storey + Conc Load											
Flanges: 90 x 45 mm, Ply webs: 7 mm F8, Wind Classification: N1, N2 & N3											
Chord Stress Grade	Box Beam Depth (mm)	Lintels Single/Upper Storey Sheet Roof 600 mm Rafters									
		Under Purlin or Hanging Beam									
		2400mm					4200mm				
		Strutting Beam Span (mm)									
		3600	4200	4800	5400	6000	3600	4200	4800	5400	6000
		Maximum Beam Span (mm)									
F5	400	3200	2200	2200	2100	2000	2000	1900	1800	1800	1800
F5	600	4400	4300	4100	3900	3700	3500	3400	3200	3000	2900
F5	800	5300	5100	4900	4800	4600	4400	4200	4100	3900	3800
F5	1200	6700	6500	6200	6100	5900	5700	5500	5200	4900	4600
MGP 10	400	3000	2200	2100	2000	1900	1900	1800	1800	1700	1600
MGP 10	600	4600	4300	4100	3900	3700	3600	3400	3200	3100	2900
MGP 10	800	5400	5200	5000	4800	4600	4400	4200	4000	3900	3800
MGP 10	1200	7000	6700	6300	6100	5800	5600	5400	5200	4900	4600
LVL 10	400	3000	2200	2100	2000	1900	1900	1800	1800	1700	1600
LVL 10	600	4600	4400	4300	4100	4000	3800	3700	3600	3500	3400
LVL 10	800	5500	5300	5100	4900	4800	4600	4500	4400	4300	4200
LVL 10	1200	7000	6700	6400	6200	6100	5900	5700	5600	5500	5400
MGP 12	400	3500	3200	3000	2300	2200	2100	2000	2000	1900	1900
MGP 12	600	4700	4500	4300	4200	4100	3900	3800	3700	3500	3300
MGP 12	800	5600	5400	5200	5000	4900	4700	4600	4500	4400	4300
MGP 12	1200	7100	6800	6600	6400	6200	6000	5800	5700	5500	5400
F17	400	3500	3400	3200	3100	3000	2800	2500	2300	2200	2100
F17	600	4700	4500	4400	4200	4100	3900	3800	3700	3600	3500
F17	800	5600	5400	5200	5100	4900	4800	4600	4500	4400	4300
F17	1200	7200	6900	6600	6400	6200	6000	5900	5700	5600	5500

Notes

i) Maximum Lintel Spans are based on the support of a maximum total sheet roof and ceiling framing mass of 40 kg/m^2 and tile roof, framing and ceiling mass of 90 kg/m^2. For guidance on roof and ceiling mass refer to Appendix A, AS1684. Lintels to internal wall openings supporting ceiling joist only shall be sized as hanging beams.

ii) Lintels in gable or skillion end walls not supporting roof loads shall be determined as per Clause 6.3.6.3.

iv) Minimum bearing length = 35 mm at end supports. Subscript values indicate the minimum and additional bearing length where required at end supports and internal supports.

v) When lintels are used to their maximum design limits, deflections of up to 10 mm (deadload) or 15 mm (live load) may be expected.

vi) For Roof Load Width determination, refer to Figure 2.

Span Tables - Lintel Beams

Table 6: Ply Box Single Span Lintel Beam Single/Upper Storey + Conc Load											
Flanges: 90 x 45 mm, Ply webs: 7 mm F8, Wind Classification: N1, N2 & N3											
Chord Stress Grade	Box Beam Depth (mm)	Lintels Single/Upper Storey Sheet Roof 1200 mm Rafters									
		Under Purlin or Hanging Beam									
		2400mm					4200mm				
		Strutting Beam Span (mm)									
		3600	4200	4800	5400	6000	3600	4200	4800	5400	6000
		Maximum Beam Span (mm)									
F5	400	3800	3700	3500	3400	3300	3700	3400	2900	2400	2100
F5	600	4500	4300	4200	4200	4100	4400	4300	4200	4100	3900
F5	800	5000	4800	4700	4600	4400	5000	4800	4600	4500	4400
F5	1200	5700	5600	5500	5400	5300	5800	5700	5600	5400	5300
MGP 10	400	3800	3700	3600	3400	3100	3700	3000	2400	2100	1900
MGP 10	600	4500	4300	4200	4200	4100	4400	4300	4200	4100	3900
MGP 10	800	5000	4900	4700	4600	4500	5000	4800	4700	4500	4400
MGP 10	1200	5700	5600	5600	5400	5300	5800	5700	5600	5400	5300
LVL 10	400	3800	3700	3600	3400	3100	3700	3000	2400	2100	1900
LVL 10	600	4500	4300	4200	4200	4100	4400	4300	4200	4100	4000
LVL 10	800	5000	4900	4700	4600	4500	5000	4800	4700	4500	4400
LVL 10	1200	5700	5600	5600	5400	5300	5800	5700	5600	5400	5300
MGP 12	400	3900	3700	3600	3500	3400	3800	3600	3500	3000	2500
MGP 12	600	4500	4300	4200	4200	4100	4400	4300	4200	4100	4000
MGP 12	800	5000	4900	4700	4600	4500	5000	4800	4700	4500	4400
MGP 12	1200	5700	5600	5600	5500	5300	5800	5700	5600	5400	5300
F17	400	3900	3700	3600	3500	3400	3800	3600	3500	3300	3200
F17	600	4500	4400	4200	4200	4100	4500	4300	4200	4200	4000
F17	800	5000	4900	4700	4600	4500	5000	4800	4700	4500	4400
F17	1200	5700	5600	5600	5500	5300	5800	5700	5600	5400	5300

Notes

i) Maximum Lintel Spans are based on the support of a maximum total sheet roof and ceiling framing mass of 40 kg/m^2 and tile roof, framing and ceiling mass of 90 kg/m^2. For guidance on roof and ceiling mass refer to Appendix A, AS1684.

ii) Lintels to internal wall openings supporting ceiling joist only shall be sized as hanging beams.

iii) Lintels in gable or skillion end walls not supporting roof loads shall be determined as per Clause 6.3.6.3.

iv) Minimum bearing length = 35 mm at end supports. Subscript values indicate the minimum and additional bearing length where required at end supports and internal supports.

v) When lintels are used to their maximum design limits, deflections of up to 10 mm (deadload) or 15 mm (live load) may be expected.

vi) For Roof Load Width determination, refer to Figure 2.

Span Tables - Lintel Beams

Table 7: Ply Box Single Span Lintel Beam Single/Upper Storey + Conc Load											
Flanges: 90 x 45 mm, Ply webs: 7 mm F8, Wind Classification: N1, N2 & N3											
Chord Stress Grade	Box Beam Depth (mm)	Lintels Single/Upper Storey Tile Roof 600 mm Rafters									
		Maximum Under Purlin or Hanging Beam Span (mm)									
		2400mm					4200mm				
		Strutting Beam Span (mm)									
		3600	4200	4800	5400	6000	3600	4200	4800	5400	6000
		Maximum Beam Span (mm)									
F5	400	3600	3000	2700	2400	2200	2400	1900	1800	1500	1300
F5	600	4900	4600	4300	4000	3800	4200	3900	3600	3300	2800
F5	800	5800	5600	5400	5200	4900	5400	5000	4700	4300	4100
F5	1200	7500	7300	7000	6800	6600	7100	6800	6500	6100	5700
MGP 10	400	3200	2900	2400	2200	1900	2100	1800	1600	1300	1200
MGP 10	600	5000	4600	4300	4100	3800	4200	3900	3300	2800	2400
MGP 10	800	6100	5800	5500	5200	4900	5400	5000	4700	4300	4100
MGP 10	1200	7900	7600	7200	6800	6500	7300	6800	6300	6000	5600
LVL 10	400	3200	2900	2400	2200	1900	2100	1800	1600	1300	1200
LVL 10	600	5100	4900	4700	4500	4000	4700	4000	3300	2800	2400
LVL 10	800	6100	5900	5700	5500	5400	5700	5400	5300	5000	4600
LVL 10	1200	7900	7600	7300	7100	6900	7400	7100	6800	6600	6400
MGP 12	400	3600	3600	3000	2800	2400	2700	2400	1800	1800	1500
MGP 12	600	5300	5100	4800	4600	4100	4800	4600	4000	3700	3200
MGP 12	800	6300	6100	5800	5600	5400	5900	5600	5400	5200	4900
MGP 12	1200	8000	7800	7500	7300	7100	7700	7300	7000	6800	6500
F17	400	3700	3600	3600	3600	3200	3600	3000	2500	2300	1900
F17	600	5400	5100	4900	4700	4100	4900	4600	4000	3800	3600
F17	800	6400	6100	5900	5700	5500	6000	5700	5400	5200	5000
F17	1200	8000	7900	7600	7300	7100	7700	7400	7100	6800	6600

Notes

i) For guidance on roof and ceiling mass refer to Appendix A, AS1684.
ii) Lintels to internal wall openings supporting ceiling joist only shall be sized as hanging beams.
iii) Lintels in gable or skillion end walls not supporting roof loads shall be determined as per Clause 6.3.6.3.
iv) When lintels are used to their maximum design limits, deflections of up to 10 mm (deadload) or 15 mm (live load) may be expected.
v) For Roof Load Width determination, refer to Figure 2.

Span Tables - Lintel Beams

Table 8: Ply Box Single Span Lintel Beam Single/Upper Storey + Conc Load											
Flanges: 90 x 45 mm, Ply webs: 7 mm F8, Wind Classification: N1, N2 & N3											
Chord Stress Grade	Box Beam Depth (mm)	Lintels Single/Upper Storey Tile Roof 1200 mm Rafters Spacing									
		Maximum Under Purlin or Hanging Beam Span (mm)									
		2400mm					4200mm				
		Strutting Beam Span (mm)									
		3600	4200	4800	5400	6000	3600	4200	4800	5400	6000
		Maximum Beam Span (mm)									
F5	400	3000	2400	2100	1900	1700	1900	1600	1300	1200	1100
F5	600	4500	4300	4200	4000	3700	4100	3800	3500	3200	3000
F5	800	5000	4800	4700	4600	4400	5000	4800	4600	4200	3900
F5	1200	5700	5600	5500	5400	5300	5800	5700	5600	5400	5300
MGP 10	400	2600	2100	1900	1700	1500	1700	1400	1200	1100	1000
MGP 10	600	4500	4300	4200	4000	3700	4200	3800	3500	3200	2900
MGP 10	800	5000	4900	4700	4600	4500	5000	4800	4600	4200	3900
MGP 10	1200	5700	5600	5600	5400	5300	5800	5700	5600	5400	5300
LVL 10	400	2600	2100	1900	1700	1500	1700	1400	1200	1100	1000
LVL 10	600	4500	4300	4200	4200	4100	4400	4300	3700	3300	2900
LVL 10	800	5000	4900	4700	4600	4500	5000	4800	4700	4500	4400
LVL 10	1200	5700	5600	5600	5400	5300	5800	5700	5600	5400	5300
MGP 12	400	3500	3000	2500	2100	1900	2200	1800	1600	1400	1200
MGP 12	600	4500	4300	4200	4200	4100	4400	4300	4200	4100	3600
MGP 12	800	5000	4900	4700	4600	4500	5000	4800	4700	4500	4400
MGP 12	1200	5700	5600	5600	5500	5300	5800	5700	5600	5400	5300
F17	400	3900	3700	3400	3000	2600	3200	2500	2100	1800	1600
F17	600	4500	4400	4200	4200	4100	4500	4300	4200	4200	3900
F17	800	5000	4900	4700	4600	4500	5000	4800	4700	4500	4400
F17	1200	5700	5600	5600	5500	5300	5800	5700	5600	5400	5300

Notes

i) For guidance on roof and ceiling mass refer to Appendix A, AS1684.

ii) Lintels to internal wall openings supporting ceiling joist only shall be sized as hanging beams.

iii) Lintels in gable or skillion end walls not supporting roof loads shall be determined as per Clause 6.3.6.3.

iv) When lintels are used to their maximum design limits, deflections of up to 10 mm (deadload) or 15 mm (live load) may be expected.

v) For Roof Load Width determination, refer to Figure 2.

Span Tables - Strutting Beams

Table 9: Ply Box Single Span Strutting Beam											
Flanges: 90 x 45 mm, Ply webs: 7 mm F8, Wind Classification: N1, N2 & N3											
Chord Stress Grade	Box Beam Depth (mm)	Roof Load Area (m²)									
		2.5	5	7.5	10	12.5	15	17.5	20	22.5	25
		Maximum Beam Span (mm)									
		Sheet Roof									
F5	400	5200	2600	1700	1300	1000	NA	NA	NA	NA	NA
F5	600	8000	4400	2900	2200	1700	1400	1200	NA	NA	NA
F5	800	8000	6400	4200	3200	2500	2100	1800	1600	1400	
F5	1200	8000	8000	7400	5600	4400	3700	3200	2800	2500	2200
MGP 10	400	4800	2400	1600	1200	NA	NA	NA	NA	NA	NA
MGP 10	600	8000	4000	2700	2000	1600	1300	1100	NA	NA	NA
MGP 10	800	8000	5700	3800	2900	2300	1900	1600	1400	1300	0
MGP 10	1200	8000	8000	6500	4900	3900	3200	2800	2400	2100	1900
LVL 10	400	4800	2400	1600	1200	NA	NA	NA	NA	NA	NA
LVL 10	600	8000	4000	2700	2000	1600	1300	1100	NA	NA	NA
LVL 10	800	8000	5700	3800	2900	2300	1900	1600	1400	1300	NA
LVL 10	1200	8000	8000	6500	4900	3900	3200	2800	2400	2100	1900
MGP 12	400	5700	2800	1900	1400	1100	NA	NA	NA	NA	NA
MGP 12	600	8000	4700	3100	2300	1800	1500	1300	NA	NA	NA
MGP 12	800	8000	6600	4400	3300	2600	2200	1900	1600	1400	NA
MGP 12	1200	8000	8000	7400	5500	4400	3700	3100	2800	2400	2200
F17	400	6800	3400	2300	1700	1300	NA	NA	NA	NA	NA
F17	600	8000	5500	3700	2800	2200	1800	1600	NA	NA	NA
F17	800	8000	7900	5200	3900	3100	2600	2200	1900	1700	1600
F17	1200	8000	8000	8000	6500	5200	4300	3700	3300	2900	2600

Notes

i) Maximum spans are based on the support of roof mass only up to a maximum sheet roof mass of 20 kg/m² and tiled roof mass of 60 kg/m². For guidance on roof and ceiling mass refer to Appendix A, AS1684.2. The mass of rafters and underpurlins is accommodated in the span calculations

ii) Where the depth to breadth ratio exceeds 3:1 G.I. strapping or similar restraint to the top edge of the beam is to be provided at the strutting points and at beam ends. Refer to Clause 7.2.26 of AS1684.2.

iii) Beam ends can not be chamfered.

iv) A minimum initial clearance of 25 mm shall be provided at the mid-span between the underside of the strutting beam and the tops of ceiling joist, ceiling lining or ceiling battens as appropriate.

v) Minimum bearing length = 70 mm at end supports.

vi) For design parameters reder to Figure 3.

vii) NA - Not applicable.

Span Tables - Strutting Beams

Table 10: Ply Box Single Span Strutting Beam											
Flanges: 90 x 45 mm, Ply webs: 7 mm F8, Wind Classification: N1, N2 & N3											
Chord Stress Grade	Box Beam Depth (mm)	Roof Load Area (m^2)									
		2.5	5	7.5	10	12.5	15	17.5	20	22.5	25
		Maximum Beam Span (mm)									
		Tile Roofs									
F5	400	3900	1900	NA	NA	NA	NA	NA	NA	NA	NA
F5	600	6500	3200	2200	1600	1300	NA	NA	NA	NA	NA
F5	800	8000	4800	3200	2400	1900	1600	NA	NA	NA	NA
F5	1200	8000	8000	5500	4100	3300	2800	2400	2100	1800	NA
MGP 10	400	3600	1800	NA	NA	NA	NA	NA	NA	NA	NA
MGP 10	600	6000	3000	2000	1500	NA	NA	NA	NA	NA	NA
MGP 10	800	8000	4300	2900	2100	1700	1400	NA	NA	NA	NA
MGP 10	1200	8000	7300	4800	3600	2900	2400	2100	1800	1600	NA
LVL 10	400	3600	1800	NA	NA	NA	NA	NA	NA	NA	NA
LVL 10	600	6000	3000	2000	1500	NA	NA	NA	NA	NA	NA
LVL 10	800	8000	4300	2900	2100	1700	1400	1200	NA	NA	NA
LVL 10	1200	8000	7300	4800	3600	2900	2400	2100	1800	1600	1400
MGP 12	400	4200	2100	1400	NA	NA	NA	NA	NA	NA	NA
MGP 12	600	6900	3500	2300	1700	1400	NA	NA	NA	NA	NA
MGP 12	800	8000	4900	3300	2500	2000	1600	1400	NA	NA	NA
MGP 12	1200	8000	8000	5500	4100	3300	2700	2300	2000	1800	1600
F17	400	5100	2500	1700	1200	NA	NA	NA	NA	NA	NA
F17	600	8000	4100	2800	2100	1600	NA	NA	NA	NA	NA
F17	800	8000	5900	3900	2900	2300	1900	1700	NA	NA	NA
F17	1200	8000	8000	6500	4900	3900	3200	2800	2400	2100	1900

Notes

i) Maximum spans are based on the support of roof mass only up to a maximum sheet roof mass of 20 kg/m^2 and tiled roof mass of 60 kg/m^2. For guidance on roof and ceiling mass refer to Appendix A, AS1684.2. The mass of rafters and underpurlins is accommodated in the span calculations.

ii) Where the depth to breadth ratio exceeds 3:1 G.I. strapping or similar restraint to the top edge of the beam is to be provided at the strutting points and at beam ends. Refer to Clause 7.2.26 of AS1684.2.

iii) Beam ends can not be chamfered.

iv) A minimum initial clearance of 25 mm shall be provided at the mid-span between the underside of the strutting beam and the tops of ceiling joist, ceiling lining or ceiling battens as appropriate.

v) Minimum bearing length = 70 mm at end supports.

vi) For design parameters reder to Figure 3.

vii) NA - Not applicable.

Span Tables - Strutting/Hanging Beams

Table 11: Ply Box Single Span Strutting/Hanging Beam Perpendicular to Rafters - Sheet Roof										
Chord Stress Grade	Box Beam Depth (mm)	Flanges: 90 x 45 mm, Ply webs: 7mm F8, Wind Class: N1, N2 & N3								
		Roof Load Width (mm)								
		1200	1800	2400	3000	3600	4200	4800	5400	6000
		Maximum Beam Span (mm)								
F5	400	4500	3600	3200	2800	2600	2400	2200	2100	1900
F5	600	5900	4800	4100	3700	3400	3100	2900	2700	2600
F5	800	7100	5700	5000	4400	4000	3700	3500	3300	3100
F5	1200	8000	7500	6500	5800	5300	4900	4500	4300	4100
MGP 10	400	4500	3700	3200	2800	2600	2400	2200	2000	1800
MGP 10	600	5900	4800	4100	3700	3400	3100	2900	2700	2600
MGP 10	800	7000	5700	4900	4400	4000	3700	3500	3300	3100
MGP 10	1200	8000	7400	6400	5700	5200	4800	4500	4200	4000
LVL 10	400	7500	6100	4600	3700	3100	2600	2300	2000	1800
LVL 10	600	8000	7900	6900	5800	4900	4200	3700	3300	2900
LVL 10	800	8000	8000	8000	7300	6200	5300	4700	4100	3700
LVL 10	1200	8000	8000	8000	8000	7900	6800	5900	5300	4700
MGP 12	400	5600	4600	3900	3500	3200	2900	2500	2300	2000
MGP 12	600	7300	5900	5100	4600	4200	3800	3500	3100	2800
MGP 12	800	8000	7000	6100	5400	5000	4600	4300	4000	3600
MGP 12	1200	8000	8000	7800	7000	6400	5900	5200	4600	4100
F17	400	8000	6800	5300	4300	3600	3100	2700	2400	2200
F17	600	8000	8000	7500	6000	5000	4300	3700	3300	3000
F17	800	8000	8000	8000	7600	6400	5400	4800	4200	3800
F17	1200	8000	8000	8000	8000	8000	6900	6100	5400	4900

Notes

i) Maximum spans are based on the support of a maximum sheet roof mass of 20 kg/m^2 plus a ceiling mass of 12 kg/m^2 (including ceiling joists) and a maximum tile roof mass of 60 kg/m^2 plus a ceiling mass of 12 kg/m^2. For guidance on roof and ceiling mass refer to Appendix A, AS1684.2. The mass of rafters, underpurlins and ceiling joists etc. is accommodated in the span calculations.
ii) Where the depth to breadth ration exceeds 3:1, G.I. strapping or similar restraint is to be provided to the top edge of the beam at beam ends. Refer to AS1684.2 Clause 7.2.26.
iii) Where hanging beams are not the same each side of the strutting/counter beam, the average of the spans may be used.
iv) Minimum bearing length = 70 mm at end supports. Subscript values indicate the minimum additional bearing length where required at end supports and internal supports.
v) For design parameters refer to Figure 3.
vi) RLW - Max of Roof Span/2 or Ceiling Joist Span/2 which ever is the greatest.

Span Tables - Strutting/Hanging Beams

Table 12: Ply Box Single Span Strutting/Hanging Beam Perpendicular to Rafters - Tile Roof										
Chord Stress Grade	Box Beam Depth (mm)	Flanges: 90 x 45 mm, Ply webs: 7mm F8, Wind Class: N1, N2 & N3								
		Roof Load Width (mm)								
		1200	1800	2400	3000	3600	4200	4800	5400	6000
		Maximum Beam Span (mm)								
F5	400	4600	3800	3200	2900	2600	2500	2300	2200	2000
F5	600	6000	4900	4200	3800	3500	3200	3000	2800	2700
F5	800	7300	5900	5100	4600	4200	3900	3600	3400	3200
F5	1200	8000	7700	6700	5900	5400	5000	4700	4400	4100
MGP 10	400	4700	3800	3300	2900	2700	2500	2300	2100	1900
MGP 10	600	6100	4900	4300	3800	3500	3200	3000	2800	2700
MGP 10	800	7300	5900	5100	4600	4200	3800	3600	3400	3200
MGP 10	1200	8000	7600	6600	5900	5300	4900	4600	4400	4100
LVL 10	400	7700	6300	4900	3900	3200	2800	2400	2100	1900
LVL 10	600	8000	8000	7100	6200	5200	4400	3900	3500	3100
LVL 10	800	8000	8000	8000	7500	6600	5600	4900	4400	4000
LVL 10	1200	8000	8000	8000	8000	8000	7200	6300	5600	5000
MGP 12	400	5800	4700	4100	3600	3300	3100	2700	2400	2200
MGP 12	600	7500	6100	5300	4700	4300	4000	3700	3300	3000
MGP 12	800	8000	7300	6300	5600	5100	4700	4400	4200	3800
MGP 12	1200	8000	8000	8000	7200	6500	5900	5000	4700	4200
F17	400	8000	7000	5700	4500	3800	3200	2800	2500	2300
F17	600	8000	8000	7800	6300	5300	4500	4000	3500	3200
F17	800	8000	8000	8000	8000	6700	5800	5100	4500	4100
F17	1200	8000	8000	8000	8000	8000	7400	6500	5700	5200

Notes

i) Maximum spans are based on the support of a maximum sheet roof mass of 20 kg/m² plus a ceiling mass of 12 kg/m² (including ceiling joists) and a maximum tile roof mass of 60 kg/m² plus a ceiling mass of 12 kg/m².

ii) For guidance on roof and ceiling mass refer to Appendix A, AS1684.2. The mass of rafters, underpurlins and ceiling joists etc. is accommodated in the span calculations.

iii) Where the depth to breadth ration exceeds 3:1, G.I. strapping or similar restraint is to be provided to the top edge of the beam at beam ends. Refer to AS1684.2 Clause 7.2.26.

iv) Where hanging beams are not the same each side of the strutting/counter beam, the average of the spans may be used.

v) Minimum bearing length = 70 mm at end supports. Subscript values indicate the minimum additional bearing length where required at end supports and internal supports.

vi) For other design parameters refer to Figure 3.

vii) RLW = Max of Roof Span/2 or Ceiling Joist Span/2 which ever is the greatest.

Span Tables - Bearers

Table 13: Ply Box Single Span Bearers Supporting Floor Load Only										
Chord Stress Grade	Box Beam Depth (mm)	Flanges: 90 x 45 mm, Ply webs: 7mm F8, Wind Class: N1, N2 & N3								
		Floor Load Width (mm)								
		3000	3300	3600	3900	4200	4500	4800	5100	5400
		Maximum Beam Span (mm)								
F5	400	2700	2400	2200	1800	1400	NA	NA	NA	NA
F5	600	4200	4000	3700	3400	3100	2900	2700	2500	2300
F5	800	5000	4800	4600	4400	4200	4100	3900	3700	3400
F5	1200	6500	6200	5900	5700	5500	5300	5100	4900	4600
MGP 10	400	2500	2200	1900	1400	1100	NA	NA	NA	NA
MGP 10	600	4100	3700	3400	3100	2900	2600	2500	2300	2200
MGP 10	800	5000	4800	4600	4400	4100	3800	3500	3300	3100
MGP 10	1200	6500	6100	5900	5600	5400	5200	5000	4900	4600
LVL 10	400	2500	2200	1900	1400	1100	NA	NA	NA	NA
LVL 10	600	4100	3700	3400	3100	2900	2600	2500	2300	2200
LVL 10	800	5700	5300	4800	4400	4100	3800	3500	3300	3100
LVL 10	1200	7300	7100	6800	6600	6400	6300	5900	5500	4600
MGP 12	400	2900	2600	2400	2200	1900	1500	1200	NA	NA
MGP 12	600	4800	4300	3900	3600	3300	3100	2900	2700	2500
MGP 12	800	5900	5700	5500	5100	4700	4400	4100	3800	3600
MGP 12	1200	7500	7200	7000	6800	6600	6100	5700	5300	4600
F17	400	3500	3100	2900	2600	2400	2200	2100	1700	1400
F17	600	4900	4700	4600	4300	4000	3700	3400	3200	3000
F17	800	5900	5700	5500	5300	5100	4700	4400	4100	3900
F17	1200	7600	7300	7000	6800	6600	6400	6000	5600	4700

Notes

i) Maximum Bearer Spans are based on the support of a maximum flooring mass of 40 kg/m^2.

ii) Minimum bearing length = 50 mm at end supports.

iii) For design parameters refer to Figure 4.7.

iv) For Floor Load Width refer to Figure 4

v) NA - Not applicable

Span Tables - Bearers

Table 14: Ply Box Single Span Floor Bearers - Floor load width 3600 mm									
Supporting single or upper storey loadbearing walls									
Flanges: 90 x 45 mm, Ply webs: 7mm F8, Wind Class: N1, N2 & N3									
Chord Stress Grade	Box Beam Depth (mm)	Floor Load Width (mm)							
		3000	4200	5400	6600	3000	4200	5400	6600
		Maximum Beam Span (mm)							
		Sheet Roof				Tile Roof			
F5	400	1200	1100	1100	1000	1000	NA	NA	NA
F5	600	1900	1800	1700	1600	1600	1400	1300	1200
F5	800	2600	2400	2300	2200	2200	2000	1800	1600
F5	1200	3800	3600	3500	3300	3300	3000	2700	2500
MGP 10	400	1100	1100	1000	1000	NA	NA	NA	NA
MGP 10	600	1900	1800	1700	1600	1600	1400	1300	1200
MGP 10	800	2600	2500	2400	2300	2300	2000	1900	1700
MGP 10	1200	4000	3800	3600	3400	3400	3100	2800	2600
LVL 10	400	1100	1100	1000	NA	NA	NA	NA	NA
LVL 10	600	1900	1800	1700	1600	1600	1400	1300	1200
LVL 10	800	2700	2600	2400	2300	2300	2100	1900	1700
LVL 10	1200	4300	4000	3900	3700	3600	3300	3000	2800
MGP 12	400	1300	1200	1100	1100	1100	1000	NA	NA
MGP 12	600	2000	1900	1800	1700	1700	1500	1400	1300
MGP 12	800	2700	2600	2400	2300	2300	2100	1900	1700
MGP 12	1200	4100	3900	3700	3500	3500	3200	2900	2700
F17	400	1400	1300	1200	1200	1200	1100	1000	NA
F17	600	2200	2000	1900	1800	1800	1700	1500	1400
F17	800	2900	2800	2600	2500	2500	2200	2100	1900
F17	1200	4400	4200	4000	3800	3800	3400	3100	2900

Notes

i) Maximum Bearer Spans supporting roof loads are based on the support of a maximum total sheet roof, framing and ceiling mass of 40 kg/m^2, a maximum total tile roof, framing and ceiling mass of 90 kg/m^2 and a maximum floor mass of 40 kg/m^2. For guidance on determination of roof mass refer to Appendix A, AS1684.2

ii) Minimum bearing length = 50 mm at end supports.

iii) For design parameters refer to Figure 4.6 AS1684.2.

iv) Bearers cannot support walls at right angles to bearer.

v) Table does not cover where bearers support roof point loads.

vi) NA - Not applicable

Span Tables - Bearers

Table 15: Ply Box Single Span Floor Bearers - Floor load width 4200 mm									
Supporting single or upper storey loadbearing walls									
Flanges: 90 x 45 mm, Ply webs: 7mm F8, Wind Class: N1, N2 & N3									
Chord Stress Grade	Box Beam Depth (mm)	Roof Load Width (mm)							
		3000	4200	5400	6600	3000	4200	5400	6600
		Maximum Beam Span (mm)							
		Sheet Roof				Tile Roof			
F5	400	NA	NA	NA	NA	NA	NA	NA	NA
F5	600	1500	1500	1400	1300	1300	1200	1100	1000
F5	800	2100	2000	1900	1900	1800	1700	1500	1400
F5	1200	3300	3100	3000	2800	2800	2600	2400	2200
MGP 10	400	1000	NA	NA	NA	NA	NA	NA	NA
MGP 10	600	1600	1500	1400	1400	1400	1300	1200	1100
MGP 10	800	2200	2100	2000	1900	1900	1700	1600	1500
MGP 10	1200	3400	3200	3100	3000	2900	2700	2500	2300
LVL 10	400	1000	NA	NA	NA	NA	NA	NA	NA
LVL 10	600	1600	1600	1500	1400	1400	1300	1200	1100
LVL 10	800	2400	2300	2100	2000	2100	1900	1700	1600
LVL 10	1200	3600	3500	3300	3200	3200	2900	2700	2500
MGP 12	400	1000	NA	NA	NA	NA	NA	NA	NA
MGP 12	600	1600	1500	1500	1400	1400	1300	1200	1100
MGP 12	800	2300	2100	2100	2000	2000	1800	1600	1500
MGP 12	1200	3500	3300	3200	3000	3000	2800	2500	2400
F17	400	1100	1000	1000	NA	NA	NA	NA	NA
F17	600	1800	1700	1600	1500	1500	1400	1300	1200
F17	800	2400	2300	2200	2100	2100	1900	1800	1600
F17	1200	3700	3600	3400	3300	3300	3000	2700	2500

Notes

i) Maximum Bearer Spans supporting roof loads are based on the support of a maximum total sheet roof, framing and ceiling mass of 40 kg/m^2, a maximum total tile roof, framing and ceiling mass of 90 kg/m^2 and a maximum floor mass of 40 kg/m^2. For guidance on determination of roof mass refer to Appendix A, AS1684.2.
ii) Minimum bearing length = 50 mm at end supports.
iii) For design parameters refer to Figure 4.6 AS1684.2.
iv) Bearers cannot support walls at right angles to bearer.
v) Table does not cover where bearers support roof point loads.
vi) NA - Not applicable

Span Tables - Bearers

Table 16: Ply Box Single Span Floor Bearers - Floor load width 5400 mm									
Supporting single or upper storey loadbearing walls									
Flanges: 90 x 45 mm, Ply webs: 7mm F8, Wind Class: N1, N2 & N3									
Chord Stress Grade	Box Beam Depth (mm)	Roof Load Width (mm)							
		3000	4200	5400	6600	3000	4200	5400	6600
		Maximum Beam Span (mm)							
		Sheet Roof				Tile Roof			
F5	400	NA	NA	NA	NA	NA	NA	NA	NA
F5	600	1000	1000	NA	NA	NA	NA	NA	NA
F5	800	1500	1400	1200	1100	1300	1200	1200	1100
F5	1200	2400	2300	1900	1800	2200	2000	1900	1700
MGP 10	400	NA	NA	NA	NA	NA	NA	NA	NA
MGP 10	600	1100	1000	1000	1000	1000	NA	NA	NA
MGP 10	800	1600	1500	1500	1400	1400	1300	1200	1100
MGP 10	1200	2500	2400	2300	2300	2200	2100	1900	1800
LVL 10	400	NA	NA	NA	NA	NA	NA	NA	NA
LVL 10	600	1200	1100	1000	NA	1100	1000	NA	NA
LVL 10	800	1700	1600	1500	NA	1400	1400	1300	1200
LVL 10	1200	2700	2600	2400	2400	2400	2200	2100	2000
MGP 12	400	NA	NA	NA	NA	NA	NA	NA	NA
MGP 12	600	1100	1100	1000	1000	1000	NA	NA	NA
MGP 12	800	1600	1500	1500	1400	1400	1300	1200	1200
MGP 12	1200	2600	2500	2400	2300	2300	2100	2000	1900
F17	400	NA	NA	NA	NA	NA	NA	NA	NA
F17	600	1100	1100	NA	NA	1000	NA	NA	NA
F17	800	1600	1600	1200	1200	1400	1300	1200	1200
F17	1200	2600	2500	2100	2000	2300	2200	2000	1900

Notes

i) Maximum Bearer Spans supporting roof loads are based on the support of a maximum total sheet roof, framing and ceiling mass of 40 kg/m^2, a maximum total tile roof, framing and ceiling mass of 90 kg/m^2 and a maximum floor mass of 40 kg/m^2. For guidance on determination of roof mass refer to Appendix A, AS1684.2.
ii) Minimum bearing length = 50 mm at end supports.
iii) For design parameters refer to Figure 4.6 AS1684.2.
iv) Bearers cannot support walls at right angles to bearer.
v) Table does not cover where bearers support roof point loads.
vi) NA - Not applicable

Span Tables - Counter Beams

Table 17: Ply Box Single Span Counter Beam									
Chord Stress Grade	Box Beam Depth (mm)	Flanges: 90 x 45 mm, Ply webs: 7mm F8, Wind Classification: N1, N2 & N3							
		Ceiling Load Width							
		2400	3000	3600	4200	4800	5400	6000	5600
		Maximum Beam Span (mm)							
F5	400	3900	3500	3200	2900	2700	2600	2400	2300
F5	600	5100	4500	4100	3800	3600	3400	3200	3000
F5	800	6100	5500	5000	4600	4300	4100	3900	3700
F5	1200	8000	7200	6600	6100	5700	5400	5100	4400
MGP 10	400	3700	3400	3100	2800	2700	2500	2400	2300
MGP 10	600	4800	4300	4000	3700	3400	3200	3100	2900
MGP 10	800	5800	5200	4700	4400	4100	3900	3700	3500
MGP 10	1200	7600	6800	6200	5700	5400	5000	4800	4300
LVL 10	400	3700	3400	3100	2800	2700	2500	2400	2300
LVL 10	600	4800	4300	4000	3700	3400	3200	3100	2900
LVL 10	800	5800	5200	4700	4400	4100	3900	3700	3500
LVL 10	1200	7600	6800	6200	5700	5400	5000	4800	4400
MGP 12	400	4100	3700	3300	3100	2900	2700	2600	2400
MGP 12	600	5200	4700	4300	3900	3700	3500	3300	3100
MGP 12	800	6200	5600	5100	4700	4400	4200	3900	3600
MGP 12	1200	8000	7200	6600	6100	5700	5400	5100	4700
F17	400	4500	4000	3600	3400	3200	3000	2800	2700
F17	600	5700	5100	4700	4300	4000	3800	3600	3400
F17	800	6800	6100	5600	5100	4800	4500	4300	4000
F17	1200	8000	7800	7200	6600	6200	5800	5500	5100

Notes

i) Maximum spans are based on the support of a maximum ceiling mass of 12 kg/m^2.

ii) Where hanging beam spans are not the same each side of the counter beam, the average of the spans may be used.

iii) Minimum bearing length = 70 mm at end supports.

iv) For design parameters refer to Figure 2.

Span Tables - Ridge and Intermediate Beams

Table 18: Ply Box Single Span Ridge and Intermediate Beam

Flanges: 90 x 45 mm, Ply webs: 7mm F8, Wind Classification: N1, N2 & N3

Chord Stress Grade	Box Beam Depth (mm)	Sheet Roof									
		Roof Load Width									
		2700	3000	3300	3600	3900	4200	4500	4800	5100	5400
		Maximum Beam Span (mm)									
F5	400	3000	2900	2800	2700	2600	2500	2400	2300	2200	2200
F5	600	4000	3900	3700	3600	3500	3400	3300	3200	3100	3000
F5	800	4900	4700	4500	4400	4200	4100	4000	3900	3800	3700
F5	1200	6300	6000	5800	5700	5500	5300	5200	5100	5000	4900
MGP 10	400	3100	2900	2800	2700	2600	2500	2400	2300	2200	2100
MGP 10	600	4200	4000	3800	3700	3600	3400	3300	3200	3100	3100
MGP 10	800	5000	4800	4700	4500	4300	4200	4100	4000	3900	3800
MGP 10	1200	6500	6200	6000	5800	5600	5500	5300	5200	5100	4900
LVL 10	400	3100	2900	2800	2700	2600	2500	2400	2300	2200	2100
LVL 10	600	4200	4000	3800	3700	3600	3400	3300	3200	3100	3100
LVL 10	800	5000	4800	4700	4500	4300	4200	4100	4000	3900	3800
LVL 10	1200	6500	6200	6000	5800	5600	5500	5300	5200	5100	4900
MGP 12	400	3100	3000	2800	2700	2600	2500	2400	2300	2200	2200
MGP 12	600	4200	4000	3900	3700	3600	3500	3400	3300	3200	3100
MGP 12	800	5100	4900	4700	4600	4400	4300	4100	4000	3900	3800
MGP 12	1200	6600	6400	6100	5900	5700	5600	5400	5300	5100	5000
F17	400	3100	3000	2800	2700	2600	2500	2400	2300	2200	2200
F17	600	4300	4100	3900	3700	3600	3500	3400	3300	3200	3100
F17	800	5200	5000	4800	4600	4400	4300	4200	4000	3900	3800
F17	1200	6700	6400	6200	6000	5800	5600	5400	5300	5200	5000

Notes

i) Maximum spans are based on the support of roof or roof plus ceiling mass for a cathedral roof. For guidance on roof and ceiling mass refer to Appendix A, AS1684.2.

ii) No birdsmouth or notching allowed.

iii) Minimum bearing length = 35 mm at end supports and 70 mm at intermediate supports

Span Tables - Ridge and Intermediate Beams

Table 19: Ply Box Single Span Ridge and Intermediate Beam											
Flanges: 90 x 45 mm, Ply webs: 7mm F8, Wind Classification: N1, N2 & N3											
Chord Stress Grade	Box Beam Depth (mm)	Tile Roof									
		Roof Load Width									
		2700	3000	3300	3600	3900	4200	4500	4800	5100	5400
		Maximum Beam Span (mm)									
F5	400	3000	2900	2800	2700	2600	2500	2400	2200	2100	1900
F5	600	4000	3900	3700	3600	3500	3400	3300	3000	2900	2700
F5	800	4900	4700	4500	4400	4200	4100	4000	3900	3600	3400
F5	1200	6300	6000	5800	5700	5500	5300	5200	5100	4900	4600
MGP 10	400	3100	2900	2800	2700	2600	2400	2200	2000	1900	1800
MGP 10	600	4200	4000	3800	3700	3600	3400	3300	3100	2900	2700
MGP 10	800	5000	4800	4700	4400	4300	4200	4100	4000	3700	3500
MGP 10	1200	6500	6200	6000	5800	5600	5500	5300	5100	4900	4600
LVL 10	400	3100	2900	2800	2700	2600	2400	2200	2000	1900	1800
LVL 10	600	4200	4000	3800	3700	3600	3400	3300	3200	3100	2900
LVL 10	800	5000	4800	4700	4500	4300	4200	4100	4000	3900	3700
LVL 10	1200	6500	6200	6000	5800	5600	5500	5300	5200	5000	4600
MGP 12	400	3100	3000	2800	2700	2600	2500	2400	2300	2100	2000
MGP 12	600	4200	4000	3900	3700	3600	3500	3400	3200	3000	2800
MGP 12	800	5000	4900	4700	4600	4400	4300	4100	4000	3800	3600
MGP 12	1200	6500	6400	6100	5900	5700	5600	5400	5300	5100	4600
F17	400	3100	3000	2800	2700	2600	2500	2400	2300	2200	2100
F17	600	4300	4100	3900	3700	3600	3500	3400	3300	3100	3000
F17	800	5200	5000	4800	4600	4400	4300	4200	4000	3900	3800
F17	1200	6700	6400	6200	6000	5800	5600	5400	5200	4900	4600

Notes

i) Maximum spans are based on the support of roof or roof plus ceiling mass for a cathedral roof. For guidance on roof and ceiling mass refer to Appendix A, AS1684.2.

ii) No birdsmouth or notching allowed.

iii) Minimum bearing length = 35 mm at end supports and 70 mm at intermediate supports.


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Stairs, Balustrades and Handrails

Class 1 Buildings - Construction

Technical Design Guide issued by Forest and Wood Products Australia

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Table of Contents

Introduction

This guide covers stairs with straight flights, with or without risers for external and internal use and balustrades.

Staircase and balustrade work is considered to be a specialised section of carpentry and joinery. This document covers stairs with *straight flights, with or without risers for external and internal use and balustrades.*

Internal stairs are often prepared in a workshop making full use of available machines and equipment. Interior stairs may differ considerably in design, from simple straight flights, commonly used in domestic work, to more elaborate stairs constructed purposely as an attractive feature in public and commercial buildings and in elaborate homes.

Exterior stairs are commonly built from treated softwood and durable hardwoods while interior stairs are commonly built from joinery-quality timber cut and seasoned especially for stairs. The finish for exterior stairs is generally paint and interior stairs is often clear polish, lacquer, etc, therefore both material and workmanship should be of the very highest standard.

The construction procedure described here would be more or less general for all stairs of either conventional or contemporary construction.

At an early stage in the construction of a building having exterior and/or interior stairs, a decision will have to be made on the length of the stairs to determine the location of any foundations, concrete pads, etc, and the opening required in the floor to accommodate internal stairs and provide sufficient headroom. Also, before the timber for the stairs can be ordered, it will be necessary to know the length of the string, newels, landing trimmers, joists, etc, and the number of treads and risers required. Refer to Appendix B for the calculations needed to determine these facts.

Scope

This guide is intended to be used by the building industry for the design, practices and construction of timber stairs, handrails and balustrades. Information with respect to both internal and external stairs is provided. Also, both open stairs (no risers) and closed stairs (with risers) are catered for. Recommendations are also provided on timber species selection, durability and finishing, etc, and example stair calculations are given in Appendix B and C.

Disclaimer

NCC – BCA Requirements

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

This publication focuses on traditional practices and current relevant Building Code of Australia (BCA) requirements.

The Guide has been prepared to comply with the requirements of the NCC-BCA including the member sizes for stringers, treads and handrails etc. which have been designed to satisfy the loading requirements specified in AS 1170.1.

From time to time the BCA is amended and states may also vary requirements. Users of this Guide should make themselves aware of any changes or differences and should develop a full understanding of the resulting implications. Only on this basis should this Guide be used.

1

Types of Stair Construction

The design and configuration of stairs can differ markedly depending upon space availability, functionality and desired appearance. This section describes different types of stair configurations and the various components of these.

The common type of stair construction is to house treads into stringers as shown in Figure 1.1. Flights may be constructed with 'open treads' without risers or 'closed treads' with riser boards.

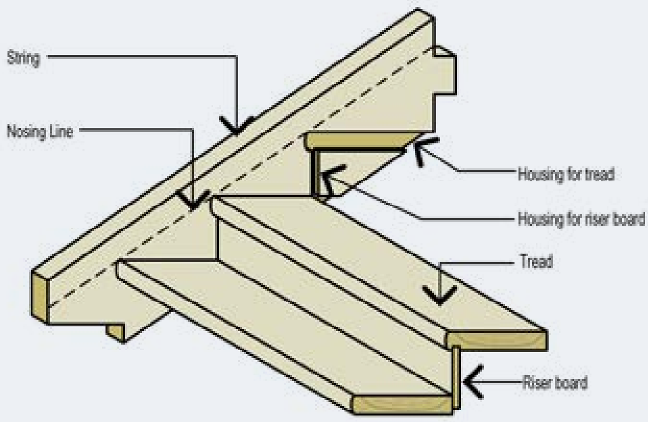


Figure 1.1: Common stair construction.

Open tread stairs are recommended for external use.

Closed tread stairs and open tread stairs are suitable for both external and internal use. However open tread stairs are recommended for external use because they give better air circulation allowing the timber to dry out more quickly and therefore improve durability. Metal angle brackets may also be used rather than housing in the treads.

As an alternative to timber, metal may be used for stringers. Metal strings are often used in external locations, but can also be used for internal stairs. They are available in some states with a 'stock' rise and going or can be ordered with a specific rise and going.

Depending on the application, flights can be configured in various ways. The following illustrates some of these.

1.1 Straight Stairs

A single flight of stairs having all treads parallel to one another. This form of stair, which is widely used for domestic construction, has no landing and may be enclosed between two walls or built against one wall and the other side open with newels and balustrade (Figure 1.2).

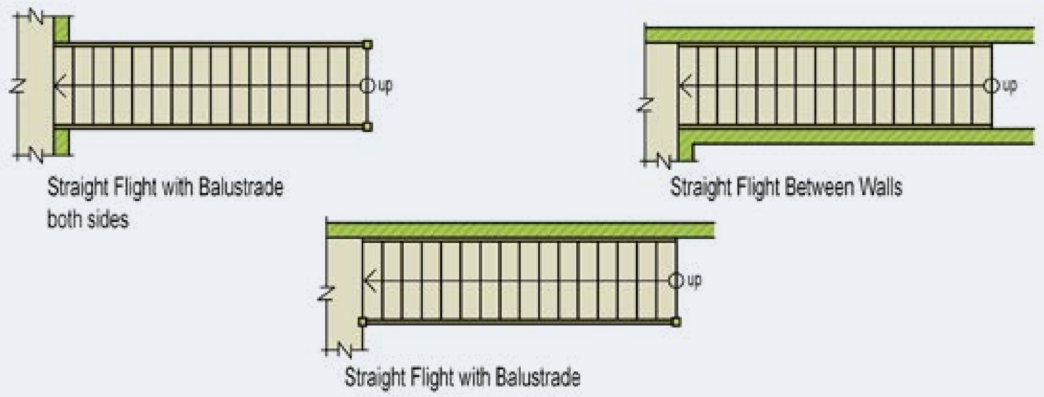


Figure 1.2: Straight stairs.

1.2 Straight Stairs with Intermediate Landing

Stairs having more than one flight rising in the same direction and all treads parallel (Figure 1.3).

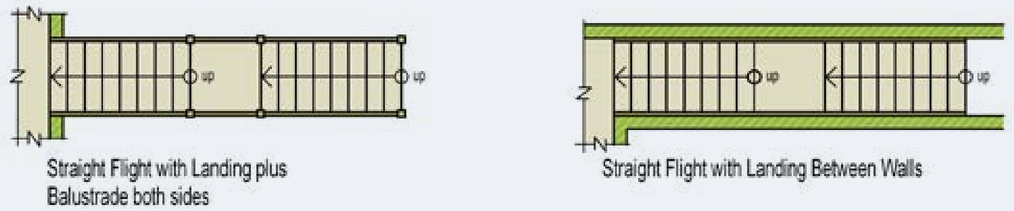


Figure 1.3: Straight stairs with landing.

1.3 Newel Stairs

All stairs which include newel posts in their construction are referred to as newel stairs.

All stairs which include newel posts in their construction are referred to as newel stairs. The newels support the handrails and/or balustrade and may also support the landings and strings. Figures 1.2 and 1.3 illustrate straight newel stairs. Figures 1.4, 1.5 and 1.6 show other forms of newel stairs.

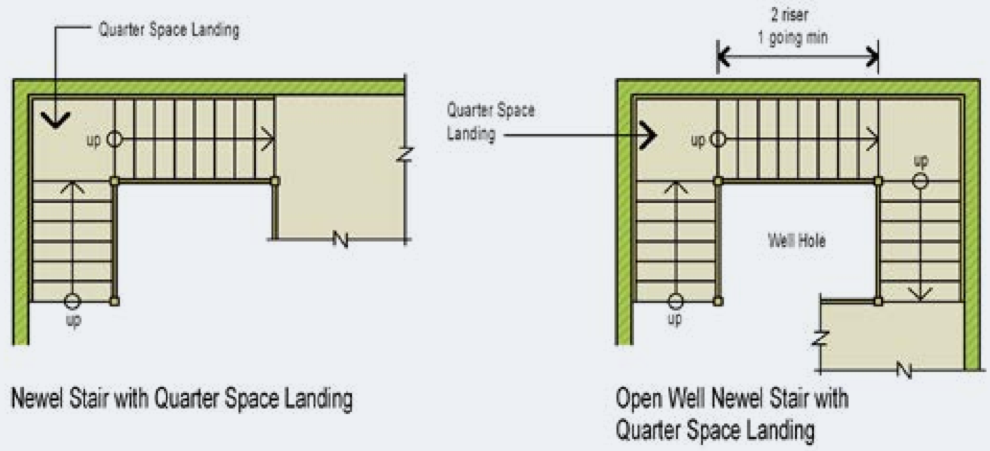


Figure 1.4: Newel stairs.

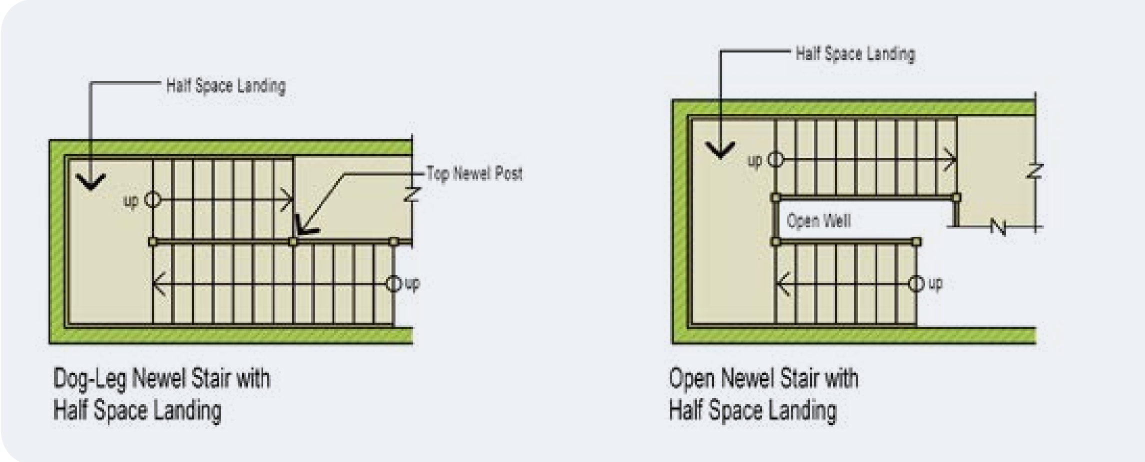


Figure 1.5: Dog-leg newel stairs.

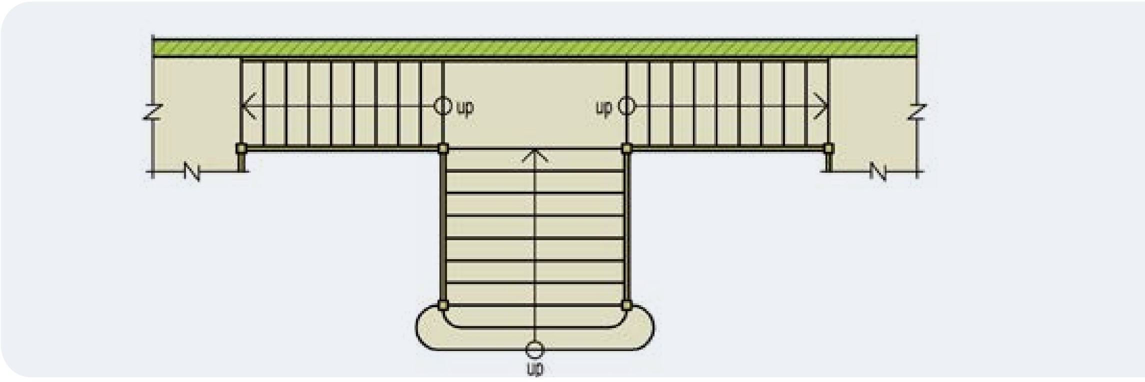


Figure 1.6: Newel stairs with wide landing.

1.4 Open Newel Stair

An open newel stair is also referred to as an 'open well stair' or an 'open well newel stair'. This form of stair has two or more flights which return on each other forming a vertical space called the well (Figures 1.4 and 1.5).

1.5 Dog-leg Stair

A newel stair having two flights built at 180° to each other from a half-space landing. The outer string of the upper flight is tenoned plumb above the outer string of the lower flight and both to a single common newel (Figure 1.5). This type of stair is not commonly used in housing.

1.6 Winders

Triangular shaped treads used to gain height and in place of a quarter-space landing in a 90° turn stair. A maximum of three winders are fitted per 90° and the centre one is named a 'kite' winder because of its shape (Figure 1.7).

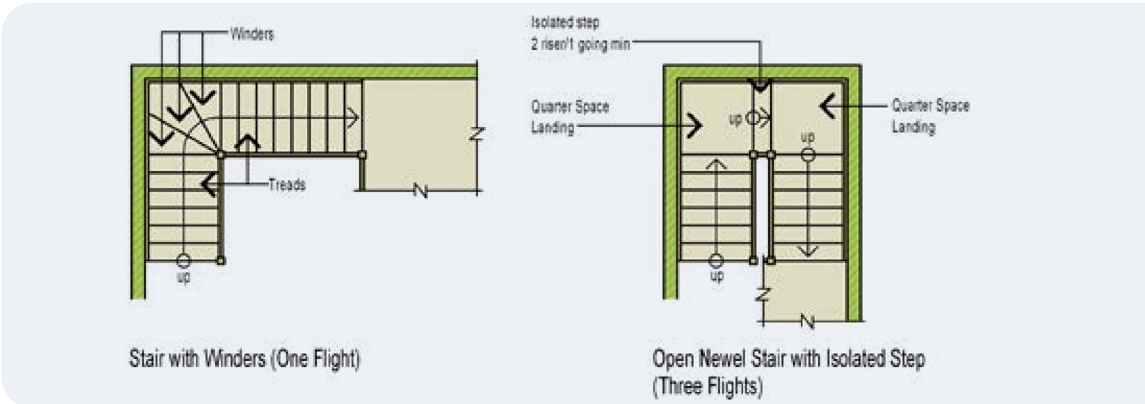


Figure 1.7: Stairs with winders or isolated step.

1.7 Geometrical Stairs

A stair which changes direction in plan without using newels. The strings and handrails are continuous from floor to floor, the curved portions being either cut from solid timber (saw kerfed), staved or laminated (Figure 1.8).

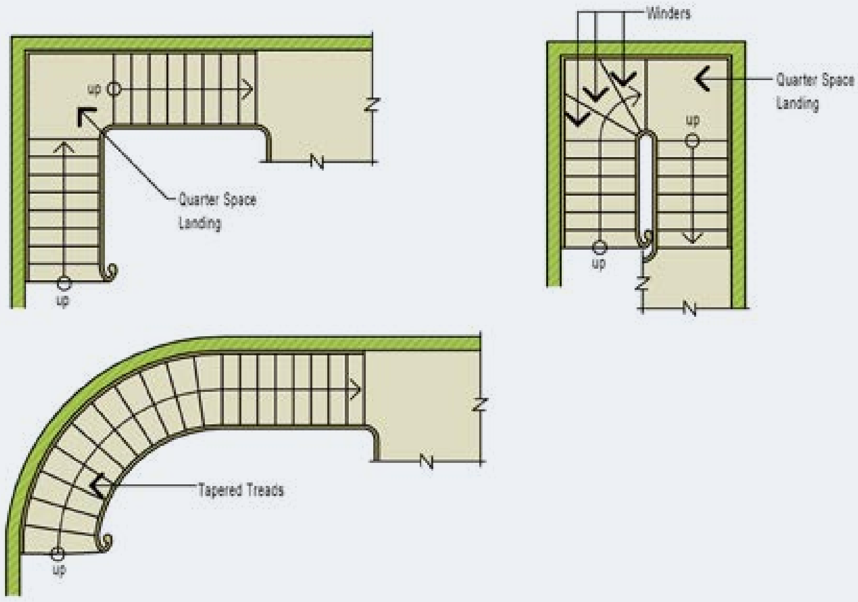


Figure 1.8: Geometrical stairs.

2

BCA Requirements

Stairs, handrails and balustrades must be designed and constructed to comply with the loadings given in AS 1170 Part 1.

The BCA does not prescribe a minimum width for stairs.

The regulatory requirements for stairs and balustrades prescribed by the BCA are primarily concerned with addressing the safety issues associated with slips, trips and falls. The basic BCA requirements relating to stair and balustrade geometry, opening width, landing sizes, handrail heights, etc, need to be strictly followed to ensure regulatory compliance.

2.1 General

For all Classes of buildings, stairs, handrails and balustrades are required to comply with the Building Code of Australia (BCA). The BCA requirements include design and construction provisions for the various components including compliance with the loading provisions of AS 1170.1 'Structural design actions Part 1: Permanent, imposed and other actions'.

For stairs, handrails and balustrades, the BCA is primarily concerned with the safety of building users and occupants. Design and construction must therefore take into consideration both the strength and durability of materials and components as well as the 'geometric' constraints prescribed by the BCA. The following provides a brief summary of some of the BCA requirements. For full details refer to the BCA.

2.2 Stairs

A summary of the requirements of the BCA for straight flights of stairs is given below.

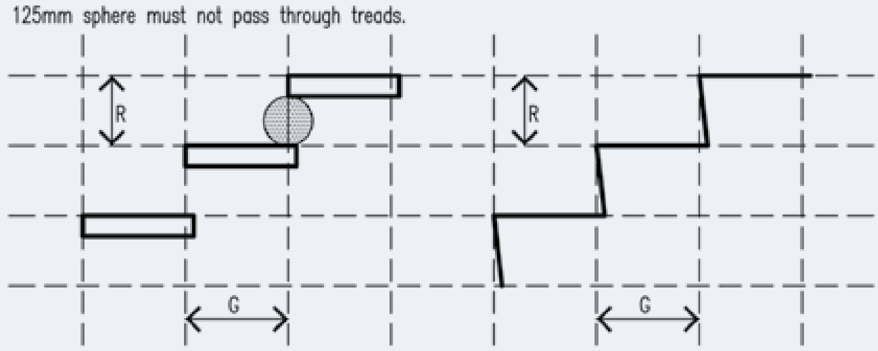
Each flight must have not more than 18 nor less than 2 risers.

- The nominal dimension of goings and risers of a stair must be constant throughout each stair flight.
- The riser opening must not allow a 125 mm sphere to pass through between the treads.
- The going (G), riser (R) and slope relationship quantity (2R+G) must be in accordance with Table 2.1.
- Landings must be not less than 750 mm long and where this involves a change in direction, the length is measured 500 mm from the inside edge of the landing (Appendix Figure A1).
- Landings must be provided where the sill of a threshold of a doorway opens on to a stair that provides a change in floor level or floor to ground level greater than 3 risers or 570 mm (Figure 2.2).

Note: The BCA does not prescribe a minimum width for stairs.

Table 2.1: Riser and going dimensions.

Stair Riser and Going Dimensions (mm)						
Stair Type	Riser(R) Going (G) (see following Figure)				Slope Relationship (2R+G)	
	Max	Min	Max	Min	Max	Min
Stairs (other than spiral)	190	115	355	240	700	550
Spiral	220	140	370	210	680	590



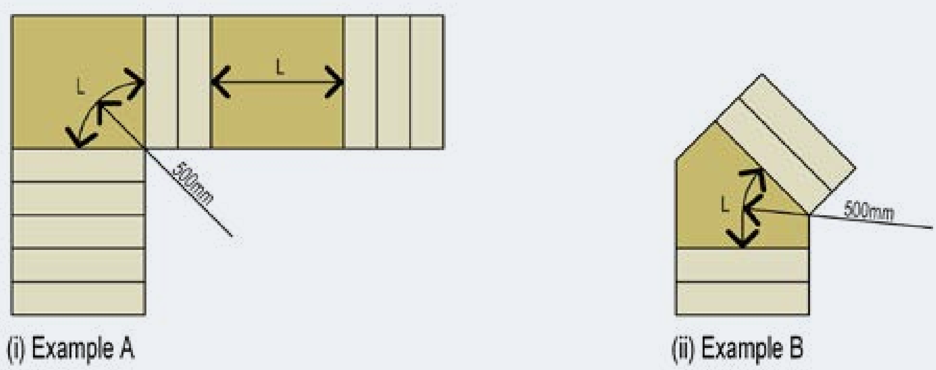


Figure 2.1: Landing length.

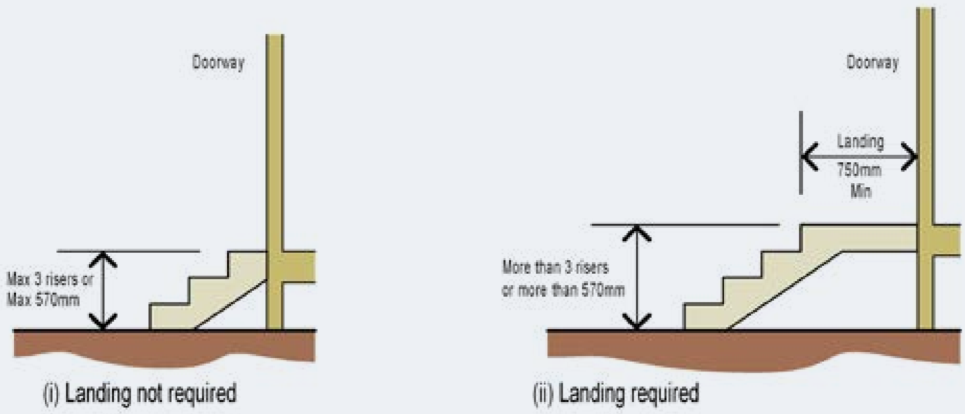


Figure 2.2: Threshold landings.

2.3 Balustrades and Handrails

A continuous balustrade or other barrier must be provided along the side of any roof to which public access is provided, any stairway or ramp, any floor, corridor, hallway, balcony, verandah, mezzanine, access bridge or the like and along the side of any path of access to a building, if it is not bounded by a wall; and any level is more than 1 m above the surface beneath (Figure 2.3).

The height of a balustrade or other barrier must be not less than 1 m above the floor of any access path, balcony, landing, etc, and not be less than 865 mm above the nosings of the stair treads or the floor of a ramp (Figure 2.4).

Balustrades and handrails are required when stairs are not bounded by a wall and any level is more than 1 m above the surface beneath.

Openings in balustrades (including decorative balustrades) or other barriers must be constructed so that any opening does not permit a 125 mm sphere to pass through it and for stairs, the space is tested above the nosing line (Figure 2.4).

For floors more than 4 m above the surface beneath, any horizontal elements within the balustrade or other barrier between 150 mm and 760 mm above the floor must not facilitate climbing.

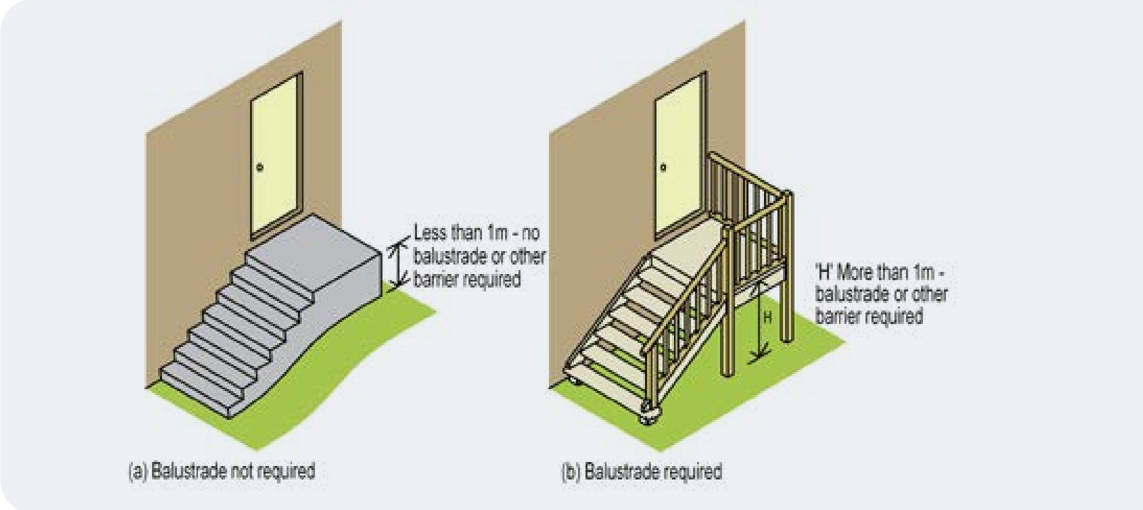


Figure 2.3: Balustrades – when required.

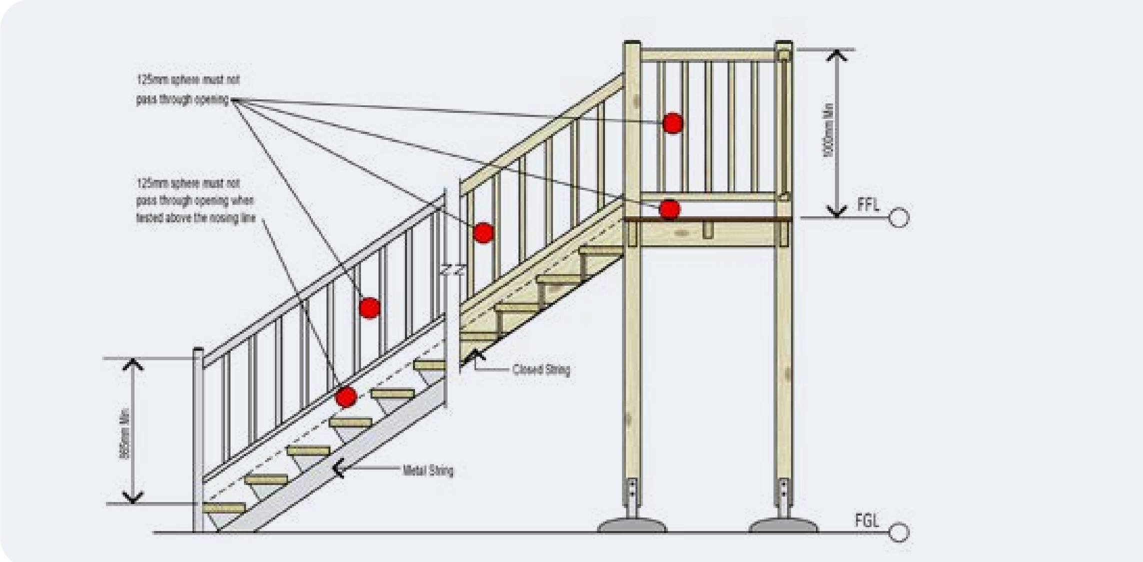


Figure 2.4: Minimum handrail height.

3

Materials for External Stairs Without Riser Boards (Open Stairs)

The construction of stairs is very demanding and requires a high level of workmanship and accuracy. Open tread stairs are recommended for external use since housed risers will trap moisture and prevent good drainage and drying out. Housed treads can also trap moisture so pre-priming before assembly is highly recommended. As per the BCA requirements, the rise and going must be uniform throughout the flight, however for external stairs the bottom rise may vary slightly.

3.1 Timber Durability and Species

In weather-exposed, above-ground applications or where subjected to other sources of moisture, stringers, treads, risers, handrails, posts, newels, balusters, and infill should be:

(i) Warm, humid tropical northern climates: either Above Ground Durability Class 1 species with any sapwood present treated to H3 (or higher) or H3 (or higher) treated softwood such as Slash, Hoop or Radiata Pine. Preservative treatment to comply with AS 1604.

(ii) Temperate, cool southern climates: either Above Ground Durability Class 2 or better species with any sapwood present treated to H3 (or higher) or H3 (or higher) treated softwood such as Slash, Hoop or Radiata Pine. Preservative treatment shall comply with AS 1604. Lower durability species can also be utilised although careful detailing of joints with application and maintenance of protective coatings (paints, stains) and/or installation of protective shielding (e.g. malthoid) on top of exposed timber edges needs to be utilised.

Suitable species are given in Table 3.1.

Note:

1. Meranti, Victorian Ash, Tasmanian Oak and Douglas Fir are not suitable for weather exposed structural applications.
2. For harsh climates timber with a sawn upper face provides greater long term weathering ability than a dressed surface. Step treads exposed to the weather should therefore be sawn all round or sized on two edges and one face (underside) only.
3. In Queensland, timber species used in structural applications including stairs and balustrades shall comply with ‘Constructions Timbers in Queensland’ as referenced by the Building Code of Australia.

Ensure timbers used for external stair construction have the required durability.

Table 3.1: Suitable species.

Species	Availability	Posts in ground contact	Posts not in ground, stringers, treads, landing framing and decking
Above Ground Durability Class 1			
Preservative Treated Pine (Caribbean Hoop, Radiata, Slash)	All states	✔ H5 Treatment	✔ H3 Treatment
Mixed Open Forest Hardwoods (Qld, Nth NSW)	Qld, NSW	See Note 1	✔
Blackbutt	Qld, NSW	See Note 1	✔
Cypress	All eastern states	Sapwood Free	✔
Gum Forest Red	Qld	✔	✔
Gum Grey	Qld, NSW	✔	✔
Gum River Red	Vic, NSW	See Note 1	✔
Gum Spotted	Qld, NSW, Vic	See Note 1	✔
Ironbark Red or Grey	Qld, NSW, Vic	✔	✔
Jarrah	WA, SA, Vic	See Note 1	✔
Kwila (Merbau)	All states		✔
Mahogany Red	Qld, NSW	See Note 1	✔
Mahogany White	Qld, NSW	✔	✔
Messmate Gympie	Qld, NSW	✔	✔
Tallowwood	Qld, NSW	✔	✔
Turpentine	Qld, NSW	✔	✔
Above Ground Durability Class 2			
Ash Silvertop	Vic, NSW		✔
Gum Southern Blue	Vic, NSW		✔
Gum Sydney Blue	Vic, NSW		✔
Gum Mountain Grey	Vic, NSW		✔
Jarrah	WA, SA, Vic	See Note 1	✔
Kapur	All states		✔
Karri	WA, SA, Vic		✔
Mahogany Southern	Vic, NSW		✔
Stringybark Blue-Leaved	NSW		✔
Stringybark Yellow	Vic, NSW		✔

Notes:

1. These timbers should only be used for in-ground applications if they can be easily replaced if degrade occurs.

2. In Queensland, timber species used in structural applications including stairs, balustrades and handrails shall comply with 'Constructions Timbers in Queensland' as referenced by the Building Code of Australia.

Structural members should be free of any major strength reducing features.

3.2 Timber Grade

As stair stringers, treads and posts, etc, are structural members, they are required to be stress graded and should be free from any major strength-reducing features. In addition, timber for stair construction should also be straight grained and free from any imperfections that may detract from durability or serviceability performance requirements. Stringers, treads and posts should be in accordance with the following table.

Table 3.2: Timber grade.

Species	Australian Standard	Grade
Hardwood	AS 2082	Structural Grade 1, Appearance grade
Softwood (Caribbean, Radiata, Slash and imported softwood)	AS 2858	Structural Grade 1, Appearance grade
Hoop Pine	AS 2858	F8 Appearance grade
Cypress Pine	AS 2858	F7 Appearance grade

Note: In addition, finger-jointed timber shall comply with AS 5068 – Timber – 'Finger joints in structural products' and laminated timber shall comply with AS 1328 – 'Glued laminated structural timber'.

3.3 Moisture Content

Allowance should therefore be made for shrinkage in unseasoned stringers, treads and any associated newel posts, landing bearers and joists, etc.

Traditionally, timber used for external stair construction is unseasoned. Depending on location and species, the amount of shrinkage occurring in unseasoned timber will vary. Generally, about 6% shrinkage (6 mm per 100 mm) should be expected for unseasoned open forest hardwoods. Allowance should therefore be made for shrinkage in unseasoned stringers, treads and any associated newel posts, landing bearers and joists, etc, and for the gaps that will develop between joints such as between stringer housings and treads.

External stair timbers exposed to the weather will reach Equilibrium Moisture Content (EMC) with their surroundings after a period of 9-18 months, depending upon prevailing weather, size and type of timber used.

For coastal Australia, stairs that are well ventilated should reach an EMC of approximately 16%. For stairs close to and over water, EMCs will normally be a little higher (18-21%) and for dry inland areas considerably lower (10-12%).

Note: If seasoned timber is used for external stairs coastal areas, consideration must be given to the expansion of the timber as the EMC rises from 12% up to about 16%, particularly at joints – such as where treads are housed into stringers – and may cause splitting.

3.4 Joint Priming

One coat of a water-repellent preservative or an oil-based primer is recommended to be applied to joints and housings, etc, prior to fabrication.

3.5 Corrosion Protection of Fasteners

Except in severe environments, hot dipped galvanised fasteners will afford the necessary protection from corrosion.

Having ensured that the maximum service life will be achieved in the timber component, it is equally important to match this with nails, screws, bolts and other metal connectors of equivalent service life. For most situations (up to and including close proximity to protected bays/mild marine) in exposed environments, hot dipped galvanised fasteners will afford the necessary protection from corrosion. The service life of hot dipped galvanised coatings will be proportional to their mass/area or thickness of galvanising and a minimum thickness of 42 microns is recommended for a service life of around 30 years. For more extreme corrosive environments or where other conditions dictate such as in contact with moist CCA/ACQ, etc, treated timber or in close proximity to swimming pools (within 600 mm of edge), guidance can be obtained from Table 3.3.

Table 3.3: Selecting corrosive resistant fasteners.

Application/Environment	Fastener Material	Remarks
Chemical, industrial and marine surf beach or large bays	Grade 316 stainless steel	Grade 304 stainless steel may require additional protective coatings such as epoxy paints.
Splash zone close to pools	Monel metal, silicon bronze and brass. Self drilling screws to be Class 4 finish.	Monel nails and screws available, usually used for boat building, are a good option close to pools. Silica bronze nails are good for acidic species such as western red cedar.
Mild marine, industrial and other	Hot dipped galvanised or mechanically plated, minimum thickness 42 microns. Self drilling screws to Class 3 finish.	Where hot dipped galvanised bolts, etc, are in contact with moist CCA/ACQ, etc, treated timber, additional protection using plastic sheaths, bituminous or epoxy paints is required.

3.6 Termite Protection

Physical and/or chemical barriers must be provided to protect the stairs and to ensure termites do not bypass protection systems to adjacent structures. Termite barriers must be designed so that they can be readily inspected and maintained.

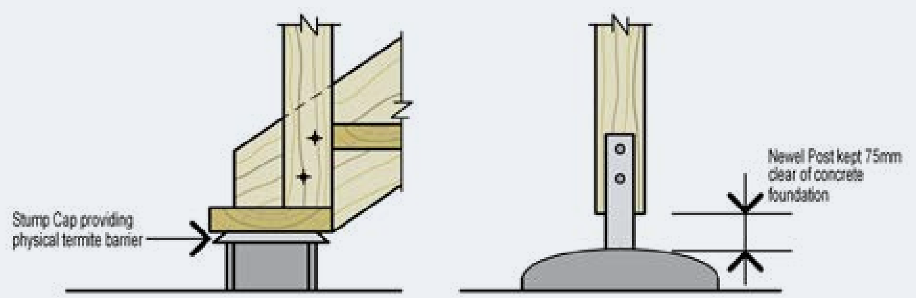


Figure 3.1: Typical termite protection methods.

3.7 Slip Resistance

The BCA requires stair treads to have a slip resistant finish or an anti-skid strip near the nose of the tread. A number of proprietary 'paints' and 'strips' are available to satisfy this requirement. *For further guidance on slip resistance, download the WoodSolutions Technical Design Guide #48 Slip Resistance and Wood Pedestrian Surfaces from www.woodsolutions.com.au.*

3.8 Sizes

The sizes and spans for stringers and treads for external stairs shall be in accordance with Table 3.4 and 3.5.

Table 3.4: Stair stringers (maximum stair width 1800 mm).

Timber Type		Stringer – [Depth (mm) x Thickness (mm)][1]				
Species/Group	Grade[2]	200x38	200x50	250x38	250x50	300x50
		Maximum Stringer Span (mm)[4]				
Messmate, Spotted Gum, Blackbutt, Kwila, etc	F27	2900	3200	3600	3900	4500
Vic Ash, Tas Oak, Jarrah	F22	2800	3100	3400	3700	4300
Spotted Gum, Blackbutt, Ironbark, Kwila, etc	F17[3]	2600	3000	3300	3600	4200
Douglas Fir (Nth American)	F11	2400	2700	3000	3400	3900
Radiata, Hoop, Slash, etc	F8	2300	2600	2900	3200	3700
H3 treated pine	F5	1600	2200	2400	2800	3400

Notes:

1. The size of stringers given in the Table are nominal sizes. Design allowances have been made for dressing (depth 10 mm max, thickness 5 mm max). Allowance has also been made for trenching stringers to accommodate treads (10 mm max).

2. Timber grading should be in accordance with the appropriate Australian Standard for milled products (i.e. AS 2796 and AS 4785). The stress grades used for design in accordance with the loading requirements of the BCA are as indicated and can be determined for AS 2082 and AS 2858 as appropriate.

3. The F17 grade included in the Table is intended for unseasoned hardwood, to be used for external stairs only.
4. Stringer span is the centre line length of the stringer.

Stringer span is the centre line length of the stringer

Table 3.5: Stair treads (with open flights).

Timber Type		Stair Width [Tread span] (mm)				
Species/Group	Grade[2]	750	1000	1200	1500	1800
		Minimum Thickness of Tread (mm)[1]				
Messmate, Spotted Gum, Blackbutt, Kwila, etc	F27	26	32	38	48	58
Vic Ash, Tas Oak, Jarrah	F22	28	34	40	50	60
Spotted Gum, Kwila, Ironbark, etc	F17[3]	28	36	42	53	65
Douglas Fir (Nth American)	F11	31	40	46	58	70
Radiata, Hoop, Slash, etc	F8	32	42	50	62	73
H3 treated pine	F5	40	46	54	70	N/A

Notes:

1. The thicknesses in the Table are minimum design thicknesses and may not represent commercially available thicknesses.

2. Timber grading should be in accordance with the appropriate Australian Standard for milled products (ie AS 2792 and AS 4785). The stress grades used for design in accordance with the loading requirements of the BCA are as indicated and can be determined for AS 2082 and AS 2858 as appropriate.

3. The F17 grade included in the Table is intended for unseasoned hardwood, to be used for external stairs only.

4

Materials for Internal Stairs – With and Without Riser Boards (Open and Closed Stairs)

Interior staircase work is considered to be a specialised section of carpentry and joinery. Flights are often prepared in a workshop making full use of available machines and equipment. Interior stairs differ considerably in design, from simple straight flights, commonly used in domestic work, to more elaborate stairs constructed purposely as an attractive feature in public and commercial buildings and in elegant homes.

Many interior stairs are built from joinery quality timber cut and seasoned specially for stairs. The specified finish is often clear polish/polyurethane, etc, therefore both material and workmanship should be of the very highest standard.

4.1 Timber Durability and Species

Hardness may need to be considered for uncovered treads.

For internal use, timber of any durability class is suitable, however hardness may need to be considered for uncovered treads.

The species chosen will generally determine the overall colour of the stairs. As a guide, Table 4.1 indicates the range of colours that may be expected. The sapwood of many hardwoods can be much lighter than adjacent heartwood and some treads, risers, strings, etc, may contain both light and dark colours.

Lyctid susceptible sapwood of some hardwood species e.g. Spotted Gum is required by some state legislation, including Queensland and New South Wales, to be preservative treated. Some treatments may impart a brown or green-grey tinge to sapwood, while boron preservative is non-colouring. LOSP treatment is also used. In this instance a H3 treatment may be used in lieu of H2 treatment to avoid the colour from dyes often used with H2 LOSP treatments.

The selection of a hard timber species ensures improved resistance to indentation and abrasion.

Hardness indicates a species resistance to indentation and abrasion. Damage to timber stairs may occur due to heavy foot traffic and in particular 'stiletto-heel' type loading. The selection of a hard timber species ensures improved resistance to indentation and abrasion. Soft timber species, if used for step treads, can be expected to indent.

Table 4.1: Species guide.

Species	Availability	Colour	Hardness
Australian Hardwood			
Blackbutt	Qld, NSW	golden yellow to pale brown	very hard
Brushbox	Qld, NSW	mid brown even colour	hard
Forest Red Gum	Qld, NSW	dark brown or dark red brown	very hard
Ironbark	Qld, NSW, Vic	dark brown or dark red brown	very hard
Jarrah	WA, SA, Vic	dark red brown	hard
Karri	WA, SA	rich reddish-browns to pale pinks	hard
Manna/Ribbon Gum	Vic	pale straw pinks	moderately hard
Messmate	Vic	pale yellow to pale brown	moderately hard
New England Blackbutt	Qld, NSW	straw to pale brown	very hard
Rose Gum	Qld, NSW	straw pink to light red	hard
Southern Blue Gum	NSW	pale brown with some pink	hard
Spotted Gum	Qld, NSW	brown, dark brown, light sapwood	very hard
Stringybark	Qld, NSW, Vic	yellow brown with pink tinge	hard
Sydney Blue Gum	Qld, NSW	pink to dark red	hard
Tallowwood	Qld, NSW	pale straw to light brown	hard
Tasmanian Oak	All states	pale straw to light brown, pink	moderately hard
Victorian Ash	All states	pale straw to light brown, pink	moderately hard
Imported Hardwood			
Kwila / Merbau	All states	dark brown	hard
Northern Box	Qld, NSW	mid brown even colour	hard
Softwoods			
Cypress	All Eastern states	straw sapwood, dark brown heartwood	moderately hard
Hoop Pine (Araucaria)	All states	straw	soft
Radiata	All states	white to straw	soft

4.2 Timber Grade

As stair stringers, treads and posts, etc, are structural members, they are required to be stress graded and should be free from any major strength-reducing features. In addition, timber for stair construction should also be seasoned, straight grained and free from any imperfections that may detract from serviceability performance requirements. For internal stairs, stringers, treads and posts should be in accordance with AS 2796, AS 4785 and the following:

Table 4.2: Timber Grade

Type	Australian Standard	Grade
Hardwood	AS 2082	Structural Grade 1, seasoned, Appearance grade
Softwood (Caribbean, Radiata, Slash and imported softwood)	AS 2858	Structural Grade 1, seasoned, Appearance grade
Hoop Pine	AS 2858	F7 seasoned, Appearance grade
Cypress Pine	AS 2858	F7 seasoned, Appearance grade

Note: In addition, finger jointed timber shall comply with AS 5068 – Timber – 'Finger joints in structural products' and laminated timber shall comply with AS 1328 – 'Glued laminated structural timber'.

4.3 Moisture Content

All components of internal stairs should be seasoned.

Unless otherwise specified, all components of internal stairs should be seasoned. Seasoned timber is usually supplied at an average moisture content between 11% and 13%. Where conditions are drier or in air-conditioned buildings, moisture content of timber may vary from 7% to 12%. In these situations the timber may need to be acclimatised on-site prior to fabrication.

Unless the staircase is in a permanently controlled environment, the timber will always move in response to changing environmental conditions.

Timber is a natural product that responds to changes in weather conditions. During periods of high humidity timber will absorb moisture from the air causing it to swell or increase in size. Conversely, during drier times when humidities are low, timber will shrink, reducing in size. Unless the staircase is in a permanently controlled environment, the timber will always move in response to changing environmental conditions. Gaps between treads and housings, treads and riser boards, etc, can be expected as the timber accommodates seasonal changes. Additional shrinkage to that normally expected may also occur when a staircase is exposed to heat sources such as fireplaces or sunlight through large doors or windows.

A small amount of noise can be expected from most timber stairs when walked on. Noises can occur from movement of treads in housings, treads against a riser board or from treads, risers, etc, moving on nails.

4.4 Termite Protection

Because termite protection of the house is required under the BCA in areas where termites are present, there is no specific requirement for individual termite protection of internal stairs unless the only method of termite protection for the house is the use of termite resistant material. In this case, termite resistant timber should be also chosen for the stairs. Refer to AS 3660.1.

4.5 Slip Resistance

The BCA performance requirements state that stair treads or near the nosing shall be slip resistant. A number of proprietary 'paints' and 'strips' are available to satisfy this requirement. *For further guidance on slip resistance, download the WoodSolutions Technical Design Guide #48 Slip Resistance and Wood Pedestrian Surfaces from www.woodsolutions.com.au.*

4.6 Span Tables

The sizes and spans for stringers for internal stairs with and without riser boards shall be the same as for external stairs (Table 3.4).

Note: For internal stringers and treads, seasoned timber only should be used.

The size of treads for internal stairs without riser boards shall be the same as for external stairs (Table 3.5).

The size of treads for internal stairs fully supported by riser boards should be a minimum of 19 mm thick for stairs up to 1000 mm wide and 30 mm for 1000-1800 mm wide.

For feature stairs, 30 mm is suggested as a minimum thickness for all treads, irrespective of stair width.

Note: For feature stairs, 30 mm is suggested as a minimum thickness for all treads irrespective of stair width.

5

Stair Construction Procedure

Before commencing the mark out for stairs, the calculations for going and rise can be determined (see Appendix B). From these, make a margin template and pitch board or set up a steel square with clamps ready to mark out strings.

5.1 Margin Template and Pitch Board

5.1.1 Pitch Board

Using a piece of plywood, masonite (such as ply or masonite bracing) or similar, mark out and cut a pitch board using the going and rise calculated (Figure 5.1).

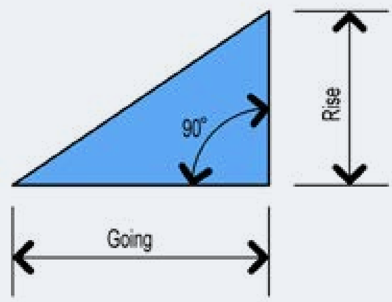


Figure 5.1: Pitch board.

5.1.2 Margin Template

Before the margin template can be prepared, the width of the margin (X) must be known. The method of finding the margin width is as follows (Figure 5.2):

i) Place the pitch board on the string, with the hypotenuse of the pitch board flush with the string edge.

ii) Use off-cut pieces of tread and riser board to draw into this trial position, the tread, and also riser and wedges if used.

Note: For stairs with riser boards, place the off-cut piece of tread upside down and align the front edge of the riser housing with the edge of the string as shown in Figure 5.2.

iii) Draw a line just below the tread (or wedges if used) and parallel to the string edge.

iv) The distance X is the width required for the margin template.

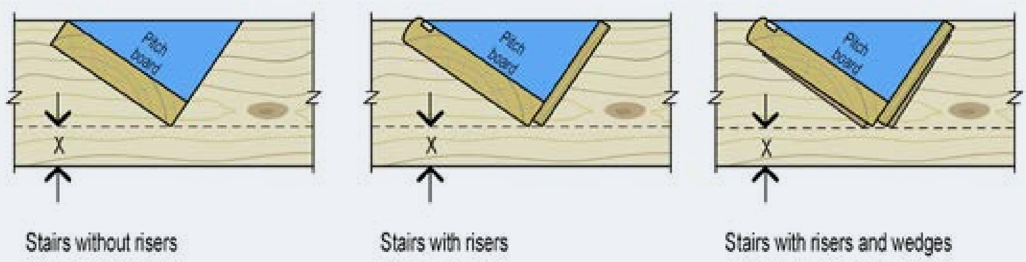


Figure 5.2: Determination of margin line.

A suitable margin template can now be constructed using off-cuts from mouldings (Figure 5.3).

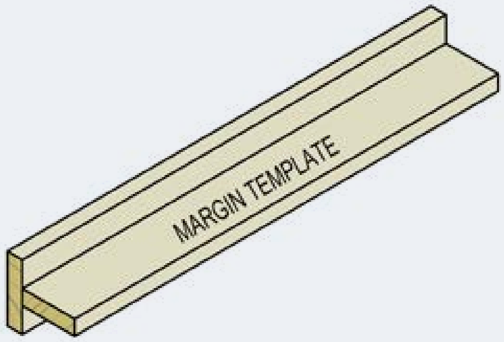


Figure 5.3: Margin template.

Note: This method may be followed to determine the width of timber required for strings.

5.1.3 Steel Square

Any large metal square such as a roofing square can be used as an alternative to a pitch board and margin template, but an understanding of the proceeding methods is necessary to be able to set the square up correctly.

Use the steel square and metal stops to find the margin line as per 5.1.2 and Figure 5.4.

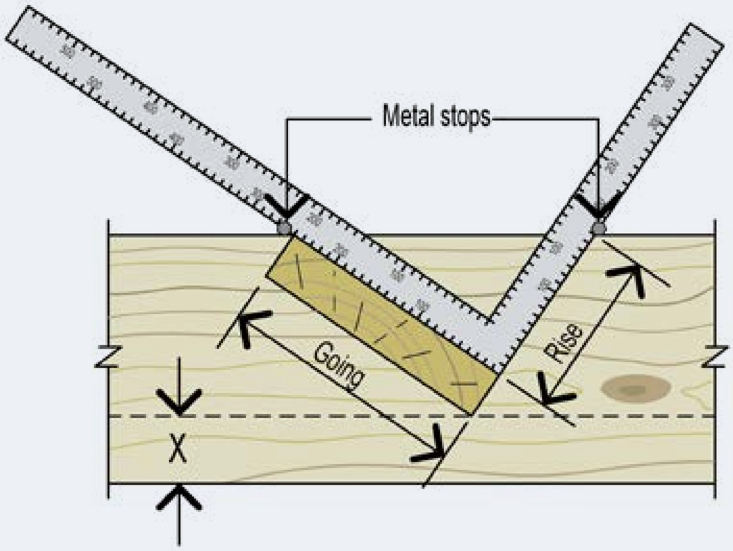


Figure 5.4: Using steel square to determine margin line.

Reset metal stops on steel square incorporating margin line (Figure 5.5).

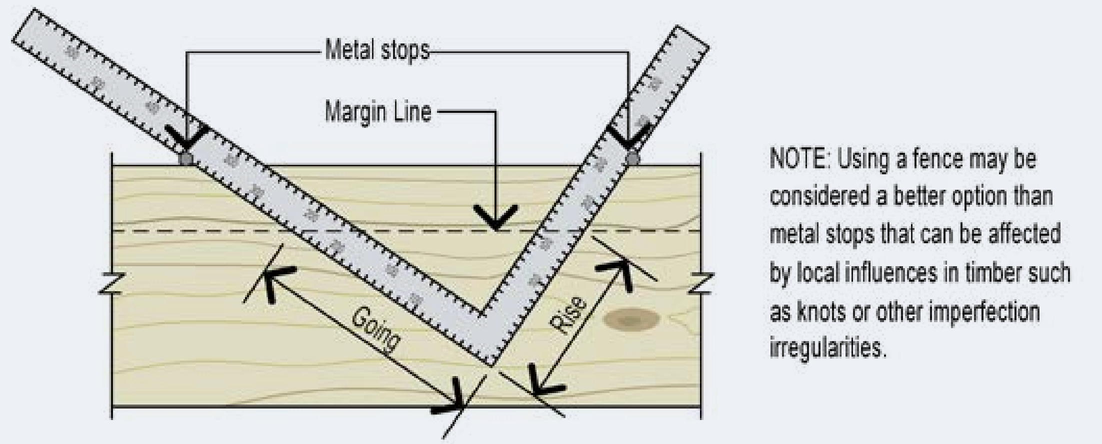


Figure 5.5: Using steel square as combined margin template and pitch board.

A good practice is to always mark out the same hand string first.

5.2 Marking Out Strings

When marking out stair strings a routine will prevent mistakes and the wasting of time. A good practice is to always mark out the same hand string first.

This practice should develop a clearer recognition of the correct positioning of members.

Note: The accepted practice of marking right hand or left hand string first varies from state to state and region to region. **The procedure below is based upon marking the left hand string first.**

Step 1
The string handing is determined by looking up the flight or at the flight from the bottom. The string to the left is the left-hand string. The two strings in one flight are a pair; one left and one right-hand string.

Step 2
Place strings in pairs on saw tools and mark inside face and top edges – consider the effect of any spring or bow. For short flights with one step bolt, place the hollow of the bow in and for longer flights with two step bolts place the hollow of the bow out. String edges should be rounds up (spring up) (Figure 5.6).

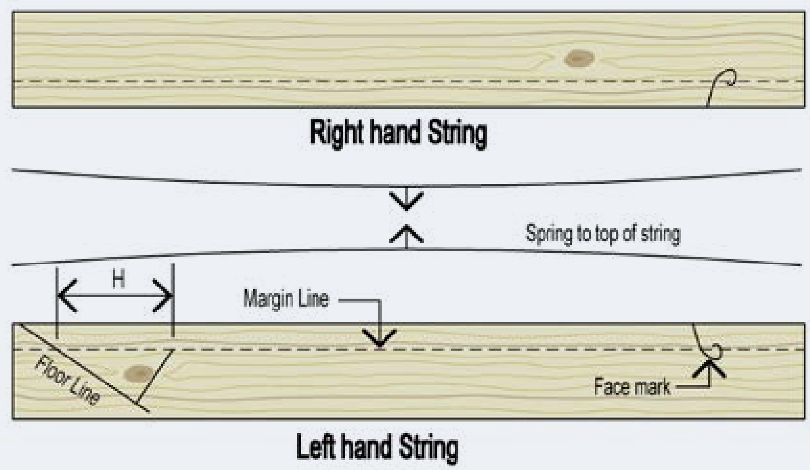


Figure 5.6: Pairing strings.

Step 3
Having paired the strings by face and edge marking them, commence marking out the left-hand string. Draw the margin line with the margin template, then using the pitch board, start at the bottom of the flight and mark the position of the floor, the first rise and going (Figure 5.6).

Before continuing to mark the string, a pair of wing dividers set to distance 'H' in Figure 5.6 should be used to mark along the margin line, the number of remaining steps in the flight. This action will serve to equalise successive marking with the pitch board and avoid possible loss or gain.

Step 4
After completing the marking of the first string, place both strings together as a pair and square the points on the margin line across from one to the other. This method will prevent length differences between the two strings (Figure 5.7 and Figure 5.8).

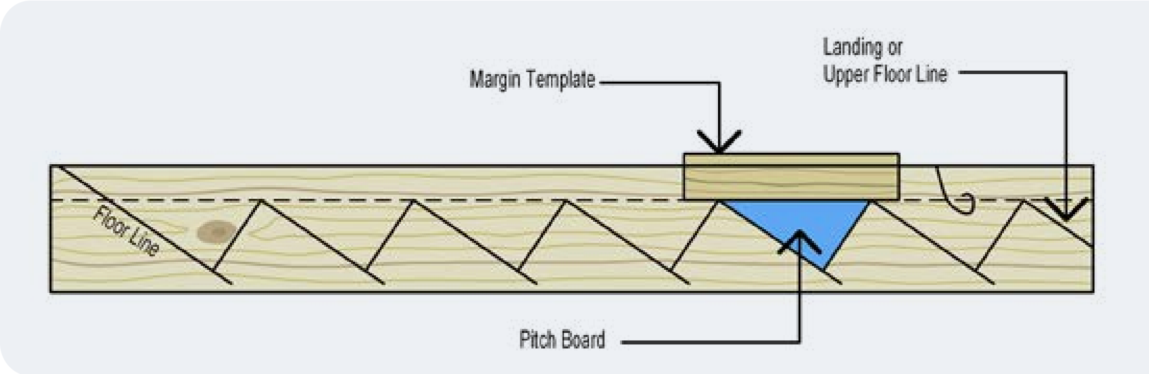


Figure 5.7: Marking out left string.

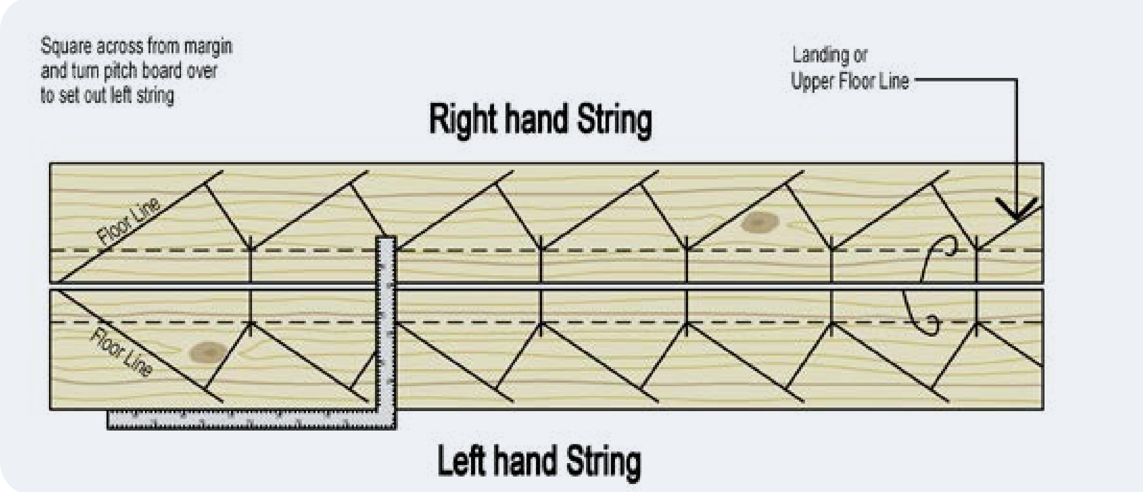


Figure 5.8: Marking out right string.

Gauge depth = tread thickness minus housing depth.

Step 5

When satisfied that the initial marking, as in Figure 5.8, is correct, proceed to complete the marking for the housings. Number each tread and riser. Select treads and risers (if used) in numerical order and scribe thickness and shape onto strings. Using a gauge, mark the housing depth (15 mm) onto the back edge of the string. Always gauge from the outside of the tread. This will account for any differences in thickness of the tread particularly when using unseasoned rough sawn timber.

Note: Gauge depth = tread thickness minus housing depth (Figure 5.9).

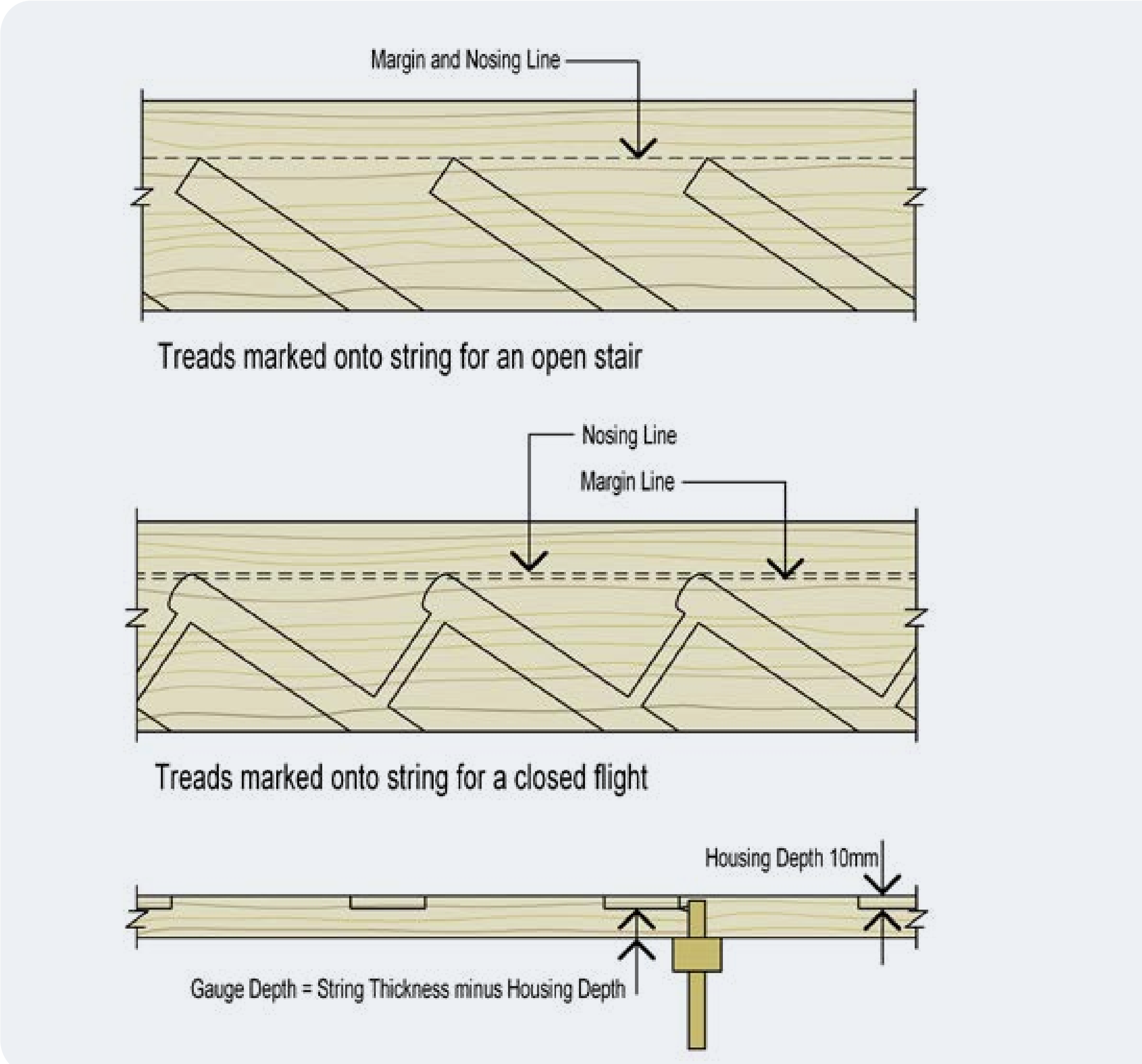


Figure 5.9: String marked out for housings.

5.3 Housing Strings

The actual housing out of the strings can be achieved by several different methods.

The simplest method, suitable for external stairs using rough sawn timber, is to use a power saw to cut along the lines marked for the treads.

Set the depth of the saw to the housing depth, 15 mm. Run the saw a number of times between these cuts and then use a mallet/hammer and chisel to remove the remaining material (Figures 5.10 and 5.11).

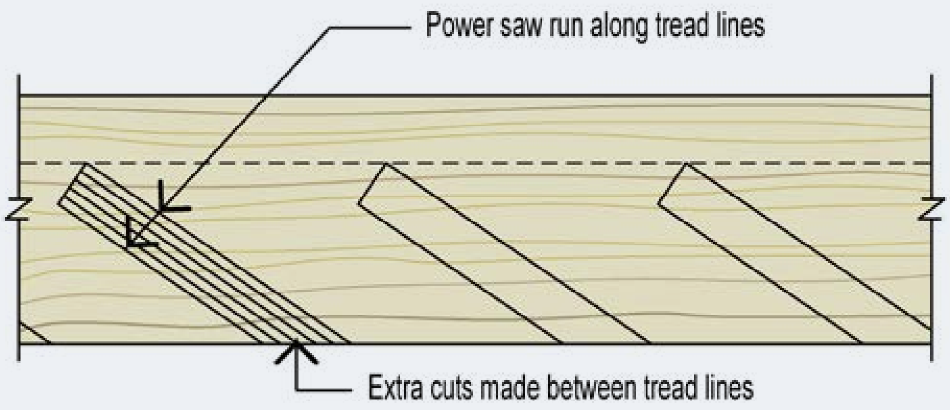


Figure 5.10: Housing strings.

A router with a template guide fitted can be used and is possibly the best and neatest method for housing strings on site (Figure 5.11).

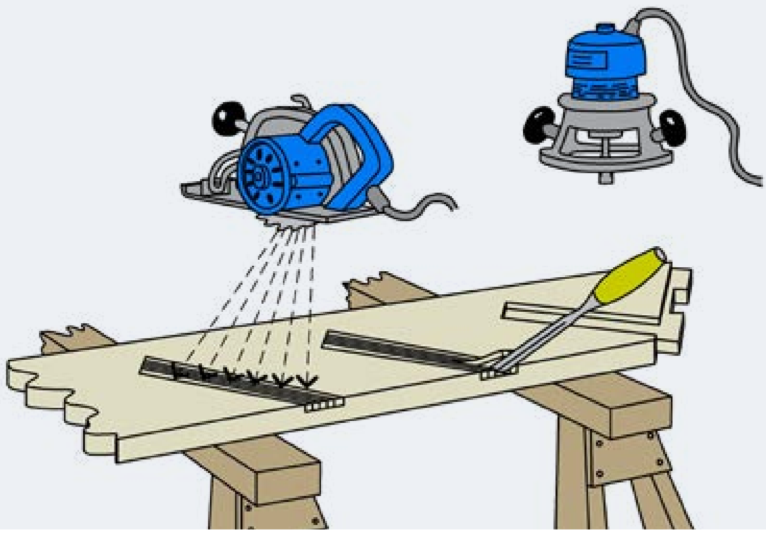


Figure 5.11: Housing string practices.

The joint used will depend on the type of stair and the structure it is being attached to.

5.4 String End Joints

The marking for the appropriate joints at the ends of the strings can now also be completed.

The joint used will depend on the type of stair and the structure to which it is being attached. For example, for a simple external flight the string is generally notched over the bearer (or landing plate) or tenoned into a newel post at the top and birdsmouthed over the bottom tread (Figure 5.12).

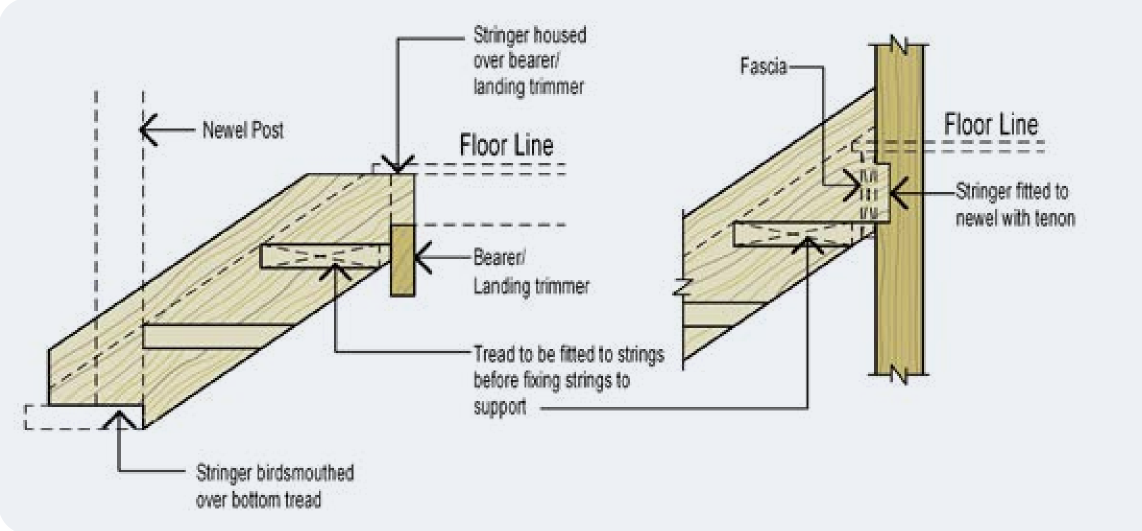


Figure 5.12: Supporting stringers.

Where newel posts are used, tenons are cut on the end of the strings and the newels morticed to suit (Figures 5.13 and 5.14).

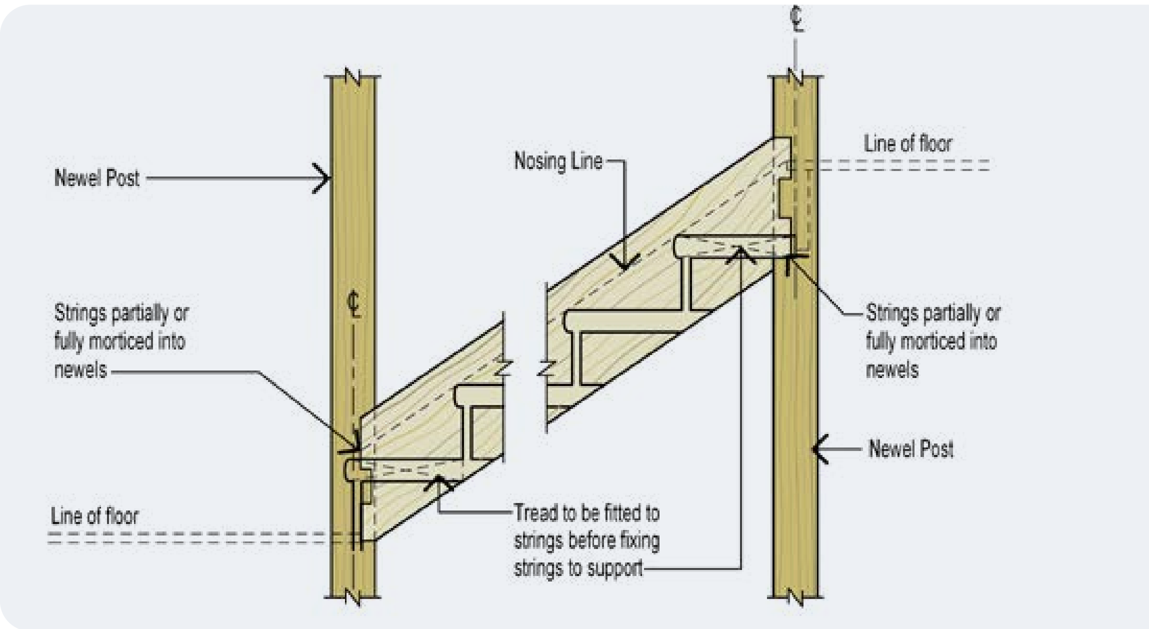


Figure 5.13: Tenons at ends of stringer.

In some cases (usually internal stairs only) the faces of the first and last risers should be in the centre of the newel posts.

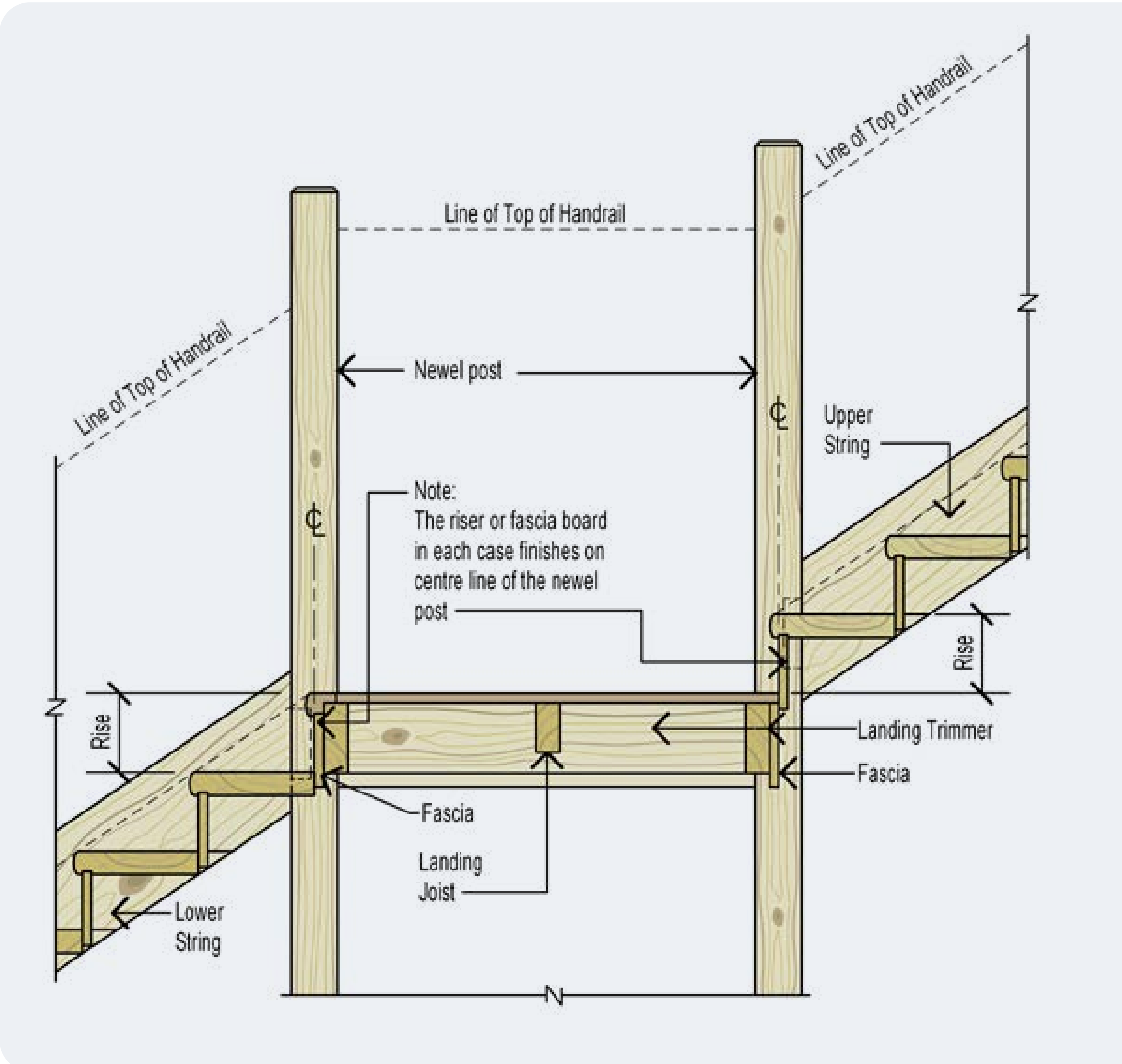


Figure 5.14: Fixing strings to landing newels.

Stringers lift and separate!

Unless the stairs fit between two walls, step bolts will be needed.

Cut treads and risers to length and number from bottom to top – make allowance for extra length on bottom tread if specified – remove arrises (edges) as required. If risers are being used and the treads are not pre-grooved, groove the treads for risers.

5.5 Step Bolts (Tie Bolts)

Unless the stairs fit between two walls, step bolts will be needed. Bore the stringers to take 12 mm step bolts at a maximum of 1350 mm centres. Position them to coincide as closely as possible to the centre line of the stringer and underside of a tread, leaving a gap between the underside of the tread and the bolt (Figure 5.15).

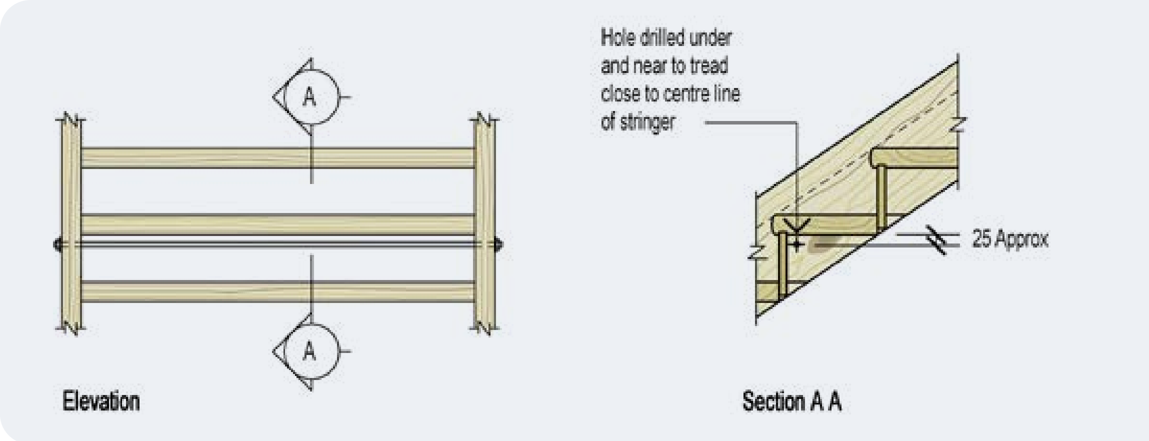


Figure 5.15: Position of step bolt.

5.6 Assembly

Before starting to assemble external stairs, prime paint or oil all joints and surfaces that will be concealed, enclosed or unable to be painted after assembly including the newels, bearer or joist where the stairs are to be fixed.

A practical way to find the position of the stumps under the bottom tread – rather than by calculation – is to take one of the cut strings, place it in position and then level the tread housings with a spirit level (Figure 5.16). Make any adjustments necessary by packing under the lower end of the string. Use pilot pegs to locate the centre and top of the stumps as shown in Figure 5.16.

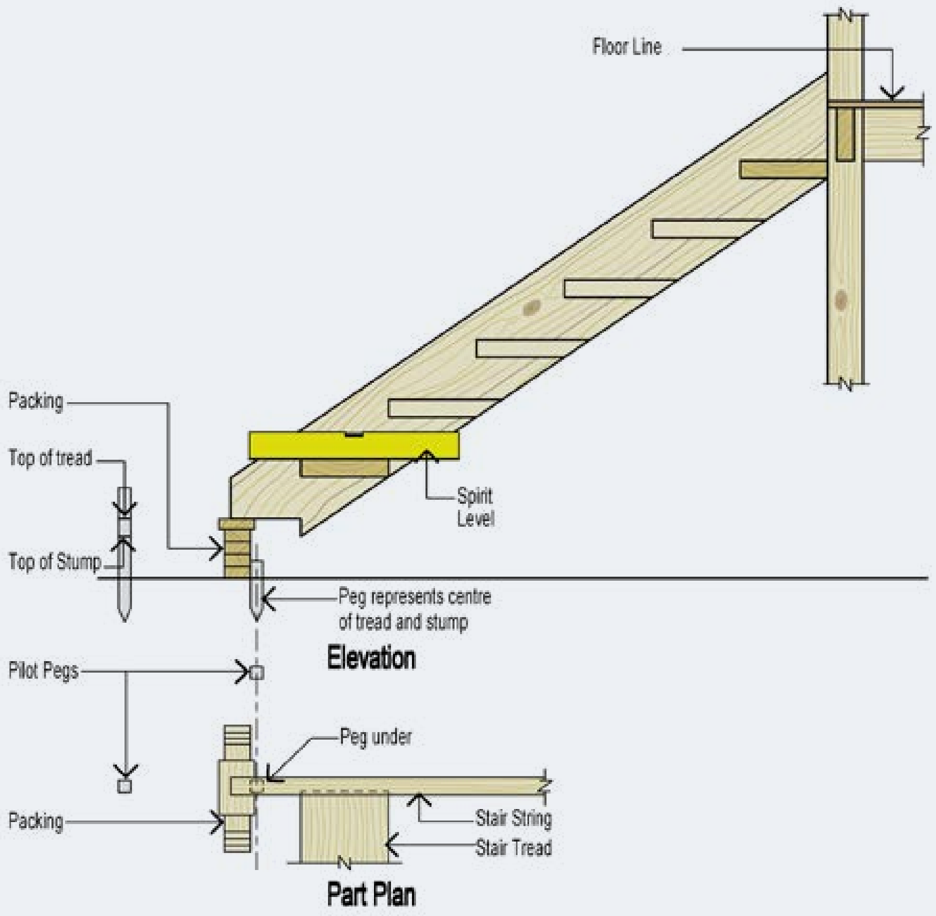


Figure 5.16: Finding position of stumps.

When using unseasoned timber it is good practice to temporarily nail treads and risers. After allowing as much time as possible for shrinkage to take place, withdraw the nails, close the joints then complete nailing and punching.

Fit top and bottom (or second bottom) treads and, for flights with risers, the bottom riser only to strings and nail together. Nail together with three 100 x 4.5 mm nails per joint. Pre-drill if necessary. For external stairs, all nails used should be hot dipped galvanised.

Fit and loosely tighten step bolts if required.

Lift this partly assembled job into position fit the stringers to the newels, bearers or joists as required.

Fit the remainder of the treads and risers where used and nail with three nails per housing.

Tighten the step bolts.

Note: When using unseasoned timber it is good practice to temporarily nail treads and risers. After allowing as much time as possible for shrinkage to take place, withdraw the nails, close the joints then complete nailing and punching.

6

Balustrades and Handrails

For all Classes of building, balustrades and handrails are required to comply with the Building Code of Australia (BCA). The BCA requirements include design and construction provisions for the various components including compliance with the loading provisions of AS 1170.1 'Structural design actions Part 1: Permanent, imposed and other actions'.

For balustrades and handrails, the BCA is primarily concerned with the safety of building users and occupants. Design and construction must therefore take into consideration both the strength and durability of materials and components as well as the 'geometric' constraints.

See Section 2 for guidance on BCA requirements, including those for where the floor surface is more than 4 m above the floor/ground below.

6.1 Loads

Balustrades and railings must resist 0.9 kN inward, outward and downward load at any point.

AS 1170.1 requires balustrades and railings together with members and connections which provide structural support to be able to resist the following factored limit state loads – 0.9 kN inward, outward and downward load at any point. It also requires balustrades and handrails to be able to resist a factored horizontal or vertical load of 0.53 kN/m for all areas within or servicing exclusively one dwelling including stairs and landings excluding external balconies, and 1.13 kN/m for external balconies in domestic and other residential buildings. Infill, including balusters, should be capable of resisting 0.75 kN in any direction.

6.2 Materials

6.2.1 Durability

Use Above Ground Durability Class 1 or H3 treated pine species for weather exposed applications.

In **weather-exposed**, above-ground applications or where subjected to other sources of moisture, stringers, treads, risers, handrails, posts, newels, balusters and infill should be:

(i) *Warm, humid tropical northern climates:* either Above Ground Durability Class 1 species with any sapwood present treated to H3 (or higher) or H3 (or higher) treated softwood such as Slash, Hoop or Radiata Pine. Preservative treatment shall comply with AS 1604.

(ii) *Temperate, cool southern climates:* either Above Ground Durability Class 2 or better species with any sapwood present treated to H3 (or higher) or H3 (or higher) treated softwood such as Slash, Hoop or Radiata Pine. Preservative treatment shall comply with AS 1604. Lower durability species can also be utilised although careful detailing of joints with application and maintenance of protective coatings (paints, stains) and/or installation of protective shielding (e.g. malthoid) on top of exposed timber edges needs to be utilised.

Suitable species are listed in Table 3.1.

Care should be taken to ensure that water is not trapped by end grain abutting horizontal surfaces (i.e. slope end grain cuts top and bottom of balusters and bottom rails where balusters abut, provide drainage holes, etc).

For **internal use**, timber of any durability class is suitable.

6.2.2 Timber Grade

The timber should be free from any major strength-reducing features, be straight grained and be in accordance with the following:

Table 6.1: Timber grade.

Type	Australian Standard	Description	Grade
Hardwood (Including Meranti)	AS 2796	Sawn and milled products	Clear or select grade
Softwood (Including imported softwood)	AS 1786	Joinery timber milled from Australian grown conifers	Clear grade

In addition, finger jointed timber shall comply with AS 5068 – Timber – 'Finger joints in structural products' and laminated timber shall comply with AS 1328 – 'Glued laminated structural timber'.

Notes:

1. Materials used in accordance with the following information must satisfy relevant Australian Standards and have the relevant minimum mechanical properties including the following:

***Hardwood –** Stress Grade F22, (characteristic bending strength f'b = 65 MPa, Modulus of elasticity E = 16,000 MPa) and Joint Group JD2. Examples – Spotted Gum, Ironbark, Blackbutt, Kwila and Merbau.*

***Meranti and Australian Softwood –** (characteristic bending strength f'b = 25 MPa, Modulus of elasticity E = 9100 MPa) and Joint Group JD4. Examples – Radiata, Hoop and Slash Pine and Meranti.*

***Imported Softwood –** (characteristic bending strength f'b = 25 MPa, Modulus of elasticity E = 6,900 MPa) and Joint Group JD4. Examples – New Zealand Radiata Pine.*

2. Unless certified by the supplier to identify that it is 'Australian Grown' softwood, handrail (balustrades) spans shall be determined from the 'Imported Softwood' spans given in Table 6.2.

6.3 Member Sizes

6.3.1 Handrails

Handrail sizes and spans shall be in accordance with Table 6.2.

6.3.2 Posts/Newel Posts

Posts and newel posts shall have a minimum stress grade of F5. Where supporting handrails/balustrades only, the minimum size of posts and newel posts shall be 80 x 80 mm (maximum post spacing 3600 mm and height of 2700 mm). Where supporting roof and or floor loads, refer to AS 1684 to determine minimum size, but shall be not less than 80 x 80 mm.

6.3.3 Infill/Balusters

The minimum size of infill/balusters should be as follows:

Hardwood – 19 x 19 mm or 21 mm diameter

Softwood – 19 x 42, 32 x 32 or 25 mm diameter.

Table 6.2: Handrail sizes.

Timber	Size/Description (mm x mm)	Maximum span of Handrail (mm)			
		Within or exclusively servicing one Dwelling (excluding external balconies)		Other areas in Residential Buildings (including external balconies)	
Hardwood	65 x 65 (profiled)	3000	3000	3000	3000
	42 x 65 (profiled)	2200	2700	2200	2700
	42 x 85 (profiled)	2400	3400	2400	3400
	35 x 70	2100	3000	2100	3000
	35 x 90	2200	3600	2200	3600
	35 x 120	2400	3600	2400	3600
	45 x 70	2500	3200	2500	3200
	45 x 90	2700	3600	2700	3600
	45 x 120	2900	3600	2900	3600
	70 x 70	3500	3500	3500	3500
	70 x 90	3600	3600	3600	3600
Meranti and Australian Grown Softwood	65 x 65 (profiled)	2700	2700	2200	2200
	42 x 65 (profiled)	1400	2000	1400	1800
	42 x 85 (profiled)	1800	3000	1700	2400
	35 x 70	1200	2400	1200	2000
	35 x 90	1600	3200	1600	2500
	35 x 120	2100	3600	1800	3400
	45 x 70	2000	2800	1800	2200
	45 x 90	2400	3400	2000	2900
	45 x 120	2600	3600	2400	3600
	70 x 70	3200	3200	2800	2800
	70 x 90	3400	3600	3200	3600
Softwood Imported or Unknown Origin	65 x 65 (profiled)	2400	2400	2200	2200
	42 x 65 (profiled)	1400	2000	1400	1800
	42 x 85 (profiled)	1800	2700	1700	2400
	35 x 70	1200	2400	1200	2000
	35 x 90	1600	2900	1600	2500
	35 x 120	1900	3600	1800	3400
	45 x 70	2000	2600	1800	2200
	45 x 90	2200	3100	2000	2900
	45 x 120	2300	3600	2300	3600
	70 x 70	2900	2900	2800	2800
	70 x 90	3000	3400	3000	3400

Notes:

1. *Handrails with no intermediate vertical supports may be used on flat or on edge (Figure 6.2).*
2. *Handrails with intermediate vertical supports shall be installed on flat with intermediate vertical supports spaced not greater than the allowable spans given for the same handrail with no intermediate vertical supports (Figure 6.2 and Note: For Type E connections refer to manufacturers' specifications).*
3. *Figure 6.4.*
4. *Where a top rail (minimum size 42 x 65) is within 150 mm of the main handrail and is rigidly fixed to it (using blocks, or balusters or dowels that pass through the mid rail and are fixed to the top rail) at least once at mid span, the allowable span of the handrail may be increased by 300 mm.*
5. *Handrail spans have been limited to 3600 mm maximum.*
6. *Profiled sections typically include bread loaf, ladies waist and colonial profiles.*
7. *There is no negative tolerance permitted on the breadth or depth dimensions (overall outside dimensions of profiled shapes) given in the above Table.*

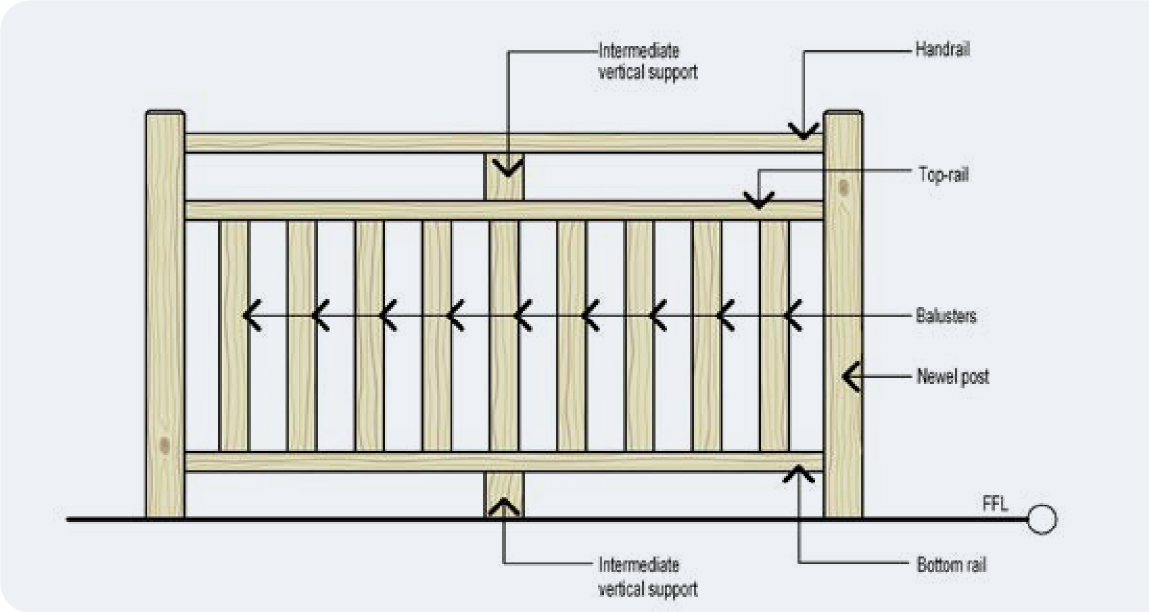


Figure 6.1: Intermediate vertical support.

Figure 6.2: Handrails – on flat and on edge.

6.4 Connections

6.4.1 Posts

Posts and newel posts should be connected to floor framing/stringers in accordance with Figure 6.3.

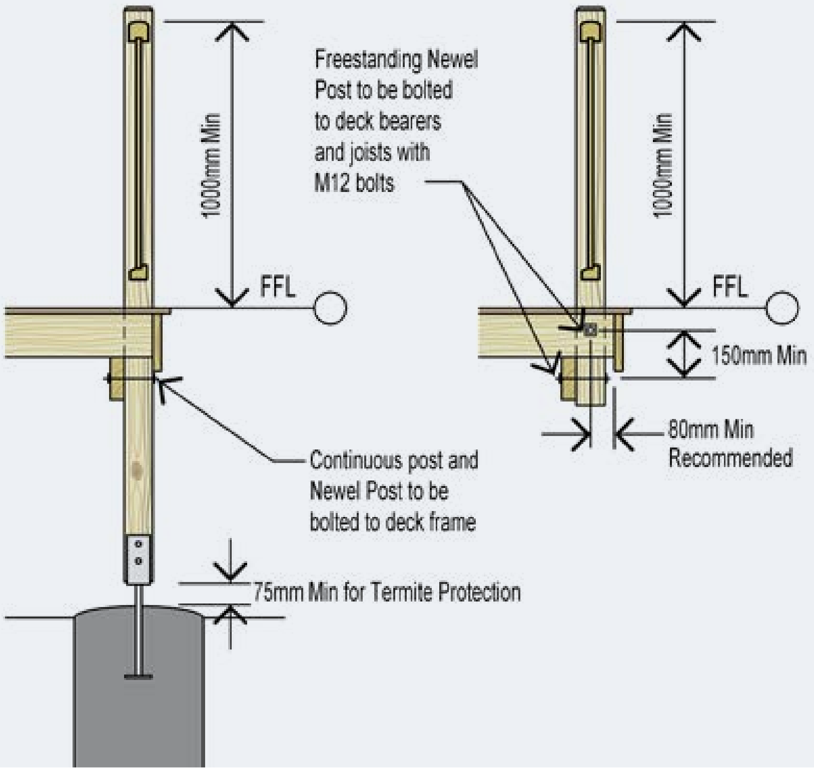


Figure 6.3 (a): Posts and newel posts.

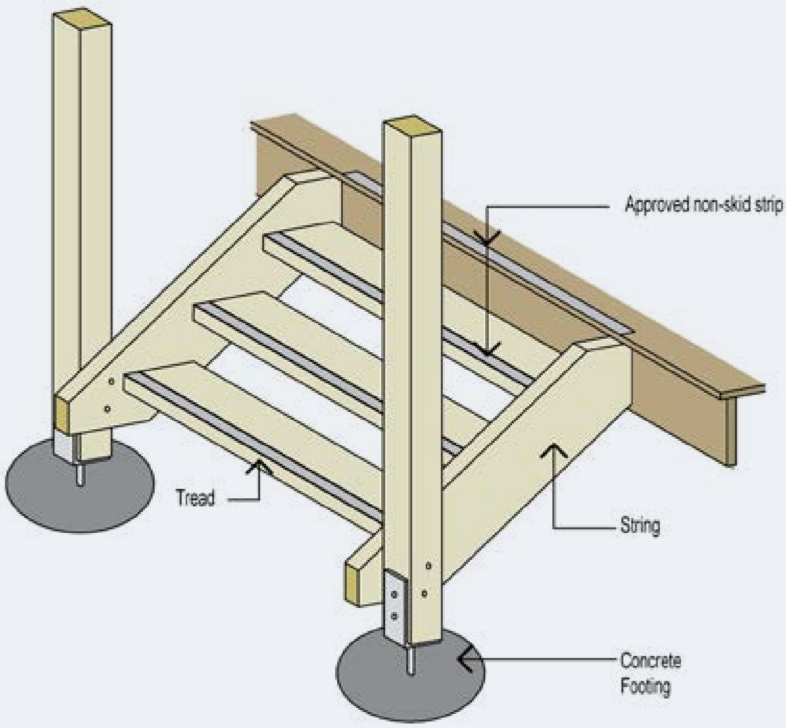


Figure 6.3(b)

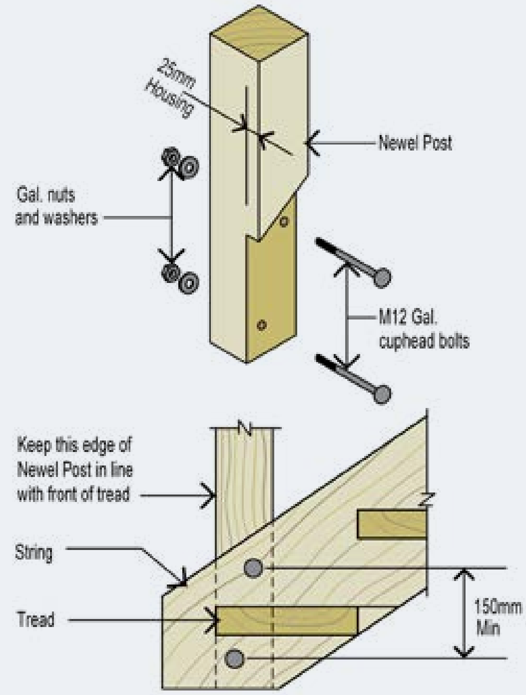


Figure 6.3(c)

6.4.2 Handrails

Table 6.3: Loads on handrails.

Span Type	Handrail Span (mm)	Handrail Connection Loads (kN)		Example Of Determining Handrail Connection
		Within or exclusively servicing one Dwelling (exc.external balconies)	Other Areas in Residential Buildings (inc.external balconies)	
Single Span	1800	0.90	1.0	The shaded areas in Tables 6-3 and 6-4 provide a guide to the selection of an appropriate connection for a continuous span softwood handrail span of 2400 mm. Step 1. From Table 6-3 determine the load on the handrail = 2.7 kN Step 2 From Table 6.4 and Figure 6.4, determine a connection with the capacity to resist 2.7 kN. Step 3 Acceptable solutions determined from Table 6-4 are:- Type A connection, 1 M10 bolt or Type B connection, 2 No 10 screws or Type D connection, 2 No 10 screws per leg of bracket.
	2100	0.90	1.2	
	2400	0.90	1.4	
	2700	0.90	1.5	
	3000	0.90	1.7	
	3300	0.99	1.9	
	3600	1.1	2.0	
Continuous Span	1800	1.1	2.0	
	2100	1.3	2.4	
	2400	1.4	2.7	
	2700	1.6	3.0	
	3000	1.8	3.4	
	3300	2.0	3.7	
	3600	2.2	4.1	

Table 6.4: Capacity of handrail connections.

Timber	Capacity of Connections (kN)											
	Type A			Type B			Type C				Type D	
	No. Bolts	Bolt Size (Cuphead)		No. Screws	Screw Size (Type 17)		Screws		Nails		2 / Screws per leg of bracket	
		M10	M12		No10	No14	2/ No10	2/ No14	2/3.15 dia	2/3.75 dia	No10	No14
Hardwood (JD2)	1	13	14	1	3.4	4.4	1.9	2.3	1.6	1.8	4.9	7.6
	2	26	28	2	6.8	8.8						
Softwood and Meranti (JD4)	1	8	9	1	2.0	2.6	1.1	1.3	0.9	1.0	2.8	4.3
	2	16	18	2	4.0	5.2						

Notes:
1. For Type A connections quantities are given for both face mounted handrails (worst case) and handrails flush full or half checked to post.
2. For Type B connections, minimum screw penetration into post is 38 mm and handrails flush full or half checked to post.
3. For Type C connections the minimum screw penetration into post is 40 mm and the minimum nail penetration into post is 38 mm.
4. Midrails and bottom rails shall be fixed with a minimum of 2/3.15 dia. skew nails.

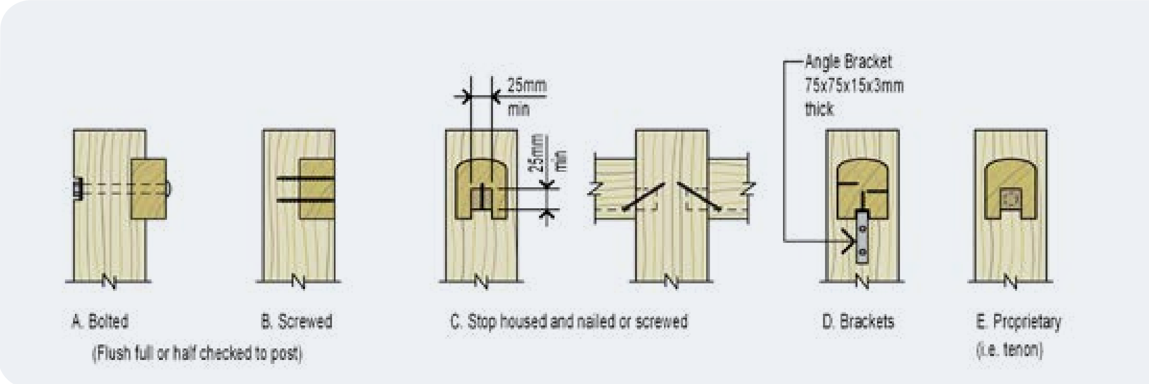


Figure 6.4: Handrail connections.

Note: For Type E connections refer to manufacturers' specifications.

7

Weathering, Finishes and Maintenance

Application and maintenance of finishes should not be considered as a substitute for ensuring that the inherent durability of the underlying timber is appropriate to the service life required.

The long-term durability and visual appeal and aesthetics of both internal and external stairs and balustrades can be greatly enhanced by application and maintenance of suitable and appropriate finishes.

7.1 External Stairs and Balustrades

Other than for aesthetic reasons, the main objective of applying and maintaining finishes (paints and stains) on timber used in external applications is to minimise the effects of weathering and therefore to maximise the service life of the timber. Exposure to sun and rain leads to wetting and drying and subsequent checking, splitting and distortion.

Application and maintenance of finishes should not be considered as a substitute for ensuring that the inherent durability (natural or by treatment) of the underlying timber is appropriate to the service life required for the applicable hazard level.

7.1.1 Unprimed Timber

Nail holes should be stopped with an exterior grade wood filler. Dirt or any loose material should be removed prior to coating. All surfaces, ends and joints should be primed prior to assembly with a quality solvent-based alkyd primer or stain, in accordance with the manufacturers' recommendations.

Final top coats of exterior paint or stain should then be applied in accordance with the manufacturers' recommendations.

7.1.2 Pre-primed LOSP Treated Timber

Pink pre-coated handrail and balustrade components should be sanded back and dusted off to remove any loose or powdery coatings prior to finishing. Nail holes should be stopped with an exterior grade wood filler.

All surfaces, ends and joints should be primed prior to assembly with a quality, solvent based alkyd primer. When the primer has dried in accordance with the manufacturers recommendations, apply two full coats of premium 100% acrylic exterior topcoat in accordance with manufacturers recommendations.

Dark coloured paints and stains should be avoided as they heat timber to elevated temperatures which cause greater loss of moisture and subsequent shrinkage and checking. Decay is also more active at higher temperatures.

7.2 Internal Stairs

The finish for interior stairs is often clear polish, lacquer, etc, therefore both material and workmanship should be of the very highest standard.

If clear finishes are to be used, extra care should be taken when marking out that pencil marks, etc, are kept light and do not leave an indentation in the timber.

Any nails should be punched a minimum of 3 mm below the surface of the boards. The punched nail holes can then be filled with either oil or non-oil based filler. Oil-based fillers may bleed oil into the timber and affect the colour of the wood surrounding the nail hole, or may not be compatible with various coating products.

The colour of the filler should be carefully selected to minimise any visual impact of the filler. Many of these products are sold in colours pre-matched to specific species. Generally all fillers are slightly darker and this allows for the boards to deepen in colour following finishing and UV exposure.

Generally all fillers are slightly darker and this allows for the boards to deepen in colour following finishing and UV exposure.

Table 7.1: Clear finishes for stairs.

Oil based Alkyds		**Composite**		**Solvent based**		**Water based**	
Tung oil	Linseed oil based varnishes	Oil modified Urethanes (OMU)	Urethane oil/alkyd 'Tung oil'	2 pack	Single pack	Polyurethane	
				Polyurethane	Polyurethane (moisture cured)	Acrylic	Single and two pack
Less wear resistant finish requiring more frequent maintenance				High wear resistant finish		Moderate to high wear resistant finishes	
6-24 hour drying by solvent evaporation				1-4 hour drying by chemical reaction		2-4 hour drying by evaporation and reaction	
Some tolerance to waxes				Not tolerant to waxes		Not tolerant to waxes	
Moderate to strong odour on application				Strong odour on application		Minimal odour on application	
Avoid inhalation and contact				Avoid inhalation and contact		Avoid inhaling cross-linkers and hardeners	
Matt to gloss levels				Matt to very high gloss levels		Matt to gloss levels	
Darkens with age				Darkens with age		Less darkening with age	
Generally ready for use 2-5 days from completion*				Generally ready for use 2-3 days from completion*		Generally ready for use 2 days from completion*	
**Varies with weather conditions and product. Full curing may take a longer time.*							

A

Appendix A – Glossary

Refer to Figures A1 and A2 for illustrations of most terms.

A1 General

Stair, Stairs: An assembly of steps or flights including all necessary landings, balustrades, etc, constructed for the easy, convenient and safe passage from one floor to another.

Staircase: Means the same as stair or stairs but includes that part of the building enclosing the stairs.

Stairway: Generally means the space provided for the stairs including the opening in the floor.

Stairwell or well hole (the opening in the upper floor for the stairs): The vertical space seen down between the outer strings of stairs having one or more return flights.

Step: A combination of a tread and riser. One unit in stairs.

Flight: That portion of stairs that has a continuous series of risers, including risers of winders, not interrupted by a landing or floor.

Riser: The height between consecutive treads (top of tread to top of next tread).

Total rise (Rise of flight, Rise of stair): The vertical measurement from the top of the first (lowest) floor or ground to the top of the last (highest) floor regardless of the number of flights in the stair.

Going: The horizontal dimension from the front to the back of a tread less any overhang from the next tread above (front of a riser line to front of the next riser line).

Total going (Going of flight, Going of stair): The horizontal distance measured in one direction over one or more flights, including intermediate landings, and taken from the front edge of the first or bottom tread in the lower flight to the front edge of the floor or landing at the top of the stairs. Again, if risers are fitted, the horizontal measurement from the face of the first or lowest riser to the face of the last or top riser in the stairs.

Stair width: The unobstructed width measurement between the inside face of the handrails, or the stringers if there are no handrails. (Note: The BCA does not prescribe a minimum width for stairs.)

A2 Members in a Staircase

String, stringers or string boards (sides of the stair): The inclined members in a stair which usually act as a beam and which span from bottom to top of each flight and support the ends of the treads and risers.

Treads: The horizontal members in a flight on which the foot is placed when ascending or descending the flight.

Step bolt (tie bolt): A horizontal threaded rod commonly used to tie the stringers together in external open flight stairs.

Riser boards: The vertical boards fixed between successive treads. Their purpose is to close the openings between and help to support and stiffen the treads.

Nosing: The front edge of a tread that may or may not be projecting over the riser. It is usually rounded.

Scotia: A small moulding having a concave face. It may be fitted against the top face of the riser and under the nosing of some boxed stairs (rarely used these days).

Newels: The posts at the top and bottom of flights to which strings and balustrades are fixed. Newels may also support landings and form part of balustrades.

Landing: An area (floor or resting place) at the top or bottom of a flight or between two flights.

A3 Members in a Balustrade

Balustrade: A coping or handrail with supporting balusters. An open balustrade comprises balusters, handrail, bottom rail or string capping. A solid balustrade may have panelling, glass or perspex instead of balusters.

Balusters: Vertical members which infill the space beneath and support the handrail.

Handrail: The support for the hands at the side of the stairs or landings/decks, etc.

Bottom rail (string): The lowest horizontal member in a balustrade that supports the balusters.

Mid rail: A rail parallel to and between a handrail and bottom rail or string.

Handrail support: A vertical piece of timber fixed between the string and handrail to strengthen the handrail and mid rail.

String capping: A timber member fixed to the top edge of the string to receive the balusters.

False tenon: A piece of hardwood inserted into a mortice in the newel post and a mortice or groove in the handrail and nailed in position. This type of joint allows easy assembly of rails to newel posts.

A4 Construction Terms

Going rod: A rod on which is marked the going of each step, the going and the position of the landings i.e. the length of the flight.

Height rod: (storey rod) A rod on which is marked the rise of flights and the rise of each tread.

Pitch board: A triangular template, usually made of galvanised iron or plywood, one of its sides equal to the going, a side at right angles to the going equal to the riser. (A roof square plus fence would be an alternative).

Margin line: A line marked on the inside face of the string 38 to 50 mm parallel to the top edge. From this line the housings are usually positioned.

Margin template: A gauge used against the top edge of the string to mark the margin line. It is used in conjunction with the pitch board to mark out the locations of the treads and risers.

Line of nosing or nosing line: A line touching the front top edge of all the treads, landing and/or floor. It is a separate line to the margin line when the nosing of the tread projects in front of the face of the riser board.

Landing joist: A beam that runs between landing trimmers to support the flooring or decking.

Landing trimmer: A beam at the front of a landing which supports the landing joists, newel posts and top of each flight.

Undercarriage or carriage piece: An additional heavy timber support system fitted beneath wide stairs.

Spandrel framing: Vertical framing and panels which may infill the triangular space between the underside of the outer string and the floor.

Stair soffit: Plywood or plasterboard lining, etc, used to cover the underside of the stairs.

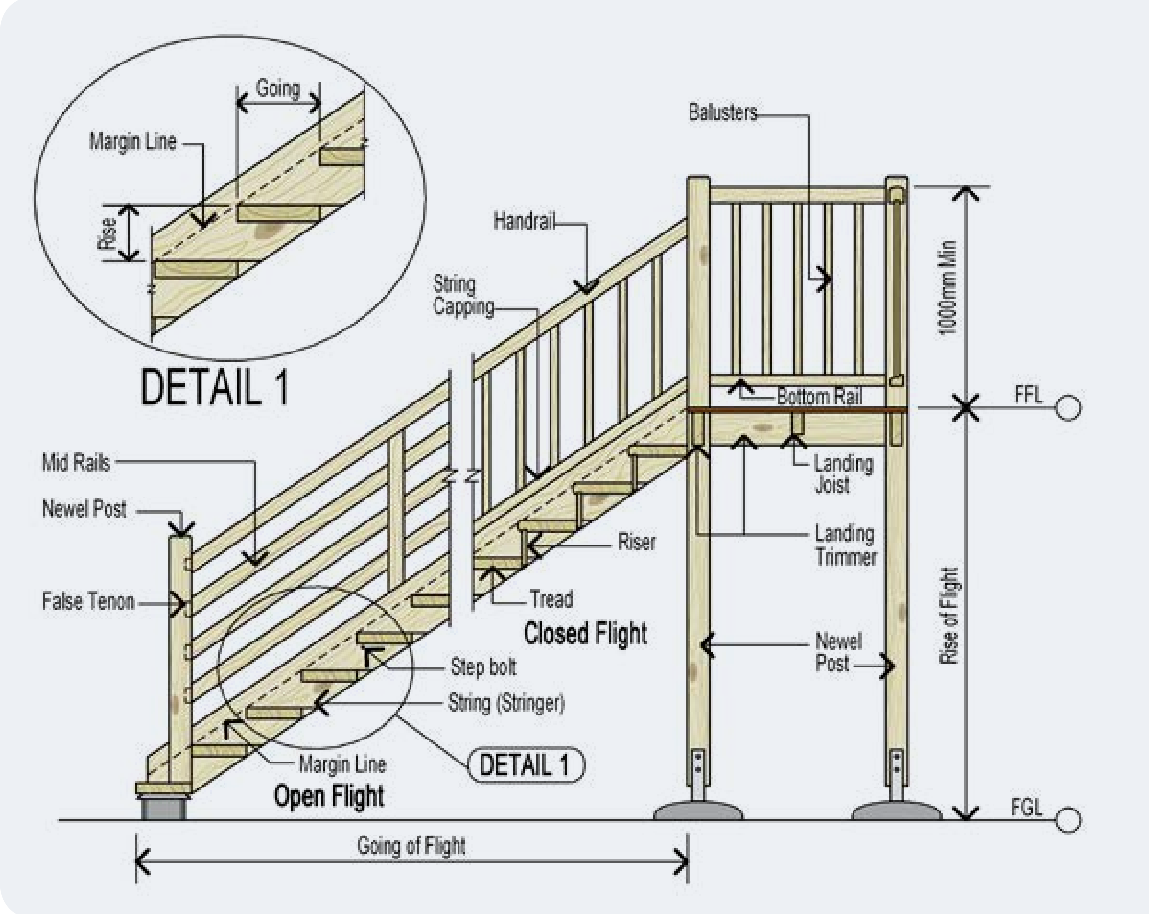


Figure A1: Terminology – Stairs and landings.

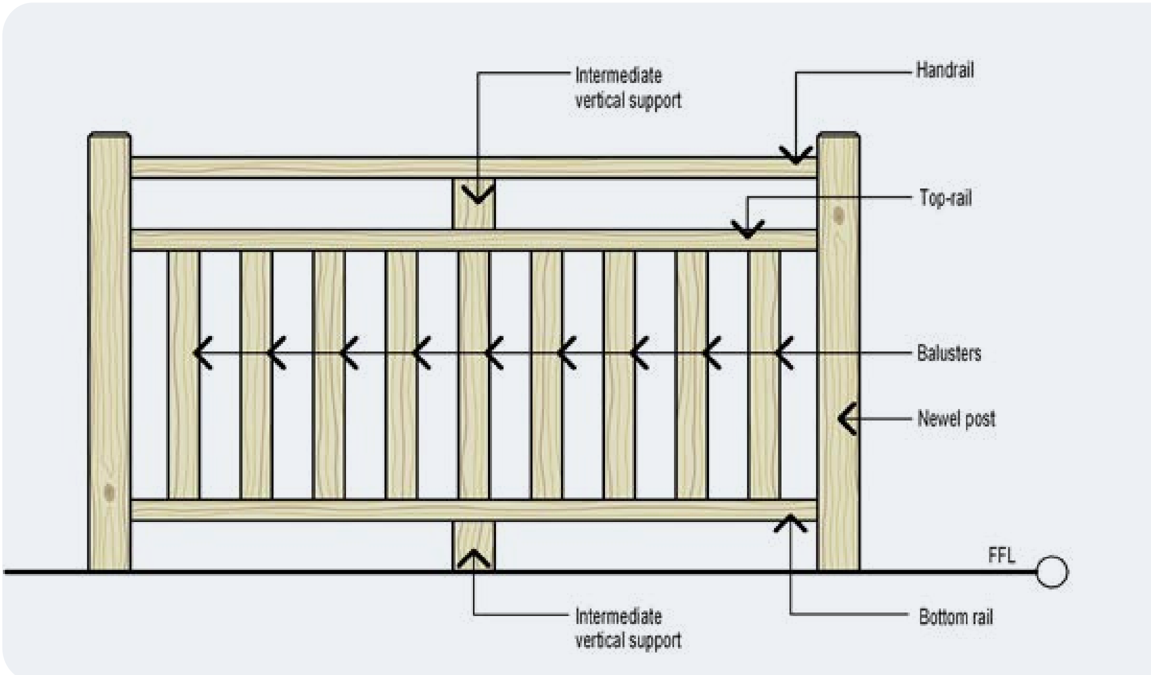


Figure A2: Terminology – Balastrades and handrails.

B

Appendix B – Stair Calculations

B1 General

To obtain the facts required to be able to set out, order material and build stairs, some detailed measuring and calculating is necessary.

To suit the stock width of material available, stairs are usually built with a 240 to 250 mm going and a rise from 160 to 180 mm. See Section 2.

The rise can only be calculated from the total rise. The total rise should be measured with a tape from the lower floor level to the upper floor level. The total rise found may now be applied to a calculation (see B2).

To determine the total rise for external stairs where the ground is not level and either slopes toward or away from the building, refer to Appendix C.

The following problems are examples of how to find the unknown such as rise, going, number of rises and goings from the known facts, i.e. total rise and as in some cases the restricted space available for the total going of a stair as well as headroom.

B2 Example 1

Straight flight of external stairs with the total rise = 2665 mm. The total going is unrestricted and the proposed treads will be 250 x 38 mm unseasoned hardwood.

Calculate rise:
Divide the rise of the flight by a trial rise of 170 mm (for external stairs the rise is generally about 180 mm and for internal about 175 mm) to obtain the approximate number of rises.

2665÷170 mm = 15.67. This gives 15 risers at 170 mm and one at 115 mm. (2665 – (170 x 15))

Although it is allowable to have a different rise at the bottom of external stairs, this should be avoided where possible, so round off to the nearest whole number = 15.

Rise = (2665÷15) = 177 mm

Note: The result of the above calculation is 177.66 but we can round down up or down to the nearest whole number. If rounded down, the result is that the rise of the flight will be 10 mm less than the total rise of 2665. However, when the stairs are built to this and put in place, the treads will have a slight slope to the front, in this case just less than 1 mm per tread. This is acceptable and for external stairs can assist water to run off the treads.

Calculate going:
The tread width is 250 mm so this can be our going. (Where an overhang on the tread is provided, the going will need to be adjusted accordingly.)

Calculate total going:
There is always one less tread than the number of risers so the going of the flight will be:
250 mm (the tread width) x 14 (15 risers - 1) = 3500 mm.

Check results with BCA requirements:

Rise: 177 mm is within the range of 115 to 190 mm.

Going: 250 mm is within the range of 240 to 355 mm.

Slope relationship: 177 x 2 + 250 (rise multiplied by 2 + the going) = 604 is within the range of 700 to 550 mm.

Another requirement of the BCA, that a 125 mm sphere must not pass through treads, should also be checked. The rise, 177 mm, less the tread thickness, 38 mm, must be less than 125 mm.
177 – 38 = 137. This is more than 125 and so is not within the BCA requirement.
A cleat could be fixed under the tread above to close up the space to comply.

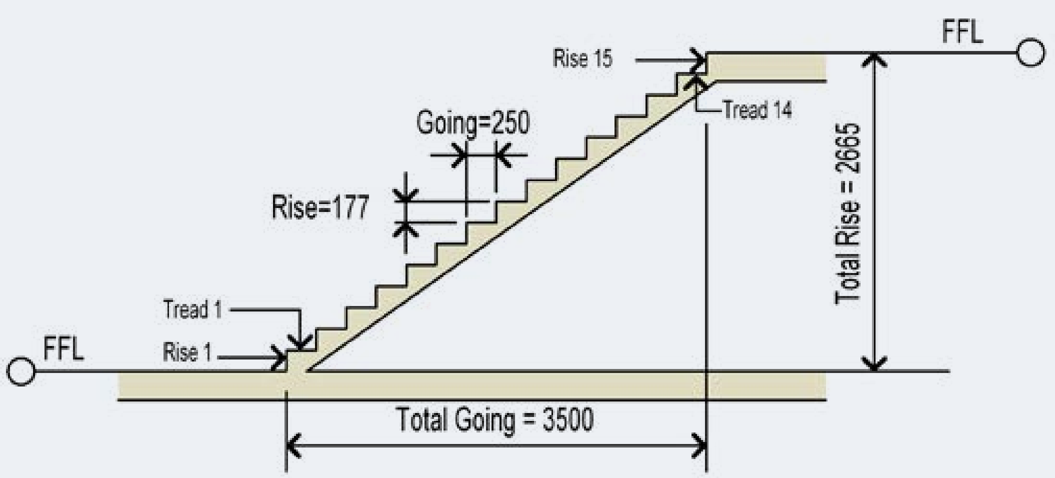


Figure B1

B3 Example 2

An internal stair in a straight flight has a total rise of 2500 and the total going of the flight is 3200.

In this instance, we have a single flight with both the going and the rise of the flight given. The procedure is much the same as in the last problem.

Calculate rise:

Divide the rise of the flight by a trial rise of 170 mm to obtain the approximate number of rises: 2500÷170 mm = 14.70. This gives 14 risers at 170 mm and one at 120 mm. (2500 – (170 x 14))

It is not allowable to have a different rise at the bottom of internal stairs so round off to the nearest whole number = 14.

Rise = 2500÷14 = 178 mm

Note: The result of the above calculation is 178.57 but we can round down to the nearest whole number. The result is that the rise of the flight will be 8 mm less than the total rise of 2500. However when the stairs are built to this and put in place, the treads will have a slight slope to the front, in this case about 0.5 mm per tread. This is acceptable. Where the slope to the front would exceed this, rounding up will be a better alternative as treads will then 'slope in' and be safer.

Calculate going:

In this example, the total going of the flight is 3200. Divide this by the number of treads (one less tread than the number of risers).

Going = 3200 ÷13 = 246 mm.

Check results with BCA requirements:

Rise: 178 mm is within the range of 115 to 190 mm.

Going: 246 mm is within the range of 240 to 355 mm.

Number of treads is greater than 3 and less than 18.

Slope relationship: 178 x 2 +246 (rise multiplied by 2 + the going) = 602 is within the range of 700 to 550 mm.

The other BCA requirement, that a 125 mm sphere must not pass through treads, should also be checked. The rise, 178 mm, less the tread thickness, 38 mm, must be less than 125 mm. 178 – 38 = 140. This is more than 125 and so is not within the BCA requirement. Add a cleat under the tread to close up the space.

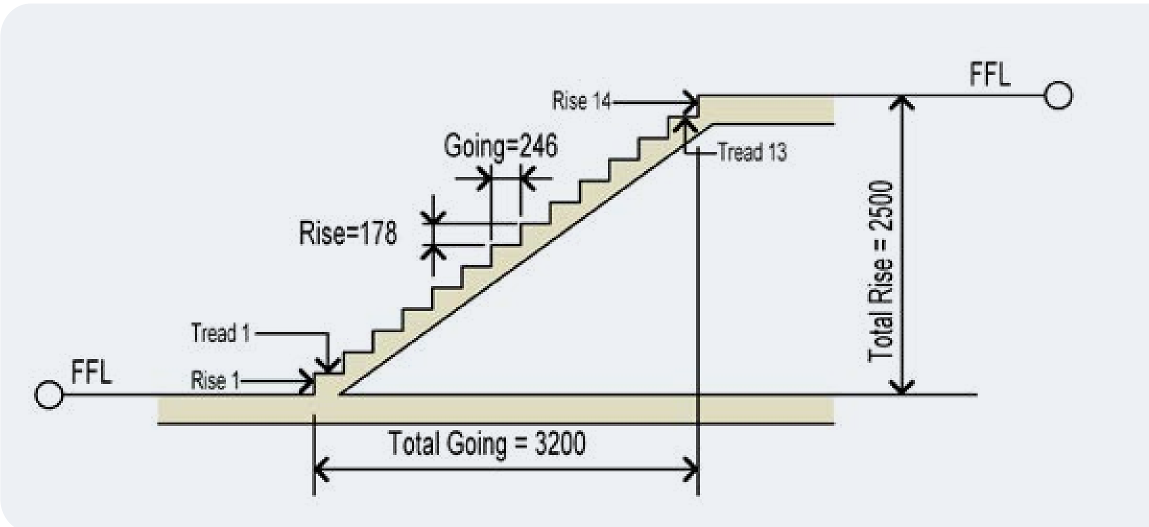


Figure B2

B4 Example 3

Straight flight of external stairs with the total rise = 3600 mm. The total going is unrestricted and the proposed treads will be 250 x 50 mm unseasoned hardwood.

Calculate rise:
Divide the rise of the flight by a trial rise of 170 mm (170 is an average rise for stairs) to obtain the approximate number of rises.

3600 ÷170 mm = 21.17 – rounded off to the nearest whole number = 21.

Rise = 3600 ÷ 21 = 171 mm (Rounded down as per the above examples)

However, the number of risers exceeds that allowed by the BCA in a single flight (not more than 18) so a landing will need to be incorporated.

Calculate going:

The tread width is 250 mm so this can be our Going.

Calculate total going:

Flight 1 – 250 mm = 9 x 250 = 2250 mm plus Flight 2 – 250 mm = 10 x 250 = 2500 mm plus the landing width 900 mm = 5650 mm.

Check results with BCA requirements:

Rise: 171 mm is within the range of 115 to 190 mm.

Going: 250 mm is within the range of 240 to 355 mm

We have already established the number of treads is greater than 18 and a landing needs to be incorporated.

Slope Relationship: 171 x 2 +250 (rise multiplied by 2 + the going) = 592, within the range of 550 to 700 mm.

The other BCA requirement, that a 125 mm sphere must not pass through treads, should also be checked. The rise, 171 mm, less the tread thickness, 50 mm, must be less than 125 mm. 171 – 50 = 121. This is less than 125 and so is within the BCA requirement.

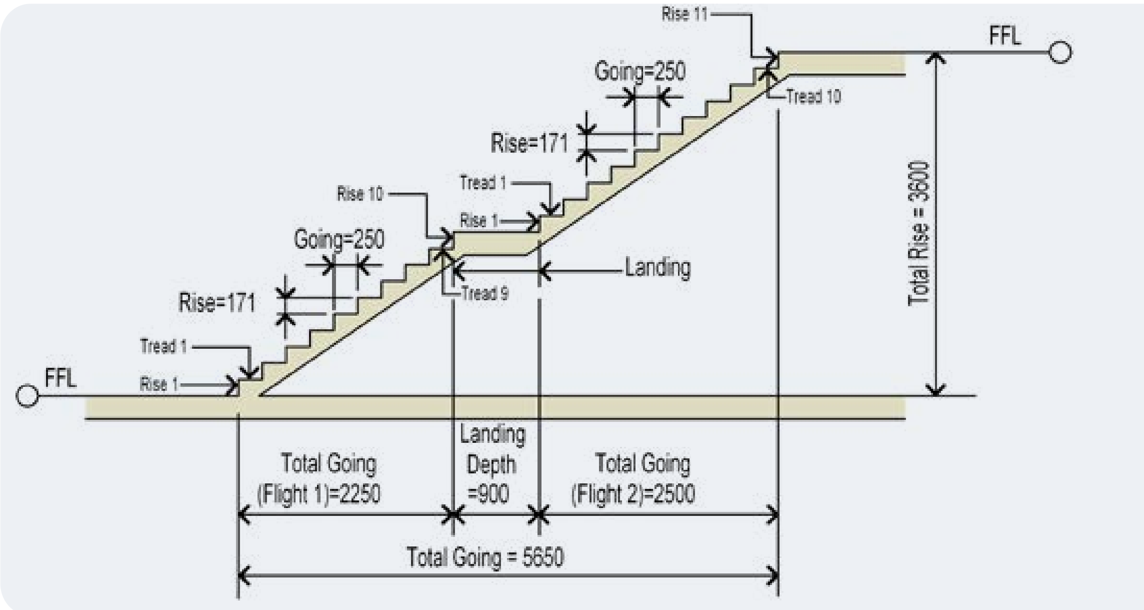


Figure B3

Slope relationship calculations:

The calculations to determine the slope relationship in the above examples worked out to be within the BCA requirement.

If the going plus twice the rise worked out to less than 550 this would indicate that the step was too small and the solution would be to leave out one step and do the calculation all over again.

If, on the other hand, the first trial rise and going caused the step to be too large (i.e. if the going plus twice the rise worked out to larger than 700) the solution would be to add another step.

The BCA minimum is 2000 mm, but 2100 mm is preferred.

B5 Headroom for Stairs

Headroom or head way: Provision should always be made for sufficient height so that the head of anyone will not strike against the edge of the landing or soffit above. This vertical height or space is called 'headroom' and it should not be less than 2000 mm. (The BCA minimum is 2000 mm, but 2100 mm is preferred).

The headroom in the stair shown in Figure B4 would be found by taking the number of risers contained within the opening of the floor (14), multiplying it by the rise and subtracting the depth of the floor. Note also that the length of the opening has the same number of treads (14) as there are risers in the headroom.

Assuming the stair in Figure B4 to have a rise of 177 mm and the depth of the floor 260 mm, the method of finding the headroom would be:

Rise x number of risers in the headroom portion of the stair minus the depth of the floor.

Headroom = 177 x 14 – 260
= 2478 – 260
= 2218 mm

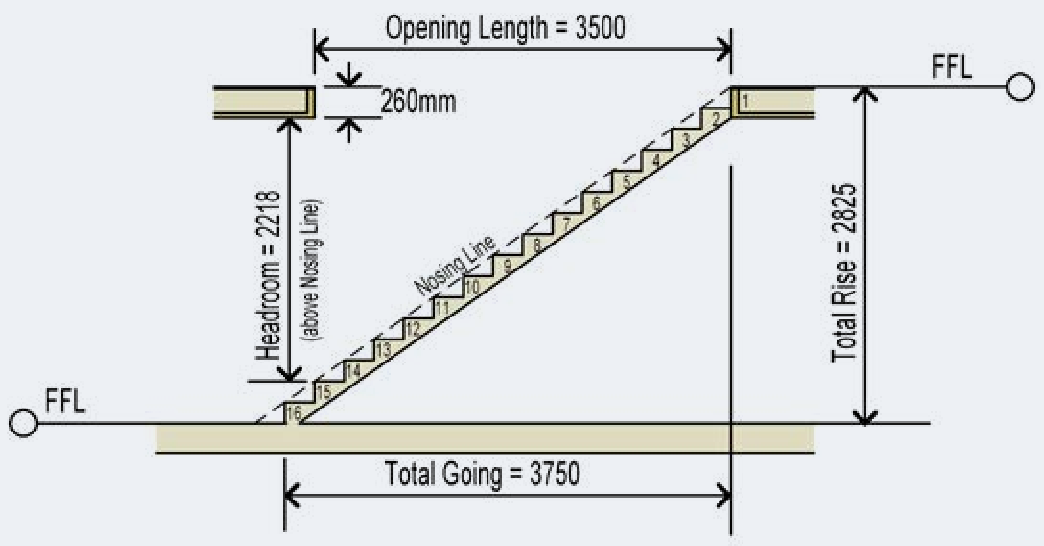


Figure B4

For stairs in two flights, the method of finding the headroom is obtained by studying Figure B5. Note that the headroom is taken from the underside of the ceiling, at the corner of the trimmer, vertically down to the nosing line.

Count the risers from the top of the stairs down to the lower arrow point marking the headroom. There are 8 risers from the top of the stair to the top of the landing, and from the top of the landing to the top of the tread (indicated by the arrow point) there are 7 risers (one less than in the upper flight) making 15 in all.

Assuming a rise of 156 mm, take the height of these 15 risers:

156 x 15 = 2340

Now subtract the thickness of the 225 mm upper floor:

= 2340 – 225 – Headroom = 2115 mm

In other words, to find the headroom double the number of risers in the upper flight, subtract one, multiply by the rise then subtract the thickness of the upper floor (Figure B5). Apart from the flight shown in Figure B5, this applies to any flight with a landing including a straight stair, dog-leg flight, etc.

This may be written as a formula as: Headroom R x (U x 2 – 1) – T, where:

R = rise
U = number of risers In upper flight
T = thickness of upper floor

The previous example can be calculated thus:
Headroom = R x (U x 2 – 1) – T
= 156 x (8 x 2 – 1) – 225
= 156 x 1.5 – 225
= 2340 – 225
= 2115

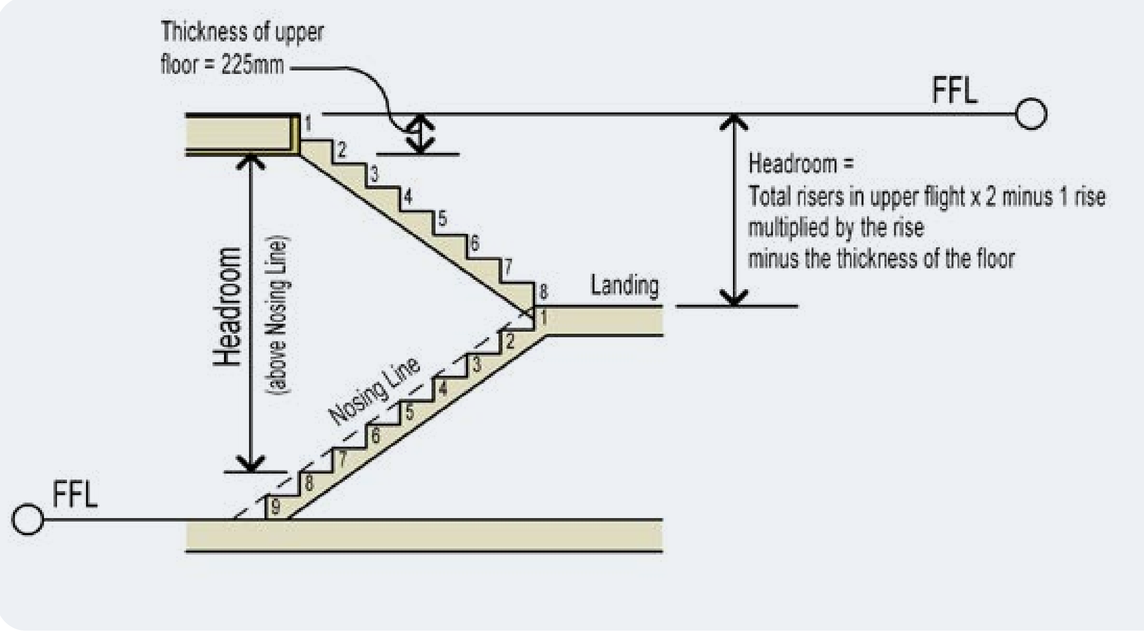


Figure B5

Note: A study of Figure B6 will show clearly the affect on headroom by taking one rise from the top flight and so adding one to the bottom flight; the result is a reduced headroom by two rises (e.g. 2115 mm – (156 x 2) = headroom of 1803 mm which would not be suitable).

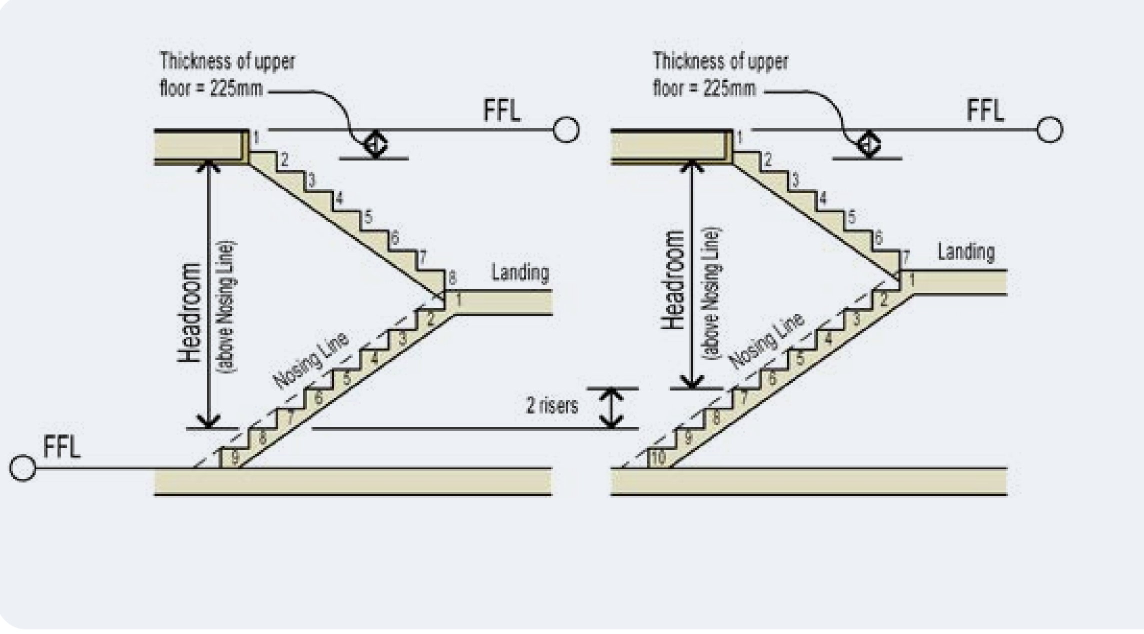


Figure B6

B6 Practical Method for Calculating Number of Rises and the Rise

After marking the total rise onto a storey rod, a pair of carpenter's wing dividers should be set to a trial rise (165 to 170 mm) and then stepped along the storey rod to finish within the total rise. While doing this, the number of spaces should be counted and recorded (Figure B7).

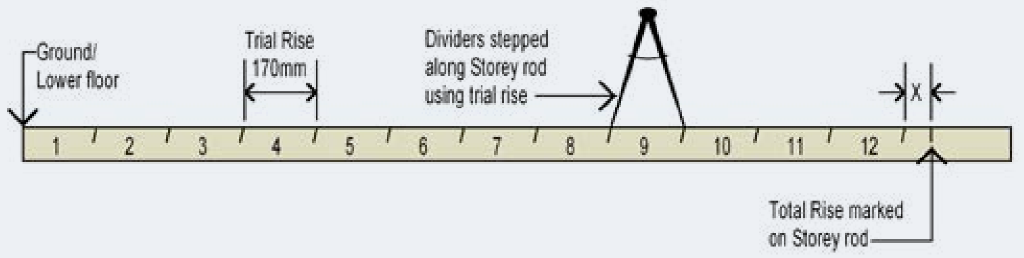


Figure B7

The distance between the last divider mark and the total rise mark on the storey rod (X) is now divided by the number of spaces counted and the result added to the first setting of the dividers.

If X = 60 mm then 60÷12 = 5
Trial rise 170 mm + 5 mm
Rise = 175 mm

Restep the dividers along the storey rod as a check, but now the last step should finish exactly on the total rise mark and the number of spaces or rises should be as before (Figure B8).

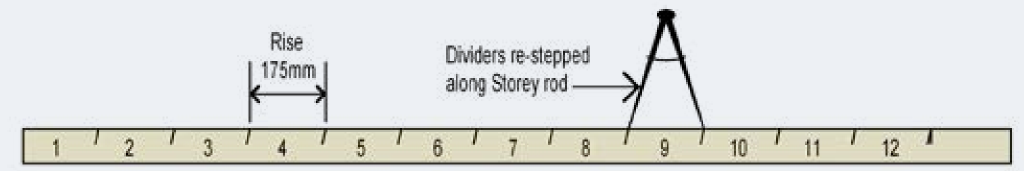


Figure B8

You should now have the number of rises and the exact rise and consequently the number of goings which is always one less than the number of rises. Remember that a landing is counted as a going so that when a landing is required in a stair there will be two flights and the number of treads in both flights will be two less than the total number of rises in the stair.

B7 Quantity Calculations

B7.1 String Length Required

This is normally determined by measurement from a full size set out of a section through the flight, showing the treatment of the string at both ends; however for ordering purposes, application of the rule 'number of treads in the flight x 300 mm + 500 mm' should provide sufficient material.

Note: The 500 mm allows for variations of treatment at top and bottom of the string.

Using Example 1 above:

No. of treads in the flight x 300 mm + 500 mm
15 x 300 mm + 500 mm
4500 mm + 500 mm
String length = 5000 mm
Two strings of 5000 mm are required. (i.e. order 2 of 5.1 m)

B7.2 Number of Treads

From the previous calculations in Examples 1, 2 and 3, the number of treads is known. The length of each tread will depend on the width of the stairs.

Using Example 1 above and width of flight = 900 mm:

No. of treads in the flight = 15
Tread length = 900 mm
15 treads @ 900 mm.

If these are ordered as 15 individual pieces, this does not allow very much margin for error or any end splits that may need to be cut off. Ordering 5 pieces 3000 mm long will allow a suitable amount without being uneconomical.

B7.3 Tread Cutting Length

The cutting length of a tread will be the overall width of the stair minus twice the gauge depth (Figure B9).

Example:

Width of stair = 900 mm
Housing depth = 15 mm
String thickness = 50 mm

Tread cutting length = 900 – (2 x (50 – 15))
= 900 – 70
= 830 mm

Figure B9: Tread cutting length.

Appendix C – Total Rise Calculations – Sloping Ground

C

These methods have generally been replaced by the use of laser levels, etc.

C1 Determining Total Rise on Sloping Ground

The following guidance can be used to determine the total rise for external stairs where the ground is not level and either slopes toward or away from the building.

Note: These methods have generally been replaced by the use of laser levels, etc.

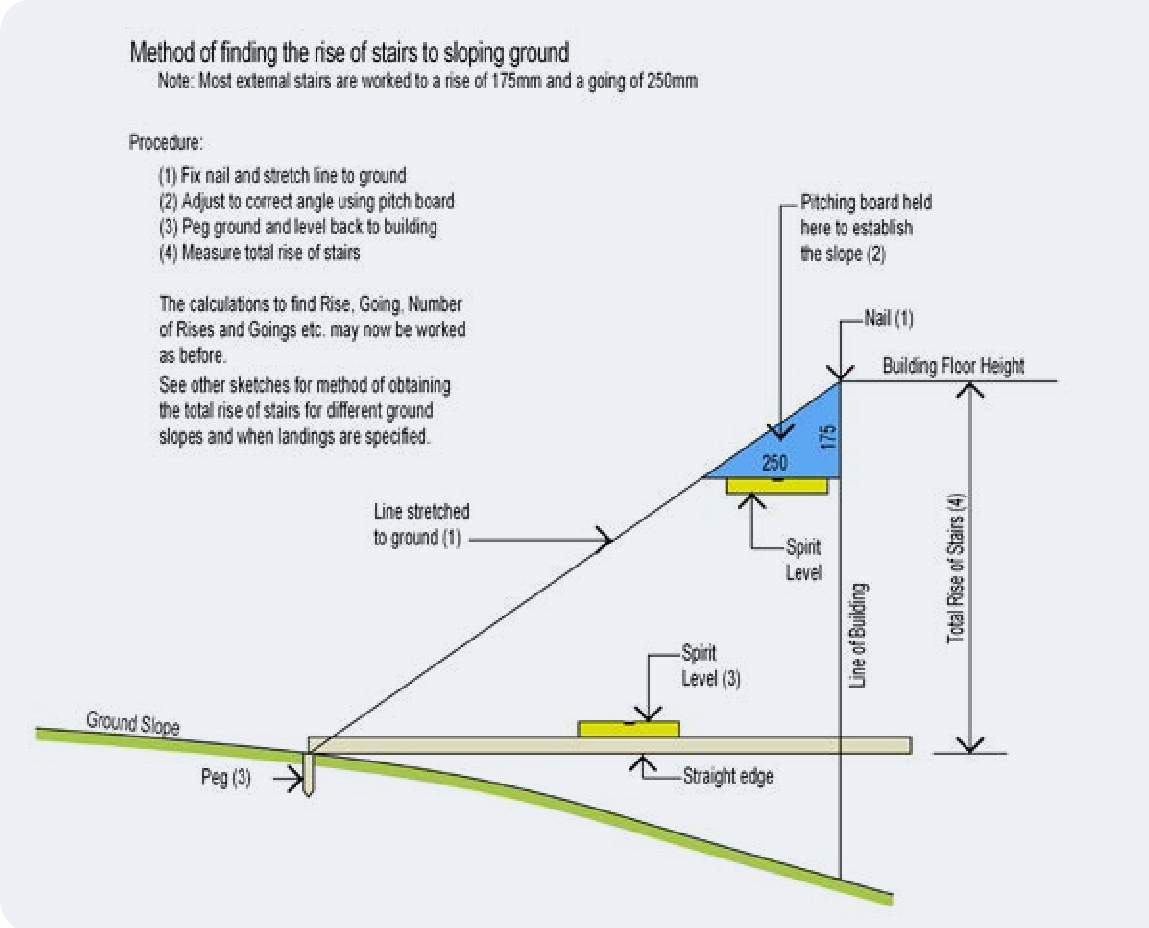


Figure C1: Stairs without landing – Land sloping towards building.

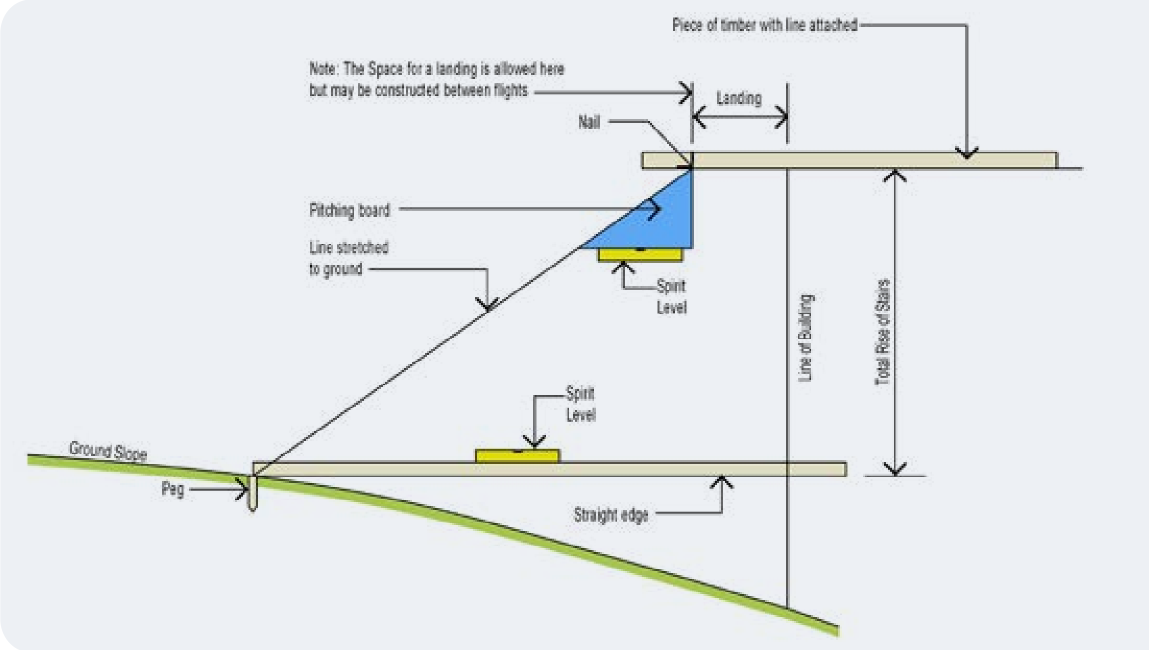


Figure C2: Stairs with landing – Land sloping towards building.

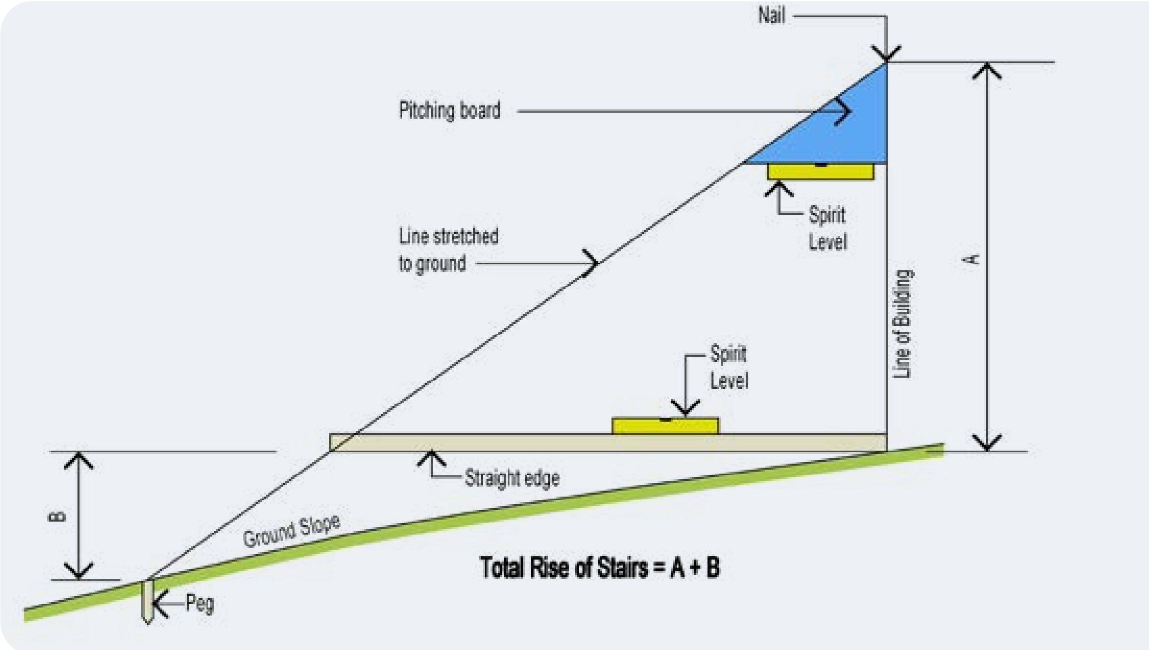


Figure C3: Stairs without landing – Land sloping away from building.

Note: this situation to be avoided wherever possible as it adds to the number of treads required.

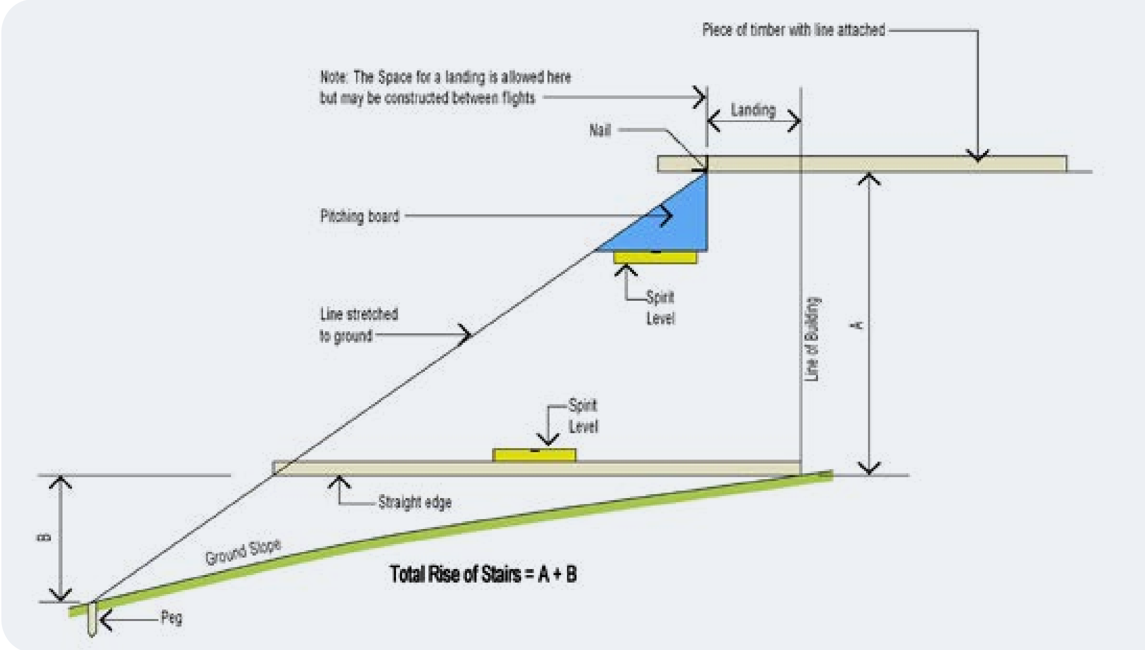


Figure C4: Stairs with landing – Land sloping away from building.

Note: this situation to be avoided wherver possible as it adds to the number of treads required.

09

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Timber Flooring

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Introduction

1.1 Scope

This publication provides a reference guide for the installation of solid timber strip flooring over bearers and joists, timber-based sheet flooring products and concrete slabs. Floors of this type fit together with a tongue and groove joint and, unless they are a prefinished product, they are sanded and finished after the flooring is in place. Also included is parquetry flooring, which is made up of short timber pieces adhered to an appropriate sub-floor. When installing solid timber flooring, many aspects must be considered, including the house design, the environment in which the floor is to be laid and the desired appearance of the finished floor. Such aspects influence the choice of species, the cover width of strip flooring, and the fixings and finish to be applied to uncoated flooring. Information relating to product selection, assessing the installation environment, floor installation and sanding and finishing are provided in this Guide together with additional information that is of importance to the floor installer, sander and finisher.

1.2 The Flooring Process

Strip timber flooring is available in a range of species and colours, including harder and softer timbers and a variety of profiles and cover widths. However, prior to the finished floor being handed over, there are a number of processes that must be correctly undertaken to achieve a floor with the performance and appearance of a professional standard. Each stage generally involves different sectors of the industry, each having specific skills. However, each stage is of equal importance with defined responsibilities and a lack of attention at any particular stage can adversely affect the finished floor. The stages are as follows.

- Manufacture – This is usually carried out by a sawmiller; however, dried rough sawn boards may be machined into finished floorboards during a separate operation. Parquetry is often manufactured as a by-product of strip flooring or is imported and prefinished. Solid flooring is also imported.
- Distribution – Flooring is often sold to timber merchants who on-sell to the installer.
- Specification – Architects, designers and owners usually specify the product to be installed.
- Sub-floor – Builders provide the joists and bearers or slab over which a floor is laid.
- Installation – Specialist floor installers and carpenters install floors over the sub-floor.
- Sanding and Finishing – Unless it is a prefinished product, this is generally undertaken by professional floor sanders and finishers.

Figure 1.1: Selective logging from sustainably managed forests often starts the process.

1.3 The Owner's Choice

Aspects relating to what customers desire are of paramount importance and should not be taken lightly. Customers are relying on the expertise of the professionals involved in the six stages outlined above, and each area can influence the owner's satisfaction with their floor. Each floor is unique and is often seen by the owner as a focal point of the interior design. Those selecting a timber floor will often choose on colour, with board width influencing how the natural colours are blended. Timber hardness, or matching to an existing floor, can also be of prime importance and other significant aspects can include the origin of the flooring in terms of country or forest type, and whether the timber is recycled.

Owners are more aware and have more access to information than ever before; however, they are unlikely to have the same depth of knowledge as those dealing with timber flooring on a day-to-day basis. It is important to accommodate customer preferences; however, this should not be to the detriment of the performance of the floor or its final appearance. Where customer preferences cannot be accommodated, this needs to be brought to their attention. Where their choices can be accommodated but may affect the appearance of the floor, then this too should be brought to their attention and followed up in writing. Colour variation between showroom samples and the product provided, provision of expansion joints, high levels of sun exposure on an area of the floor are all areas that affect appearance and may need specific discussion with the owner.

Left: Figure 1.2: Client wishes need accommodating but not at the expense of floor performance.

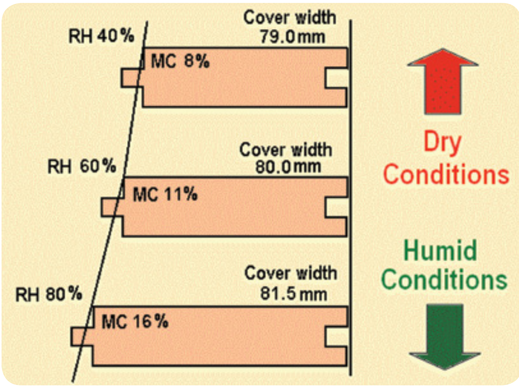
Right: Figure 1.3: Showrooms provide an excellent environment where clients can see many types of floors and finishes and valuable information about floor systems, performance and care of timber floors can be provided.

2

Timber Flooring and Floor Finishes

2.1 Movement in Timber Floors

Prior to discussing timber flooring products, it is important to understand the relationship between timber, humidity in the air surrounding it and the dimensional changes that occur from changes in humidity. During weather conditions of consistently high humidity, timber will absorb moisture from the surrounding air, causing it to swell or increase in size. Conversely, during drier times when humidity is low, timber will shrink, reducing in size. Unless tongue and groove (T&G) flooring is placed in a permanently controlled environment, it will always move in response to changing environmental conditions. Gaps between individual T&G boards will occur as the floor shrinks in dry weather. Similarly, during either persistent wet weather or times of naturally high humidity, strip floors will tend to be tighter and show fewer and smaller gaps.



Left: Figure 2.1: Cover width variation with changing relative humidity.
Right: Figure 2.2: Small gaps at board edges may occur, particularly during dry weather.

Therefore, a 'continuous mirror finish' cannot be expected from site-applied floor finishes. Prefinished strip flooring is generally manufactured with arrised edges, so board edges are defined and a higher quality of surface finish is generally obtained.

Localised shrinkage may also occur when areas of flooring are exposed to heat sources, such as fireplaces or sunlight through large doors or windows. The overall movement and rate of movement of timber varies depending on the timber species and cutting pattern of individual boards. Small moisture content variations in boards at the time of installation and differing conditions within the house (e.g. from sun exposure or fireplaces) will also cause variation in board movement. In general, parquetry flooring is less susceptible to movement due to the patterns used in laying and the piece size being smaller.

Consequently, gapping across a strip floor can be expected and may be relatively even, depending on individual circumstances, but actual gap size between individual boards will vary. Wider boards will move more than narrower boards for the same changes in moisture content. Therefore, gaps in wide-board floors are generally wider and more noticeable. An uneven distribution of gaps can detract from the appearance of the floor and may occur if a number of boards are bonded together by the finish penetrating into the joints. Floor finishes will not prevent timber movement, but may reduce the rate of response to climatic changes. Applying a finish to the underside of a floor may help reduce the impact of sudden changes in the weather.

2.2 Timber Species and Characteristics

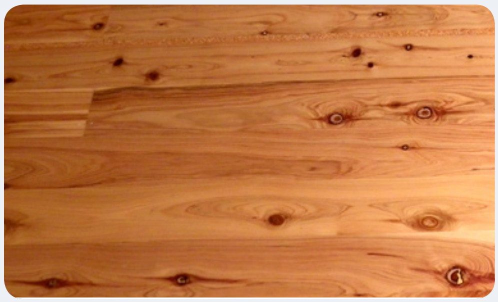
2.2.1 Species, Colour, Grade and Hardness

The species or species mix will generally determine the overall colour of the floor. Mixes may contain different species from one producer to another and may therefore appear different. Even when a single species is chosen, there can be a wide variation in colour and a limited number of boards of a different species may be present due to similarity in appearance. As a guide, the following tables indicate the range of colours that may be expected. The sapwood of many hardwoods can be much lighter than adjacent heartwood and some boards may contain both light and dark colours. Large colour variations can occur, even within a single species and individual trees. The age of the tree can have a significant influence on the colour, with younger timber often being lighter than more mature timber. The product supplied may differ in colour to showroom samples, and this should be discussed with flooring suppliers and owners. Due to these factors, it is preferable that flooring is supplied from one manufacturing source and that the packs are of a similar age.

In Australia, lyctid-susceptible sapwood of some hardwood species (e.g. Spotted Gum), is required to be preservative treated under AS 2796.1 Timber – Hardwood – Sawn and milled products. Some treatments may impart a brown tinge to sapwood, while boron preservative is non-colouring. Light organic solvent preservative (LOSP) treatment is also used. In this instance, H3 treatment may be used in lieu of H2 treatment to avoid the coloured dyes often used with H2 LOSP treatments. Some imported hardwood such as American and European Oak are also lyctus susceptible, and it can be unclear as to whether these have been adequately treated. In line with the intent of AS 2796, it is considered to be the importer's responsibility to provide flooring that is not lyctid susceptible.

The character of the floor is influenced by the species' characteristics and therefore the grade. Grading is a process that sorts boards according to the number and size of features present (e.g. gum veins and knots). The following tables indicate the grades contained in relevant Australian Standards, but it should be noted that manufacturers often have their own grades. Flooring that contains more features is often more moderately priced yet, irrespective of the features present, there is no difference between the grades in terms of machining tolerances, permitted machining imperfections and moisture content. Imported flooring may or may not comply with Australian grading rules; however, it is considered that applicable grade descriptions should be available with those products. Structural requirements for boards are covered by Australian Standards (AS 2796 for hardwoods) and, for any grade not complying with these Standards, it is the importer's responsibility to provide a structurally adequate product when used in that application. Use of an Australian Standard grade name automatically means compliance to all aspects of that Standard.

Tasmanian Oak – Medium Feature Grade.



Cypress – Grade 1.

Jarrah – Select Grade.

Blackbutt – Select Grade.

Figure 2.3: Grade, colour and board width dictate the floor's appearance.

It is important to realise that the overall colour or blend of colour in a floor is dependent on the species or species mix chosen and that the character of the floor – in terms of the features present (such as gum veins) – is determined by the grade. If choosing an alternative species from the one originally considered, not only will the overall colour differ, but the dominant type of feature may also change. It is important that suppliers, installers and clients work closely together to ensure that the desired look of the flooring is clearly understood by all.

Hardness indicates a species resistance to indentation. Damage to timber floors may occur due to continual movement of furniture, heavy foot traffic and – in particular – stiletto heel type loading. The selection of a hard timber species ensures improved resistance to indentation. Soft timber species, if used in feature floors, can be expected to indent. Floor finishes will not significantly improve the hardness of timber flooring. In some species, the hardness of the younger-growth material can be much lower than the mature timber, but this varies from species to species.

Figure 2.4: Even hard timbers will indent from stiletto heels.

Table 2.1: Australian Hardwoods – to AS 2796 – Timber – hardwood – sawn and milled products.

Species	Origin	Colour	Hardness	Common cover widths (mm)	Thickness (mm)
Hardwood flooring species grown in Queensland and Northern New South Wales (may also be supplied as a mix of similar colour) Select Grade, Medium Feature/Standard Grade and in some species High Feature Grade					
Blackbutt *(Eucalyptus pilularis)*	Qld, NSW	golden yellow to pale brown	very hard	60, 80, 85, 130, 180	19,12,13,14
Bloodwood *(Corymbia gummifera)*	NSW	medium to deep red brown	hard	60, 80, 130	19
Brushbox *(Lophostemon confertus)*	Qld, NSW	mid red-brown even colour	hard	60, 80, 85, 130	19,12,14
Forest Red Gum *(Eucalyptus tereticornis)*	Qld	dark brown, dark red brown	very hard	60, 80, 85, 130	19,12,14
Grey Box *(Eucalyptus microcarpa)*	NSW	mid brown with paler tones	very hard	60, 80, 85, 130	19,12,13,14
Grey Gum *(Eucalyptus propinqua)*	NSW	red brown paler sapwood	very hard	60, 80, 85, 130	19,12,13,14
Grey Ironbark *(Eucalyptus siderophloia)* *(Eucalyptus paniculata)*	NSW Qld	dark brown or dark red brown, light sapwood	very hard	60, 80, 85, 130, 180	19,12,13,14
Gympie Messmate *(Eucalyptus cloeziana)*	Qld	yellow brown	very hard	60, 80, 130	19
Manna Gum *(Eucalyptus viminalis)*	NSW	pale straw pinks	mod. hard	60, 80, 130	19,12
New England Blackbutt *(E.andrewsii)*	NSW	straw to pale brown	very hard	60, 80, 85, 130	19,12,13,14
Red Gum *(Eucalyptus tereticornis)*	NSW	deep red with paler sapwood	very hard	60, 80, 85, 130	19,12,13,14
Red Ironbark *(Eucalyptus crebra & fibrosa)* *(Eucalyptus sideroxylon)*	Qld NSW	dark brown, dark red brown	very hard	60, 80, 130	19,12,14
Red Mahogany *(Eucalyptus pellita)*	Qld, NSW	dark red with paler sapwood	very hard	60, 80, 85, 130	19,12,13,14
Rose Gum *(Eucalyptus grandis)*	Qld, NSW	straw pink to light red-brown	hard	60, 80, 85,130	19,12,13,14
Spotted Gum *(Corymbia citriodora)* *(Corymbia maculata)*	Qld NSW	brown, dark brown, light sapwood	very hard	60, 80, 85,130,180	19,12,13,14
Stringybark (Silver top - *Eucalyptus laevopinea,* White - *Eucalyptus eugenioides*)	NSW Qld, NSW	pale brown, some pinks pale brown with pink tinge	hard	60, 80, 85,130	19,12,13,14
Sydney Blue Gum *(Eucalyptus saligna)*	NSW	straw pink to light red-brown	hard	60, 80,85,130,180	19,12,13,14
Tallowwood *(Eucalyptus microcories)*	Qld, NSW	greyish yellow, olive green	hard	60,80,85,130	19,12,13
Turpentine *(Syncarpia glomulifera)*	Qld, NSW	pale reddish brown	very hard	60,80,85,130	19,12
White Mahogany *(E. acmenioides)*	Qld, NSW	pale yellow brown	very hard	60,80,130	19,12
Hardwood flooring species grown in Victoria, Southern New South Wales and Tasmania					
Alpine Ash *(Eucalyptus delegatensis)*	Vic, Tas	pale straw to light brown	mod. hard	60, 63, 68, 80, 85, 108, 112, 133	12,13,14,19
Blackwood *(Acacia melanoxylon)*	Tas	light golden to deep brown	mod. hard	60, 65, 85, 108, 112, 113	13,19
Brown Barrel *(Eucalyptus fastigata)*	Vic	pale brown, lighter sapwood	mod. hard	63, 80, 85, 108, 133	12,19
Manna Gum *(Eucalyptus viminalis)*	Vic	pale straw pinks	mod. hard	63, 80, 85,108, 133	12,19
Messmate *(Eucalyptus oblique)*	Tas	pale straw to light brown	mod. hard	60, 68, 85,108, 112 ,113	10,12,13, 14 19
Mountain Ash *(Eucalyptus regnans)*	Vic, Tas	pale straw to light brown	mod. hard	60, 63, 68, 80, 85, 108,112,133	12,13,14,19
Myrtle *(Nothofagus cunninghamii)*	Tas	straw & light pink, light sapwood	mod. hard	60, 65, 85,108,112 133	13,19
River Red Gum *(Eucalyptus camaldulenis)*	Vic	rich deep reds	hard	63, 80, 85,108,133	12,19
Shining Gum *(Eucalyptus nitens)*	Vic	pale brown some pinks	mod. hard	63, 80, 85,108,133	12,19
Silvertop Ash *(Eucalyptus sieberi)*	Vic	pale brown some pinks	hard	63, 80, 85,108,133	12,19
Southern Blue Gum *(Eucalyptus globulus)*	Vic, Tas	pale brown with some pink	very hard	60, 63, 80, 85,108, 112, 133	12,13,19
Tasmanian Oak *(Eucalyptus regnans, E. oblique, E.delegatensis)*	Tas	pale straw to light brown	mod. hard	60, 65, 85,108,133 160, 180, 85,112	10,12, 13, 14 19, 20, 21
Victorian Ash (Eucalyptus regnans, E.delegatensis)	Vic	pale pink to yellow brown	mod. hard	63, 68, 80, 85, 108, 133, 160, 180	12,14,19, 20, 21
Yellow Stringybark (E. muelleriana)	Vic	even, yellow brown	hard	63, 80, 85, 108, 133	12,19

Table 2.1: Australian Hardwoods – to AS 2796 – Timber – hardwood – sawn and milled products (continued).

Species	Origin	Colour	Hardness	Common cover widths (mm)	Thickness (mm)
Hardwood flooring species grown in Western Australia					
Jarrah *(Eucalyptus marignata)*	WA	rich reddish-browns to soft salmon pinks	hard	80,85,105,125, 130	12,13,19
Karri *(Eucalyptus diversicolor)*	WA	rich reddish-browns to pale pinks	hard	80,85,125,130	12,13,19
Marri *(Eucalyptus calophylla)*	WA	pale brown lighter sapwood	hard	80,85,125,130	12,13,19
WA Blackbutt *(Eucalyptus patens)*	WA	pale yellow brown	hard	80,85,125,130	12,13,19
Cypress – to AS 1810 – Timber – seasoned Cypress – milled products Grades No.1 and No. 2					
Cypress (White) (Callitrus glaucophylla)	Qld, NSW	pale straw sapwood, dark brown heartwood	mod.hard	62,85	20
Australian Softwoods – to AS 4785 – Timber – softwood – sawn and milled products except Araucaria (hoop pine) for which industry grades apply Standard Grade for AS 4785					
Araucaria *(Hoop) (Araucaria cunninghamii)*	Qld, NSW	light straw	soft	87,89,102,133, 152	19, 20, 21
Radiata *(Pinus radiata)*	Vic, NSW WA, SA	straw	soft	104	19, 21
New Zealand Species Grades - Industry grades					
Kauri *(Agathis Australis)*	NZ	pale sapwood, heartwood pale to reddish brown	soft	65, 85, 110, 135	12, 13, 18, 19, 21
Matai *(Podocarpus spicatus)*	NZ	white sapwood, straw brown to orange heartwood	soft	65, 85, 110, 135	12, 13, 18, 19, 21
Red Beech *(Nothofagus fusca)*	NZ	light brown sapwood, light to medium red brown heartwood	soft	65, 85, 110, 135	12, 13, 18, 19, 21
Rimu *(Dacrydium cupressinum)*	NZ	pale brown sapwood, red to yellow brown heartwood	soft	65, 85, 110, 135	12, 13, 18, 19, 21
Tawa *(Beilschmiedia tawa)*	NZ	white sapwood, pale to very dark brown heartwood	mod. hard	65, 85, 110, 135	12, 13, 18, 19, 21
Imported Hardwoods – to AS 2796 – Timber – hardwood – sawn and milled products Select Grade, Medium Feature / Standard Grade and in some species High Feature Grade					
Kempas *(Koompassia malaccensis et al)*	S.E. Asia	red brown, yellow streaks	hard	80,130	19
Kwila / Merbau *(Instsia bijuga)*	S.E. Asia	dark brown	hard	80,130	19
Maple *(Rock or Sugar) (Acer saccharum)*	North. America	light straw	mod. hard	50, 57, 83	19
Northern Box *(Tristania obovata)*	S.E. Asia	mid brown even colour	hard	80,130	19
Oak *(Quercus spp)*	Europe, North America	pale yellow brown	mod. hard	narrow to wide	19

Note: Not all species, width and thickness combinations are available. Check with suppliers before specifying.

2.2.2 Cover Widths, Profiles, Spans and End-matching

Typical cover widths and thicknesses for T&G strip flooring are as shown in the Table 2.1. Actual cover widths may vary from those shown and should be checked with individual suppliers. Typical T&G profiles are shown in Figure 2.5. Some profiles are produced with grooves or rebates on the underside. Where the underside of a floor forms a ceiling, the board edges may be arrised to form a 'V' joint profile. Both profiles are used for top (face) nailing and secret fixing. The standard profile is more commonly found on wider boards and some manufacturers indicate that such boards should be top (face) nailed. Some wider board flooring has the secret nail profile that allows temporary secret fixing prior to top (face) nailing. With some installations wider boards may also be fully adhesive fixed.

Figure 2.5: Typical T&G profiles.

If the species or species mix contain a significant variation in colours, the appearance of the floor will differ depending on the cover width. Narrower boards tend to blend the colour variations together. Gapping between individual boards during drier times is also less with narrower boards than it is with wide boards. A board width of 100 mm or less will limit potential gap size and other movement effects such as cupping (where the edges of the board are higher or lower than the centre). If wider flooring is used then wider gapping can be expected and, under certain conditions, some cupping becomes more likely.

End-matching is a process where a T&G joint is provided at the ends of boards. The majority of flooring is now end-matched. For floors laid direct to joists or battens this allows joints to be placed between the joist or batten, resulting in less wastage than plain-end flooring, which must have its ends fixed over the joist or batten.

Figure 2.6: Plain end and end-matched flooring.

2.2.3 Floor Lengths

Strip flooring to be sanded and coated is generally supplied in random length packs of up to 4.8 m in length.

The average length is often between 1.8 m and 2.1 m. Packs of shorter overall length are also available from some suppliers to facilitate floors in high-rise buildings that require product to be taken to the appropriate floor by a lift. The minimum length for timber being fixed to joists is 900 mm, based on a 450 mm joist spacing. In some instances, if it is known that the floor will be laid over a structural sub-floor, lengths shorter than 900 mm may be provided. Prefinished strip flooring is usually provided in set length packs and not in longer lengths. For information about parquetry flooring, refer to Section 6.

2.2.4 Ordering Flooring

When ordering timber flooring, the following details should be provided to the timber supplier:

- species (or species mix)
- grade
- profile and end-joint type
- cover width
- thickness
- quantity (in linear metres)

Flooring is generally supplied within the moisture content range from 9% to 14%. For larger jobs in specific environments a different range may be specified.

To calculate the linear metres of flooring required, the following method is recommended:

$$\text{Total length of flooring required} = \frac{\text{Area of floor (m}^2\text{) x 1000}}{\text{Cover width (mm)}} + \text{Wastage}$$

Allowance for waste should be approximately 10%, but may vary by about 5% above or below this, depending on the installation.

For parquetry flooring, the floor area needs to be determined but the pattern and product used will dictate what needs to be ordered.

Figure 2.7: Due to the patterns, ordering parquetry can require greater considerations.

2.3 Floors over Different Sub-floors

Depending on the sub-floor supporting system (e.g. joists, plywood on slab, etc), timber floors will both feel and sound differently when walked on. Generally, strip timber floors laid over joists or battens will have more spring underfoot and there is likely to be some vertical movement at board edges and end-matched joints when walked on. Some squeaks can therefore be expected from most timber floors of this type. Squeaks can occur from movement of one board edge against another or from boards moving on nails. Squeaks are often more prevalent during drier weather due to loosening at the joints. Floors that are laid over plywood on a slab will have a firmer feel underfoot and some areas may sound 'drummy'. Similarly, when floors are glued directly to concrete, the feel is firmer, and again some boards may sound drummy when walked on.

In cooler climates, slab heating may be present and, due to the direct heating effect on the timber and intermittent use of this type of heating system throughout the year, substantial seasonal movement can occur. Although strip flooring can be used, if care is taken with appropriate product selection and installation practices (refer to Appendix E – Underfloor heating), it may be preferable to use engineered timber flooring products where less dimensional changes would be expected. Even with these products, care is still necessary.

2.4 Floor Finishes – Types and Characteristics

The coating system that is ultimately chosen for a site sanded and coated floor will depend on a variety of considerations. In some instances, the coating system will be specified and this is generally the case for commercial projects. However, with domestic floors, it is often the client who either requests a specific coating type or is expecting the contractor to provide information from which they can make an informed decision. If a coating is specified, it is still necessary that the contractor considers the consequences of using that coating and informs client about any reservations they may have.

Aspects relating to coatings that may need to be considered and conveyed to the client include issues such as potential health hazards, including the potential of the coating to taint any food that may be in the dwelling when the coating is being applied. Floor maintenance is another important issue, as it is recognised that some coating types require more frequent maintenance than others and the owner must be prepared to undertake this. Other aspects to consider are the yellowing of the coating with age and the fact that both the timber and the coating can result in tone variation over time. With domestic floors on stairs, there is also a National Construction Code (formerly BCA) requirement for step treads to be slip resistant. This can be achieved with the correct coating, but requires the use of those with low sheen levels.

Timber floor finishes (coatings) can be grouped into five main categories:

1. Penetrating oils and waxes. This includes sub-categories of:
   - penetrating oils, including air curing and burnish curing
   - penetrating waxes, including oil/wax blends
   - film-forming hard wax oil technology with or without external cross-linker
2. Curing oils (air curing and chemical cross-linked) and alkyds
3. Urethane-modified oils
4. Acid-catalysed coatings
5. Polyurethanes including:
   - solvent-based moisture cure one-pack
   - two component solvent-based
   - waterborne one-pack
   - waterborne two-pack
   - acrylic urethane blends or copolymers.

Below is a description of each of these categories with information about their properties, benefits and disadvantages.

2.4.1 Penetrating Oils and Waxes

Products in this category can have the lowest Volatile Organic Compound (VOC) levels, although some individual products can also have a high VOC. These materials are based on sustainable natural oils and have extensive use, mainly in Europe. Routine maintenance may be higher than other categories, but the ease of repairing worn areas is an advantage. With periodic application of a rejuvenation coating, the floor may never have to be re-sanded back to bare timber in its lifetime. Hard wax oils are film forming and can have good durability. They may be one component or two component with an isocyanate cross-linker. Ease of application and timber colour enhancement are key properties. They can be 'asthma friendly' due to being low VOC and the particular types of VOC components used.

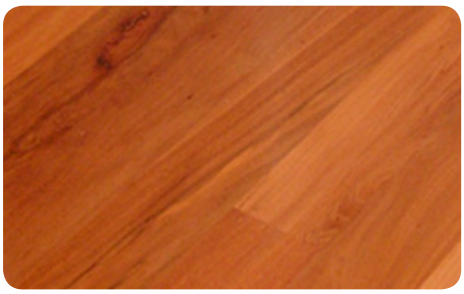


Figure 2.8: Penetrating oil.

2.4.2 Curing Oils and Alkyds

Curing oils are natural vegetable oil blends that harden (cure) by reacting with oxygen in the air. Curing is enhanced by the incorporation of metal 'dryers' such as cobalt and zinc that speed the slow hardening reaction with oxygen in the air. Contractors must take care as contaminated rags and sanding dust can spontaneously catch fire (these should be moved outside the building and damped down). These oils are film forming and are one of the earliest types of floor coatings. Good colour enhancement of the timber is a feature, but some types may be very slow when curing in cold weather. Buff burnishing of the oil into the surface can allow floors to be used soon after they have been coated. On-going maintenance is higher for curing oils than for other types of coatings.

Alkyds are based on the reaction of vegetable curing oils to a synthetic resin. This creates products with improved film build and gloss properties. As with the curing oils, they can be slow when curing in colder weather. Colour enhancement of timber is a key property as is ease of application. Alkyds are generally spirit or turpentine based with intermediate VOC levels.

2.4.3 Urethane-modified Oils

Urethane-modified oils are also commonly referred to as oil modified urethanes (OMUs). They are formed from the reaction of an oil with a urethane to form a copolymer, which is then dissolved in solvents. Properties vary depending on the ratio of oil to urethane. A higher oil ratio provides more flexibility but lower durability or wear resistance. Conversely, higher urethane content leads to a harder film and greater wear resistance. Use of these products has increased as they are more resistant to edge bonding than the moisture cure urethanes. They optimise timber colour enhancement. Wear resistance performance and maintenance and refurbishment requirements of these coatings are considered to be in-between those of the curing oils and polyurethanes. VOC levels are on the higher side; however, some water-based urethane modified oils are also available with low VOC levels. The water-based products provide reduced timber colour enhancement and may not have the durability of the solvent-based products.

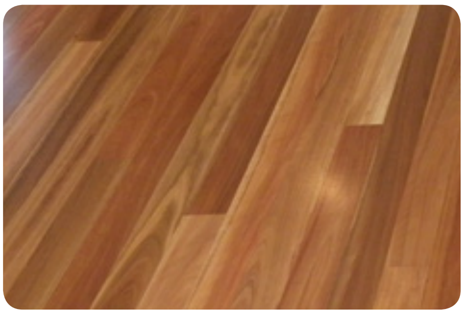


Figure 2.9: Oil-modified urethane.

2.4.4 Acid-catalysed Coatings

The principal use of this class of coatings is in furniture coating, although some use occurs with timber floors. The advantages are that they are fast drying and quick to reach initial cure, so multiple coats can be applied in the one day, but full curing takes some days. They produce a richer, darker colour in the coated timber and their rejection resistance is good. The main disadvantage is their very strong odour. Their high VOCs are mainly ethanol (ethyl alcohol).

Figure 2.10: Acid catalysed coating.

2.4.5 Polyurethane – Solvent-based

This class may be a one-pack moisture cure (MC) polyurethane where cure is achieved by a reaction of isocyanate with moisture in the air, or a two-pack product that uses a polyol component and a polyisocyanate component that react together when the two are mixed.

The solvent-based polyurethanes are the toughest and most hard wearing and have the highest gloss levels of all the classes of timber floor coatings. Their disadvantages can be an increased risk of edge bonding, high VOC and the need for particular care when using them, due to the fact that the isocyanate components of both types (and many water-borne cross linkers) are respiratory sensitisers.

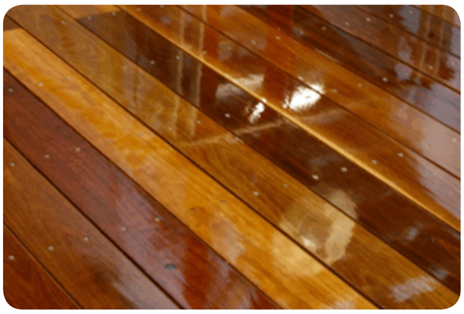


Figure 2.11: One pack solvent-based.

2.4.6 Polyurethane – Water-based

Water-based polyurethanes have the most diverse range of sub-categories.
The polymer bases used include:

- oil-modified urethane
- acrylic/polyurethane blends
- co-polymer acrylic-urethane
- 100% polyurethane.

Additionally, each group may be available in a one-pack or a two-pack. A few one-packs still feature a polyazeridine crosslinker, which is a class two carcinogen and care when using it is advised. Most two-packs use a polyisocyanate hardener, which also requires care in use.

On-floor performance (wear resistance or durability) can vary markedly within this class so care is required when selecting a particular finish. Two-pack types are generally superior to one-pack types in this regard. The Taber (wear resistance) test is a meaningful comparison test for wear resistance within this class. Key advantages are low solvent fumes (low VOCs) when they are being applied and the use of water to clean up tools. This leads to them being promoted as being less hazardous and less toxic. One-pack types are less hazardous to use than two-packs, as they do not use a hardener. They also have good edge bonding resistance. Disadvantages may include an increased tendency for application marks, and some products can develop ‘tram lining’ (a white stretch effect) at board edges as the floorboards expand and contract.

Figure 2.12: Water-based polyurethane.

2.4.7 Fast Dry Sealers

These high-solvent content sealers are usually based on a vinyl-type polymer combined with fast-drying solvents. Their intent is to seal the surface and the gaps between boards to reduce the tendency for following coatings to soak into the timber surface. They are generally used with solvent-based film forming coatings; some types can also be used under water-based coatings.

Advantages of using fast dry sealers include the ability to complete all the needed final coatings within the one day. Disadvantages can be a lower final coating film thickness than if all coats had been made with the final coating system, lighter-coated timber shades and a higher solvent fume hazard during use, due to their very high VOC content.

2.4.8 Quick Reference Guide

The following table is presented as a guide only. Performance of different coatings within the same class can vary markedly. Consult your coatings supplier for objective data on the product you may intend to use. Claims provided in writing by the supplier are always preferable.

Table 2.2: Timber floor coatings selection guide.

Technology and Property	Penetrating oil	Hard wax oil 1 and 2 component	Oil alkyd (e.g. Tung Oil)	Oil modified urethane	Acid catalysed coating	Solventborne moisture cured 1 pack polyurethane	Solventborne 2 pack polyurethane	Waterborne 1 pack polyurethane	Waterborne 2 pack polyurethane
Technical Properties									
Durability	Low - Med	Med	Low	Med	Med - High	High	High	Med	Med - High
Typical expected years to requiring a refurbishment coat in a more severe wear situation	1 - 2	1 - 6	3	4	4 - 5	6	6	4 - 6	5 - 6
Maintenance requirement - Care daily, weekly, monthly	Low - High	Low - High	Med	Medium	Low	Low	Low	Low	Low
Repairability of localised damage	Good	Good	Difficult	Difficult	Difficult	Very difficult	Very difficult	Difficult	Difficult
Earliest 'with care' use time @ 25°C	5 days	2 days	3 days	3 days	3 days	2 days	1 day	1 day	1 day
Earliest re-occupancy time @ 25°C	7 days	7 days	5 days	5 days	5 days	3 days	2 days	4 days	3 days
Ability to cure in cold and dry weather (non-burnished)	Low	Low	Medium	Medium	Good	Good	Good	Fair	Medium
Ability to cure in cold and damp weather (non-burnished)	Low	Low	Low	Low - Medium	Low - Medium	Medium	Good	Low	Medium
Rejection resistance (From surface tension)	Good	Good	V. Good	Good	V. Good	Fair	Fair	V. Good	V. Good
Edge Bonding resistance	V. Good	V. Good	V. Good	V. Good	Good	Poor	Poor	V. Good	Good
Timber colour impact	Darkens	Yellow / honey	Darkens	Darkens	Darkens	Yellow / honey	Yellow / honey	Natural / pale honey	Natural / pale honey
Tram lining	Nil	Nil	Nil	Low	Nil	Low	Low	High	Medium
Application marks resistance	High	Medium	High	Medium	High	High	High	Poor to Medium	Medium
U.V. yellowing resistance	Poor	Fair	Poor	Poor	Poor	Poor	Poor	Fair to Good	Good
Surface scuff resistance	Poor	Good	Poor	Poor	Good	Very Good	Very Good	Poor to Good	Good to v. good
Dust pimples from electrostatic attraction of dust to the coating	Low	Low	Low	Low	Low	Medium	High	Low	Low
Quilting resistance	V. Good	V. Good	V. Good	V. Good	V. Good	Poor	Medium	V. Good	V. Good
Grain raise effect on apply	Low	Low	Low	Low	Nil	Low	Low	Medium	Medium
External use	No	No	No	No	No	No	No	No	No
Safety, Health and Welfare (consulting the manufacturer's MSDS / SDS is essential)									
Odour – short term	Noticeable	Low	Medium	Medium	V. High	V. High	V. High	Low	Low - Medium
V.O.C. – solvent content – grams per litre	0 – 800	0 - 480	600 - 700	600 – 700	440 - 450	300 - 600	500 –550	35 – 190	85 - 190
Breathing equipment needed in use per MSDS	Cartridge type	Cartridge type	Cartridge type	Cartridge type	Cartridge type with daily change	Cartridge type with daily change	Cartridge type with daily change	No	Cartridge type
May contain a listed or suspect carcinogen	No	Suspect white spirits in some	Suspect white spirits	Suspect white spirits	Yes - Ethanol Class 2	Yes – TDI Class 2	Yes – TDI Class 2	No	Maybe if Part B is Polyazeridine - Class 2
Asthma and respiratory warning	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Flammability	Low - High	Low - High	Low	Low	High	V. High	V. High	Nil	Nil

3

Pre-installation Requirements

3.1 Storage and Handling Procedures

Site sanded and coated strip flooring should be delivered by the supplier with plastic wrapping (to top, sides and ends) in good condition to maintain the flooring at the appropriate moisture content. It is the floor installer's responsibility to check that the timber is at the appropriate moisture content at the time of installation, so flooring products must be protected from weather exposure and other sources of dampness.

Ideally, delivery during rain should be avoided and flooring should not be delivered to the site until it can be immediately stored under permanent cover. If this is not achievable, other precautions that are equally effective to prevent moisture uptake and excessive sun exposure will be needed.

Plastic wrapping is easily damaged and should not be relied upon to keep the flooring dry. If moisture penetrates the plastic or timber is stored over a moist surface, subsequent moisture uptake can result in significant swelling of some boards. Flooring should not be laid in this condition, as wide gaps at board edges may result as boards re-dry. Wrapped packs should also be protected from excessive sun exposure due to possible detrimental effects.

Prefinished strip flooring is often supplied in plastic-wrapped boxes and parquetry in cardboard boxes. These products should be stored inside the weather-tight dwelling in an area away from external walls and direct sun exposure. It is also important not to place these products directly on new concrete slabs.

Figure 3.1: Inappropriate site storage can void manufacturer warranties.

3.2 Timber Flooring Standards and Specifications

When timber flooring is received on site it should generally meet the following requirements:

- Grade – strip flooring and parquet (also refer to Section 6) are to be supplied to the specified grade, which may be a manufacturer's grade. Note that if a manufacturer has given a specific name to a grade, the product may be similar to one of the grades contained within an Australian Standard but is likely to differ in some respects. This may or may not be important to customers and should be resolved prior to supply. With imported product, grading applicable to the country of origin may apply and differ to that within the Australian Standard.
- Moisture content – should be in the range of 9% to 14% (10% to 15% for Cypress) with the average moisture content for all pieces approximately 10% to 12.5%. The moisture content range for parquet is 8% to 13%. For prefinished solid flooring, which is generally imported, the moisture content range should also be to this specification (refer to Section 7 for further information).
- Timber moisture contents should be checked and recorded. (Resistance moisture meter readings must be corrected for species and temperature, and may be affected by other factors. Corrected readings are estimates only. If in doubt confirm results by oven-dry tests.) Water marks or a significant variation in cover width within a board may be indicative that the timber has been moisture affected.

- Cover width of strip flooring should be checked and recorded – for strip flooring, solid and prefinished, not more than 1 mm difference between one board and another. Cover widths should generally be within ± 0.5 mm of the nominal cover width. (If in excess of this it can reflect changes to board dimensions that can occur after milling and prior to installation and therefore outside of manufacturing limits). Refer to Section 6 for parquetry.
- Boards should not be visibly cupped – the cupping allowance in Australian manufacturing standards for site sanded flooring prior to installation is 1 mm per 100 mm of board width and is to cater for drying stress effects. This allowance does not apply after sanding and nor does it apply to prefinished flooring.
- Tongue and groove tolerance in strip flooring – should not to be less than 0.3 mm nor greater than 0.6 mm. Boards should slot together to form a 'snug' fit. The fit should not be loose and sloppy or overly tight. A tighter tolerance may be applicable with prefinished flooring, particularly if edges are not bevelled.
- Undercut or relief in site sanded and coated floors – this is the difference between the upper and lower cover width of the boards. Generally, an undercut of about 0.5 mm is appropriate for an 80-mm-wide board and a little more as board width increases. If the undercut is large and there is significant expansion pressure after installation, 'peaking' (pressure-related cupping) can occur. The smaller the undercut, the less the effect. Note that imported product (both site sanded and coated and prefinished) has been supplied with undercut significantly wider than outlined here and, should peaking occur with such products, the manufacture of the product is often considered a contributing factor.

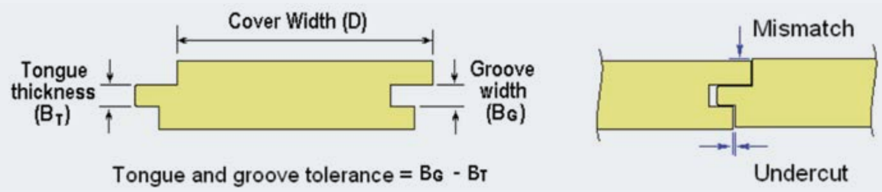


Figure 3.2: Tongue and groove tolerance.

Grading rules for Australian manufactured solid T&G strip flooring and parquetry are contained in the following Australian Standards:

- AS 2796 – Timber – Hardwood – Sawn and milled products
- AS 1810 – Timber – Seasoned Cypress pine – Milled products
- AS 4785 – Timber Softwood – Sawn and milled products

Any concerns relating to the above should be addressed prior to laying the floor. Although installers have a responsibility to check product prior to laying, suppliers have a responsibility to ensure product is adequately cared for, particularly during transport and storage, and manufacturers have a responsibility to supply product meeting the relevant manufacturing standard.

3.3 Borer Activity in Flooring

All flooring meeting the requirements of the Australian hardwood manufacturing Standard AS 2796 requires that any sapwood of lyctid-susceptible species is treated. Although lyctid attack is not common in Australian species due to treatment processes, some imported species including American and European Oak are lyctid susceptible and not all flooring is treated. Should lyctid attack occur in untreated flooring, the responsibility to address the problem lies with the importer or supplier.

Where T&G site sanded and coated Araucaria floors and floor framing are not fully enclosed, it is necessary to seal the framing members and lower surface of the floorboards to prevent attack from the Queensland pine beetle. Attack is specific to the Araucaria species (including Bunya) and is generally restricted to the area from Bundaberg to Murwillumbah and east of the Great Dividing Range. In this region, exposed framing and floors (including ventilated sub-floor spaces) require sealing to meet building requirements. The provided sealer needs to have a film-forming finish and this may also reduce the effects from rapid weather changes.

3.4 Evaluating Site Conditions and the Installation Environment

3.4.1 Why the Installation Environment Needs to be Considered

Solid timber flooring is manufactured to an average moisture content that is suited to the majority of building environments in the major capital cities throughout Australia. Due to this, the majority of floors perform with flooring laid as supplied by the manufacturer. However, a large number of timber floors are not laid under these average conditions, due to their location within Australia or conditions that differ from a 'normal' environment within a locality. It is therefore the installer's responsibility to assess the installation environment, as this will affect decisions as to whether the flooring needs acclimatisation prior to installation and the degree of expansion allowance that may be needed within the floor. Due to this, the nature of manufacture and the variations in moisture content that can occur through transport and storage, the floor installer needs to check both flooring moisture content and board widths upon accepting the flooring for laying.

3.4.2 Effect of Relative Humidity and Temperature on Floor Movement

Changes in the temperature and relative humidity within a building influence the seasonal movement (shrinkage and swelling) of timber floors. Relative humidity is a measure of the moisture vapour in the air at a particular temperature and will largely govern the seasonal moisture content range of the floor and therefore the seasonal movement. During more humid times of the year, floors absorb moisture from the air and swell, while during drier times with lower relative humidity some shrinkage can be expected. Consequently, as the moisture content changes so does the board width. Temperature is also important because in warmer climates the air holds more water vapour at a particular relative humidity, thereby making the flooring much quicker to respond. Therefore, floors in high temperature conditions will absorb moisture from the air or release moisture to the air much faster than those in low temperature conditions. The internal dwelling climate is also modified through the use of heating and cooling systems, and this too is an important aspect that influences the seasonal movement in a floor. The degree of heating and cooling is largely influenced by the locality. It also needs to be considered that different heating and cooling systems will affect floors differently. In addition, there are also significant differences that occur within a locality or region, such as conditions on the coast being quite different to those a few kilometres inland.

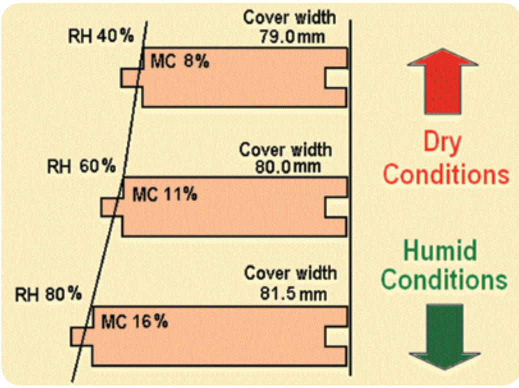


Figure 3.3: Indicative relationship between relative humidity, timber moisture content and board width.

It is therefore necessary that every site and the expected in-service environment is assessed for the floor to be able to perform to its optimum. Due to differing conditions throughout the country, installation practices have developed over many years in each state, and even within each state, to accommodate the specific climatic effects in that location. If the moisture content of the timber flooring is close to the average in-service moisture content, subsequent changes in temperature and humidity will only result in small changes in moisture content and therefore small changes in board dimensions.

It is important to know the climate in the area where a floor is being laid and then consider how the dwelling environment will be modified by heating and cooling systems. Additionally, as outlined above, it is important to note the conditions at installation, as the flooring will be more prone to movement (shrinkage or swelling) under higher temperatures. The external climate can be assessed from weather data taken at both 9 am and 3 pm.

Relative humidity data is available for Australia from the Australian Bureau of Meteorology (BOM) website at www.bom.gov.au/climate/data. Another useful international website is weatherspark.com, which provides relative humidity and other data. The relative humidity data on this site provides annual graphs of both daily maximum and minimum and includes Australia, New Zealand and worldwide locations, but it does not cover the same number of Australian weather stations as the BOM website.

Based on the humidity and temperature, the Equilibrium Moisture Content (EMC) can be determined. This can be thought of as the moisture content that timber will approach under set conditions of humidity and temperature. Seasonal changes in temperature and humidity influence the seasonal movement (shrinkage and swelling) of timber floors and therefore it is appropriate to consider a seasonal EMC range, being the seasonal in-service moisture content variation that the floor will experience. The following table provides EMC at a range of relative humidities and temperatures.

Table 3.1: EMC at various relative humidities and temperatures.

Equilibrim Moisture Content at various relative humidities and temperatures																				
Relative Humidity		5%	10%	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
Temperature	0 °C	1.4	2.6	3.7	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.4	11.3	12.4	13.5	14.9	16.5	18.5	21.0	24.3
	10°C	1.4	2.6	3.6	4.6	5.5	6.3	7.1	7.9	8.7	9.5	10.3	11.2	12.3	13.4	14.8	16.4	18.4	20.9	24.3
	20°C	1.3	2.5	3.6	4.5	5.4	6.2	7.0	7.7	8.5	9.3	10.1	11.0	12.0	13.1	14.5	16.0	18.0	20.5	23.9
	30°C	1.2	2.4	3.4	4.3	5.2	6.0	6.7	7.5	8.2	9.0	9.8	10.6	11.6	12.7	14.0	15.5	17.5	20.0	23.4
	40°C	1.1	2.2	3.2	4.1	5.0	5.7	6.4	7.1	7.9	8.6	9.4	10.2	11.1	12.2	13.4	15.0	16.8	19.3	22.7

Relative humidity and temperature graphs for the major capitals throughout Australia are provided in the following figures along with EMC values and comments regarding specific seasonal conditions. Relative humidity and temperature fluctuate significantly on a daily basis. With regard to timber floors, houses are more likely to be open during daylight hours and the internal environment will be more influenced by external conditions during these times. In view of this, these graphs have been generated by averaging the 9 am and 3 pm BOM data for each city. However, as will be discussed later, closing up a dwelling and using either heating or cooling systems will significantly influence internal conditions and often moderate them. It is evident that the climate profile is similar between certain cities and these have been grouped accordingly.

Brisbane and Sydney

The temperate climates of Brisbane and Sydney are summarised in the graphs below and in both locations the EMC is at a maximum in summer during the first six months of the year. Summer rainfall generally results in floor expansion during the first few months from January. During summer, with the warmer temperatures and higher humidities, dwellings are also often open and floors are more responsive to swelling. Drier westerly winds usually occur in mid-winter from August to October and, with rising temperatures and low afternoon relative humidity, the onset of seasonal shrinkage is initiated. This is particularly so in Brisbane, where temperatures are a little higher. Minimal winter heating is needed in Brisbane, but some is required in Sydney. Average in-service EMC is often 10% to 12% in both cities, with Sydney considered as being the more stable of the two climates.

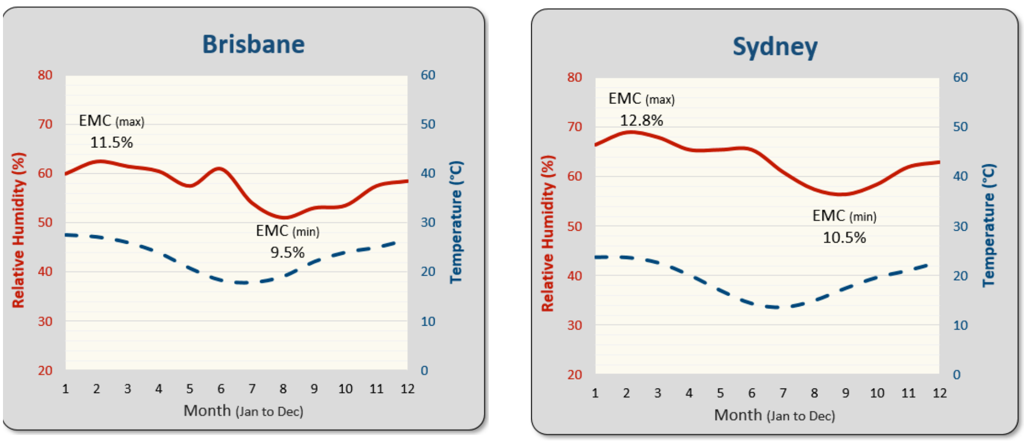


Figure 3.4: Brisbane and Sydney climate summaries.

Canberra, Melbourne and Hobart

The climate profiles of these three cities are similar, as summarised in the graphs below for Canberra and Melbourne, and they are considered as the colder southern climates. In these cities, the EMC is a maximum in the wetter winter months when temperatures are also a minimum, with Canberra experiencing temperatures a little lower than Melbourne. Due to cold winter temperatures, these cities use high levels of winter heating, which results in dry internal environments during the winter period even though external humidity is high. During summer, higher afternoon temperatures and very dry conditions can be experienced in Melbourne and Canberra, resulting in bushfire conditions. Due to winter heating, the average internal in-service EMC is often 9% to 12%.

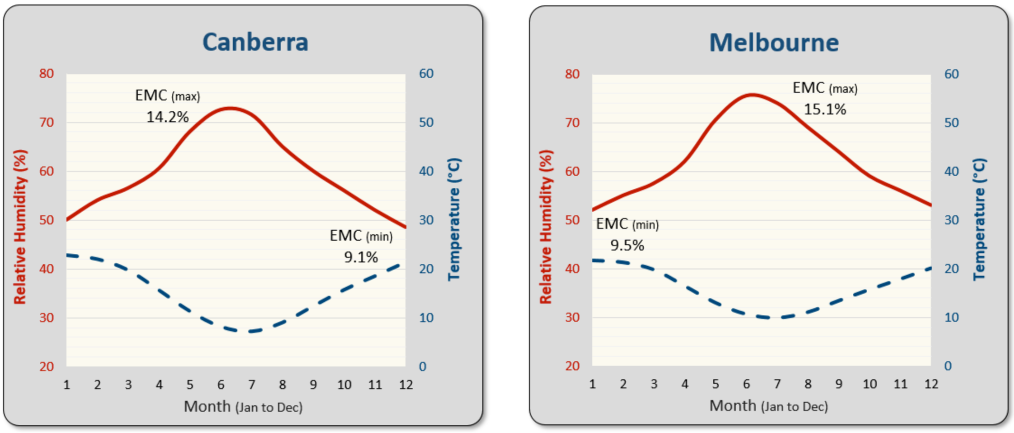


Figure 3.5: Canberra and Melbourne climate summaries.

Adelaide and Perth

Although there is considerable distance between these two cities, their climates have similarities. The climate profiles are similar in shape to that of Melbourne, but the average temperatures are higher and humidity is lower, as shown in the graphs below. In these cities, the EMC is similarly a maximum in the wetter winter when temperatures are a minimum. As such, some winter heating is used in these cities, but not to the degree used in Melbourne and Canberra. In summer, both cities can experience very hot dry conditions and low humidity conditions. During these times, bushfire conditions can be experienced. The internal in-service EMC is often 9% to 11% in Adelaide and 10% to 12% in Perth. The coastal winds and more moderate winter temperatures in Perth result in the EMC range being a little higher.

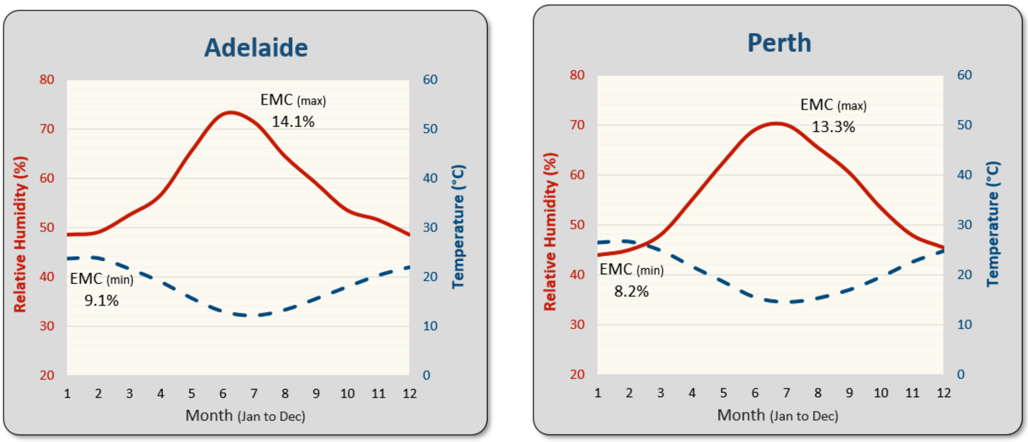


Figure 3.6: Adelaide and Perth climate summaries.

Although external conditions influence seasonal floor movement, the conditions within a dwelling are also moderated with heating and cooling used to achieve a comfortable living space and, as indicated above, internal EMC is generally between about 9% and 12% in the main city centres, which is indicative of relative humidity within dwellings of about 45% to 65%. However, within this range, floors are generally more prone to shrinkage in cities with drier internal environments (e.g. Adelaide and Canberra) and more prone to some swelling in warmer more humid cities (e.g. Brisbane).

Other Australian climates

Tropical and inland locations differ significantly to the main populated cities to the south of Brisbane. Provided below are the graphs for Cairns and Darwin. In both localities, temperatures remain significantly higher throughout the year compared to the main capital cities. In Cairns, humidity remains at higher levels for the first half of the year and, due to building practices in this area (floors often over open sub-floor spaces), the average in-service EMC is between 13% and 14%. In Darwin, there are few solid timber floors, reflecting the difficulty for timber floors in that climate. Again, temperatures remain high throughout the year causing timber flooring to be very responsive to moisture content change. The seasonal variation in humidity is much more severe in Darwin than Cairns and the resulting high levels of seasonal movement are difficult to satisfactorily accommodate. Both locations have distinct wet and dry seasons with large amounts of rainfall during the wet season over summer.

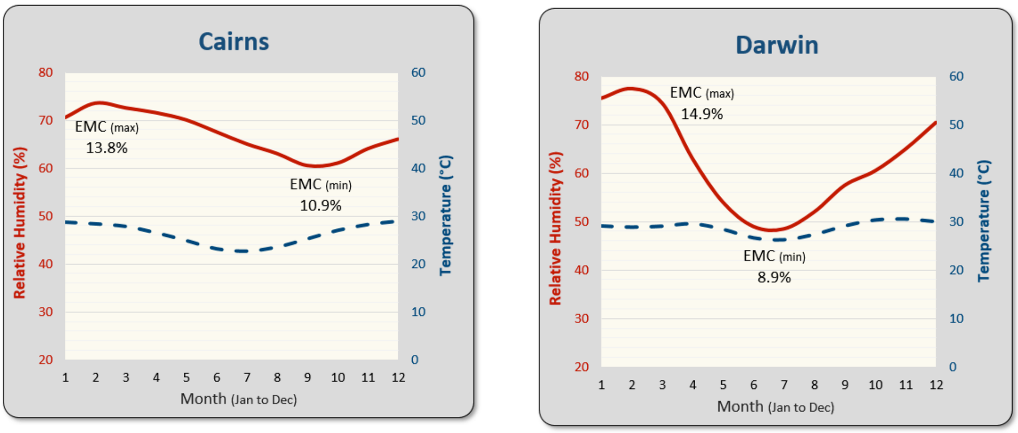


Figure 3.7: Cairns and Darwin climate summaries.

In contrast to this are the dry inland regions, and the graph provided for Mt Isa illustrates the seasonal EMC range varying from low to very low in the latter part of the year. Associated with this are moderate to high temperatures year round and characteristically very little rainfall.

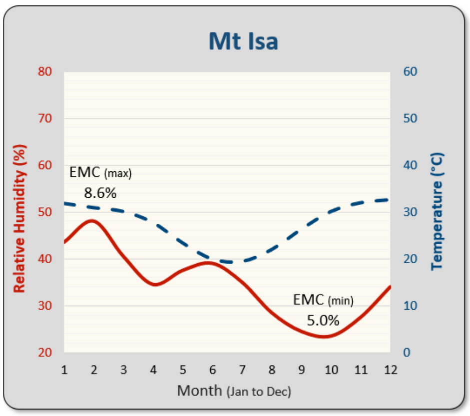


Figure 3.8: Mt Isa climate summary.

These examples of tropical regions and an inland locality serve to emphasise the extremes that occur in Australia. Again, there a limited number of timber floors in locations such as Mount Isa, but there are many timber floors from Brisbane and further north to Cairns.

It is important that, when laying timber floors in Australia, due consideration is given to the variances that occur. This should particularly include dwellings that tend to be naturally ventilated and require less heating or cooling, or floors that are exposed beneath – as external conditions can have a greater effect on seasonal floor movement.

It is evident from these graphs that both the humidity and temperature of the locality will affect the degree of heating and cooling, and that this in turn has a significant effect on moderating the internal environment and resulting in floors that perform well.

It is also evident from these graphs that the climate may result in moisture content that can be either higher or lower than the average moisture content of the flooring that has been supplied. Many manufacturers in Australia target a moisture content of between 10% and 11% to suit the in-service EMC of the capital cities. Some manufacturers selling to the tropical areas may target a moisture content that is a little higher, up to about 12.5%. It is due to these significant differences in the in-service EMC, occurring throughout Australia, that acclimatisation (covered in a latter section) or additional expansion allowance may be necessary for floors to perform.

New Zealand

In New Zealand, climate data is available from the website www.weatherspark.com, which provides both mean maximum and mean minimum relative humidity and temperature information. The data differs to that available for Australia, but through interpolating the data similar graphs can be generated to those above and can be used for general comparative purposes. Graphs have been provided for Auckland, Wellington and Christchurch. These indicate the New Zealand climate experiences cold winters and cool summers with winter heating the norm for longer periods. Relative humidity generally remains relatively high throughout the year when compared to the cooler winter climate of Australia cities that experience dry hot summers. New Zealand's main populated areas do not experience the hotter tropical weather or the extremes of dry inland climates within Australia. Therefore, buildings have moderate heating and cooling and floor moisture contents are often in the range from 9% to 12%.

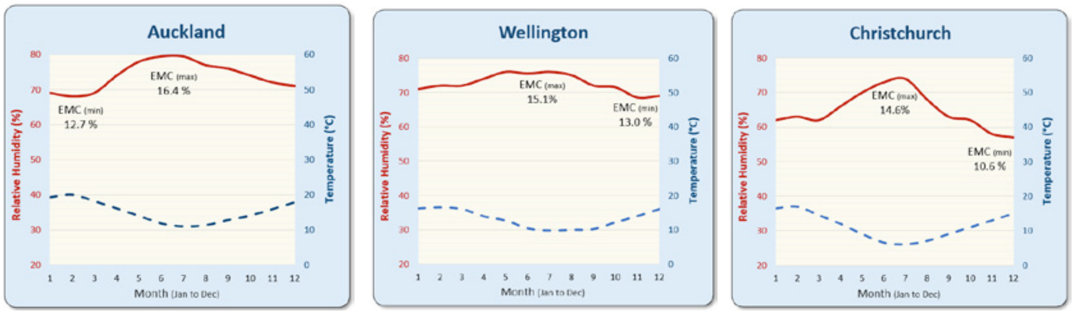


Figure 3.9: Auckland, Wellington and Christchurch climate summaries.

3.4.4 Climatic Variations within a Locality

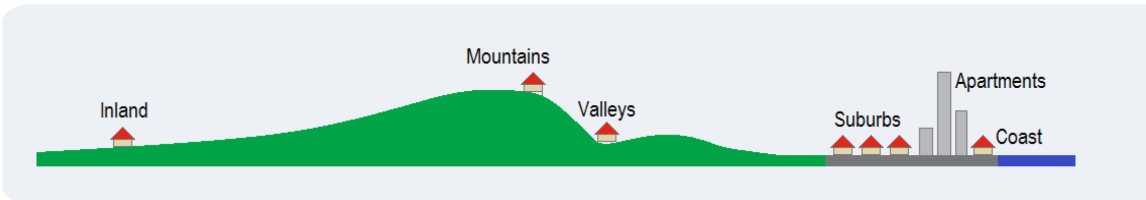


Figure 3.10: Dwellings in different geographic regions.

It is also important to understand that within a locality there are going to be geographic differences between one dwelling and another. This is best explained with reference to the figure above showing dwellings that are on the coast, in suburban environments, and also in valley, mountain and inland areas. This is indicative of the types of geographic differences that can occur. Similar principles can be applied to specific locations within the country.

This example illustrates how the foreshore has cool sea breezes that often prevail, causing lower afternoon temperatures and higher afternoon humidity. In such locations, internal EMC may range from 12% to 13% with natural ventilation more likely. Apartments along the coastal fringe may be similar, if naturally ventilated, although many have controlled cooling systems and therefore internal EMCs may be 9% to 11%. In the suburbs, there are many roads and closely spaced houses. Roads heat up and rainwater is quickly drained away from roofs and roads. As such, internal conditions are usually drier than on the coastal fringe and may be 10% to 11%. The valley environment often has more open land and trees that hold moisture and there is greater shading of the dwelling. This may result in internal EMCs of 12% to 16%. Houses elevated on the likes of escarpments can be prone to periods of lower temperatures due to the height and higher humidity, and more rain and mist, yet at other times of the year they are subject to dry winds. Houses may also be open beneath. Consequently, quite variable seasonal conditions can occur and internal EMCs could vary from 11% to 16%. Further inland, the effects of dry winds and moderate rain may see internal EMCs range from 9% to 12%.

3.4.5 The Effects of Heating and Cooling Systems

Heating systems vary considerably and include wood fires, heat pumps and convection and radiant heating. In addition, some dwellings have underfloor heating (refer to Appendix E). As a result, the intensity from the different heat sources will also vary. Heating systems are generally used when external conditions are cold and external humidity is naturally high.

The effect of heating the air within a dwelling reduces the relative humidity in the room significantly. For example, if the air temperature outside is 8°C with an external EMC of 18%, then heating raises the internal temperature to 18°C and will cause the internal EMC to be reduced to about 8%. There are many factors in this, such as hot air rising and heating only being used for part of the day, but it is also the reason why heating in cold climates results in dry internal environments at that time of the year.

Therefore, heating to maintain comfortable living conditions within the dwelling generally serves to moderate internal conditions to be within the acceptable range for timber floors. Excessive heating and high localised heat sources from, for example, wood heaters can cause significant localised shrinkage and when this occurs it is often the result of the choice of heating system and how it is operated by the owner. The flooring simply reflects the conditions it is exposed to.

Figure 3.11: Intense heating sources can cause localised shrinkage.

The two common types of air conditioning used in domestic housing are refrigerative (often referred to as reverse cycle, ducted or split system) and evaporative. Air conditioning is primarily used to lower the temperature in the building to more comfortable levels but it also has an effect on air humidity. The diagram illustrates how each can influence the relative humidity inside a dwelling. The refrigerative air conditioner extracts moisture from the air and this lowers the humidity. On the other hand, evaporative air conditioning puts cool moist air into the dwelling and increases the humidity.

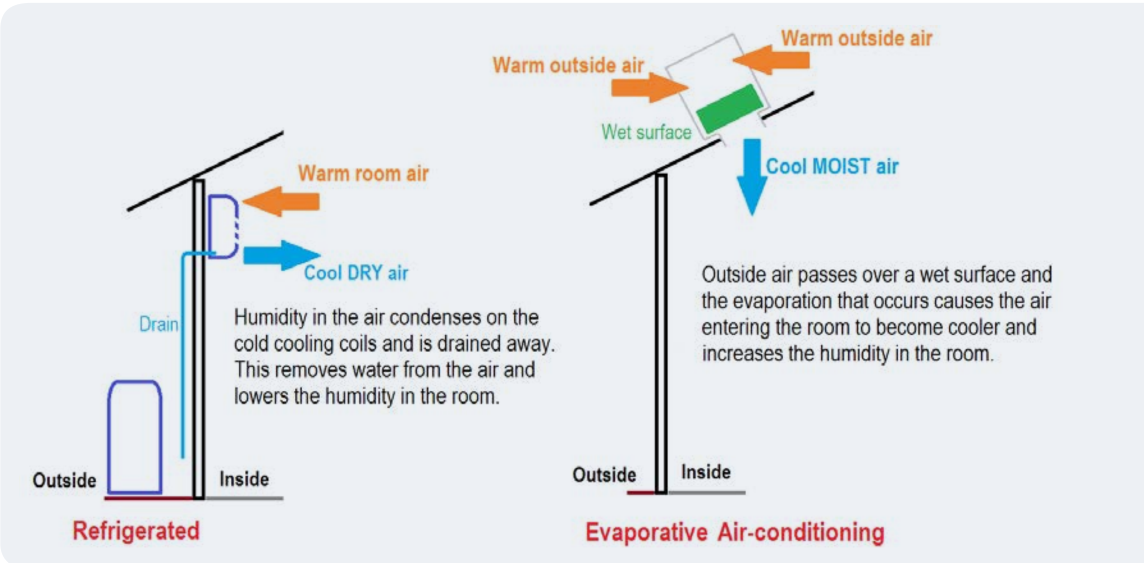


Figure 3.12: Influence of air conditioning on relative humidity inside a dwelling.

It needs to be recognised that air-conditioning is often partly countering more extreme conditions occurring outside the dwelling. Refrigerative air conditioners work well in warmer humid conditions; therefore humidity is often higher outside when lower humidity inside the dwelling can be beneficial. Evaporative air conditioning works well in hot dry conditions and some moisture added to a dry internal environment can also be of benefit. With evaporative air conditioning, it is necessary to leave some windows partly open so that the fresh air entering the dwelling can expel the warmer air present. The key is really to maintain a balance between both of these systems to provide a comfortable internal living environment. That is, cooling when necessary and relying on natural ventilation at other times of the day.

Therefore, in domestic applications air conditioning is not generally used throughout the whole year but is used to moderate the internal environment from more extreme conditions occurring outside at the time. When used in this manner, no concerns from air conditioning use generally arise with timber floors. When the occasional concern does occur, it often relates to more extreme and prolonged use of air-conditioning systems causing overly dry or overly moist conditions in the dwelling, depending on the air-conditioning system used. However, with intermittent use of air conditioning, the effects are generally relatively small and floors perform well, but solid timber floors may gap at board edges a little or tighten up a little, again depending on the air-conditioning system used.

Where excessive use of air conditioning has caused concerns with a floor, it is considered that the owner has contributed to their concerns. This, however, differs from flooring that may have been installed at too high a moisture content and where refrigerative air conditioning has promoted more rapid shrinkage. A check on the moisture content of the boards and width measurements of the floor and boards can be used to provide guidance on the cause.

Even if a dwelling may be air conditioned or is going to be air conditioned, it is the average in-service moisture content throughout the year that must be considered, and that use of the cooling equipment often moderates internal conditions from the more extreme conditions outside the dwelling. In buildings that generally use refrigerative air conditioning throughout much of the day for five or seven days a week, it can be necessary to acclimatise the flooring prior to installation to minimise shrinkage effects (see Section 3.7).

Figure 3.13: In warm climates these units are referred to as reverse cycle split system refrigerative air conditioners. In cold climates such as New Zealand they are referred to as heat pumps.

3.4.6 Other Building Considerations that Affect Floor Movement and Performance

In addition to the many different location factors and heating and cooling options, the dwelling design can also influence seasonal movement (shrinkage and swelling) of the floor. Dwellings or buildings with large glassed windows can be subject to high degrees of sunlight. The resulting higher temperatures and lower internal humidity can result in localised shrinkage in the floor, particularly where it is sun exposed. Window tinting or low emissivity glass should be used to minimise the effects from direct sunlight on the floor.

Figure 3.14: Window tinting or low emissivity glass should be considered with floor to ceiling windows to reduce shrinkage effects from direct sun.

In two-storey houses, the upper level can be hotter in summer and cooler in winter than the lower level. Consequently, seasonal movement can differ between levels, with the upper level more prone to seasonal shrinkage gaps. Some studies have shown that the EMC on the upper level of a two-storey house was about 2% lower, therefore the floorboards on the upper level would be under less pressure and narrower than the lower-level floorboards and may show some gapping, whereas on the lower level board joints may be tight.

Although now less common, with T&G site sanded and coated timber floors that are laid directly onto joists and where the house is open underneath it needs to be considered that the underside of the floor is directly exposed to external conditions. In some locations, and particularly on sloping land and escarpments, this can cause the underside of the floor to be exposed to very dry winds or wind-blown rain or fog. This can result in either extreme shrinkage or extreme swelling. In the latter case, the floor may lift off the joists and structural damage to the building may occur. Also, where there is little restriction to the prevailing wind, floors can react more rapidly to dry winds. The species used in the floor and board cover width affect the rate of movement and shrinkage that occurs. Depending on the severity of the exposure, options to protect the floor include providing an oil-based sealer to the underside of the floor, which may provide short duration protection to changes in weather, and installing a vapour resistant lining to the underside of the joists or building-in the underfloor space.

3.5 Sub-floor Ventilation

Many dwellings are 'bricked' in or enclosed around their perimeter and a lack of sufficient ventilation can result in high humidity in the sub-floor space. Inadequate ventilation and a ground surface that does not remain dry can also result in severe expansion and cupping of floorboards.

Quoted figures for sub-floor ventilation are based on sub-floor spaces that are not subjected to seepage or where ventilation through the sub-floor space is inhibited. Where humidity remains constantly high beneath a floor, coatings to the underside of the boards will not reduce the moisture uptake into the flooring. The sub-floor being dry and well-ventilated is generally a builder's or home owner's responsibility and, if necessary, needs to be corrected prior to floor installation. Failure to attend to this has resulted in a significant number of poor-performing or failing floors.

Therefore, when the lower surface of timber floors or structural sub-floors (over which a timber floor is laid) are exposed to the ground and the space is enclosed (by brickwork, etc) the sub-floor space must be adequately ventilated with permanent vents installed in the masonry during construction. In existing dwellings where a floor may be replaced, these requirements are also necessary and therefore some additional work may be required by the owner.

Figure 3.15: A dry sub-floor space and adequate ventilation is essential for floor performance.

The humidity in an enclosed sub-floor space can have a profound effect on the performance of a floor. If conditions are very moist, the lower surface of the boards may take up moisture, causing substantial swelling. Differential movement between the upper and lower surfaces of floorboards may also cause boards to cup. Similarly, caution needs to be exercised with timber floors laid in areas where the microclimate is often moist. In such locations, the floor may reach higher moisture contents than in other nearby areas and additional allowance for expansion of the floor may be required. Timber floors are not to be laid over enclosed moist sub-floor spaces, and structural sub-floors (e.g. plywood) cannot be relied upon to prevent moisture uptake in the T&G flooring if humidity in the sub-floor space remain high for extended periods. The floor installer has a responsibility to check that the sub-floor space is dry and adequately ventilated for both new floors and replacement floors to existing dwellings. When these aspects are not adequate, the builder or home owner is generally responsible for remedial works and the floor should not be laid until attended to.

3.5.1 Ventilation Requirements in Australia

Site sanded and coated solid floors in Australia should be provided with sub-floor ventilation that exceeds minimum National Construction Code (NCC) requirements. The levels outlined in the NCC (currently limited to 6,000 mm^2 per metre length of wall for higher humidity areas) are primarily to limit the moisture content of sub-floor framing timbers, which can generally tolerate greater fluctuations in moisture content than timber floors. The recommended minimum ventilation for T&G timber floors is 7,500 mm^2 per metre length of wall, with vents evenly spaced to ensure that cross ventilation is provided to all sub-floor areas (see Figure 3.16).

In some localities, it may be decided to reduce ventilation levels to the values provided in the NCC to meet constraints associated with energy efficiency. The NCC also outlines that a moisture membrane over the soil beneath the building reduces ventilation requirements and this approach is equally applicable to timber floors. If ventilation below the recommended level is used, due consideration should be given to alternative measures as outlined above and particular attention should be paid to ensuring that the sub-floor space remains dry throughout all seasons. The type of vent may need to be considered with buildings in bushfire areas, which limits the mesh size used in vents. Some commercially available vents of various types and their dimensions, net ventilation area and required spacing are illustrated in Table 3.2, for coastal Zone 3. NCC relative humidity zones and associated NCC ventilation requirements are also provided below. It should be noted that the maximum vent spacing irrespective of net ventilation area is 2 m and that any screens that may be necessary in bushfire areas or for vermin proofing may restrict airflow, and this may need to be compensated for.

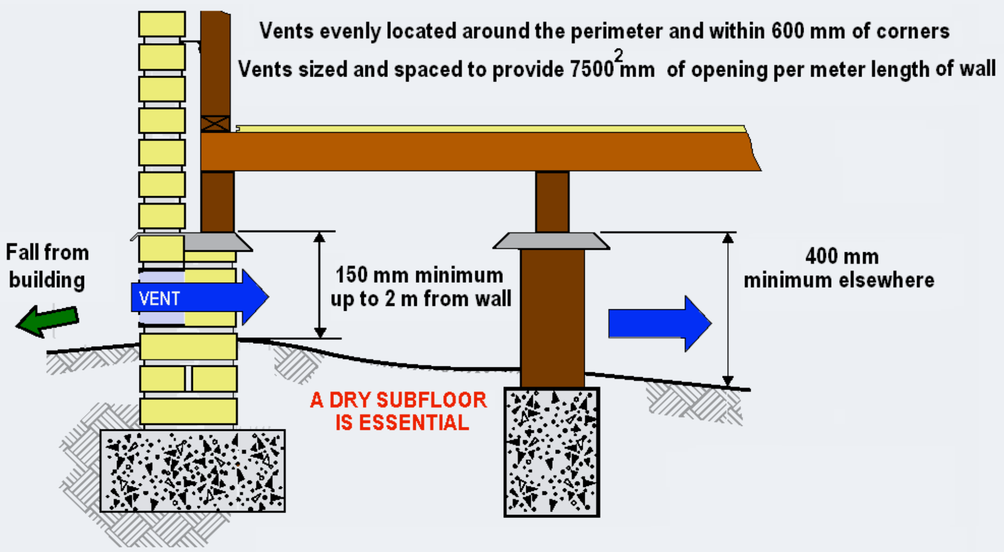
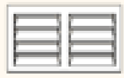
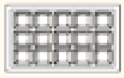
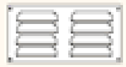
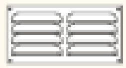
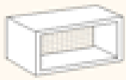
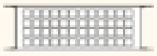


Figure 3.16: Cross ventilation must be provided to sub-floor areas.

Table 3.2: Some available vent types and specifications for coastal Zone 3.

Vent Type and Specifications				Nett Ventilation Area Provided per Vent (mm²)	Maximum Vent Spacing (mm)	
Material	Diagram	Vent size	Vent Pattern		ZONE 3 NCC Requirements (6000mm²/m) No-membrane	T&G Flooring Requirements (7500mm²/m)
Clay		160 x 230	8 slots each 75 mm x 8 mm	4800	800	640
Clay		160 x 230	15 holes each 16 mm x 16 mm	3840	640	512
Metal		200 x 400	8 slots 10 slots each 100 mm x 8 mm	5900 7400	983 1233	787 987
Metal		200 x 400	8 slots 10 slots each 175 mm x 8 mm	10700 13360	1783 2000	1427 1781
Block		200 x 400	1 slot each 310 mm x 110 mm	34000	2000	2000
Gradwell Cast Aluminium Air Vent		9" x 6" (230 x 160)	4 slots each 195 mm x 10 mm	7800	1300	1040
Pryda Vent Pryda Vent		230 x 75 230 x 165	52 holes 117 holes each 11 mm x 11 mm	6292 14157	1049 2360	839 1888
Pryda Slim Vent (GVS90) Pryda Slim Vent (GVS90H)		250 x 90 130 x 90	12 slots 6 slots each 110 mm x 8 mm	10560 5280	1760 880	1408 704

3.5.2 Ventilation Efficiency and Site Drainage in Australia

The sub-floor space must be free from all building debris and vegetation. Obstacles that prevent airflow to and from vents will reduce the efficiency of the sub-floor ventilation system. Landscaping should not limit airflow around the external perimeter of the sub-floor space, and structural elements should not limit air-flow. Vents should be installed in the masonry course below floor bearers, and should not be obscured by engaged piers or piers/stumps/columns that support the floor structure, or by any services present. Where external structures (fences, etc) or landscape may reduce airflow, consideration should be given to the use of more than the minimum number of vents. Figure 3.17 shows the NCC requirements.

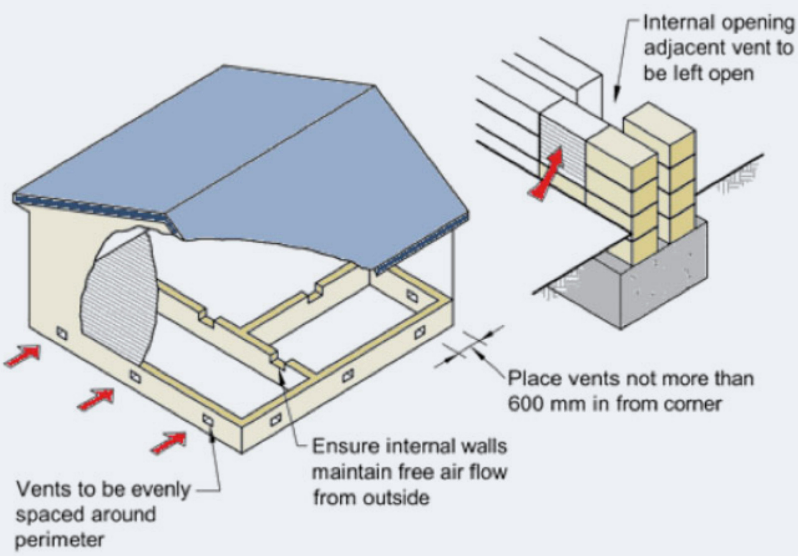


Figure 3.17: NCC requirements. Source: NCC 2015 Vol 2

Where verandas or decks are constructed outside the dwelling perimeter, care should be taken to ensure that the amount of ventilation provided around the veranda or deck perimeter is equivalent to or greater than the amount required for the adjacent external wall. Where ventilation is obstructed by patios, etc, additional ventilation should be provided to ensure that the overall level of ventilation is maintained and crossflow is achieved.

If adequate natural ventilation cannot be provided to sub-floor spaces, a mechanical ventilation system should be installed that replaces all of the air in this space on a regular basis, preventing the formation of 'dead-air' pockets.

If there are doubts over the sub-floor humidity (areas of high water table, reduced airflow due to minimum clearances between the sub-floor framing and ground, external structures, etc) a polyethylene membrane laid over the soil should be considered (taped at joints and fixed to stumps and walls). As discussed above, this can significantly reduce moisture uptake by the sub-floor air. Increased levels of ventilation should also be considered in such instances. With dwellings on sloping blocks that have enclosed sub-floor spaces, the possibility of seepage should be considered and appropriate control measures taken prior to the installation of the floor. The drainage system provided to the dwelling site is also to ensure that run-off water will drain away from the building perimeter (not towards it) and that run-off water is prevented from entering the sub-floor space.

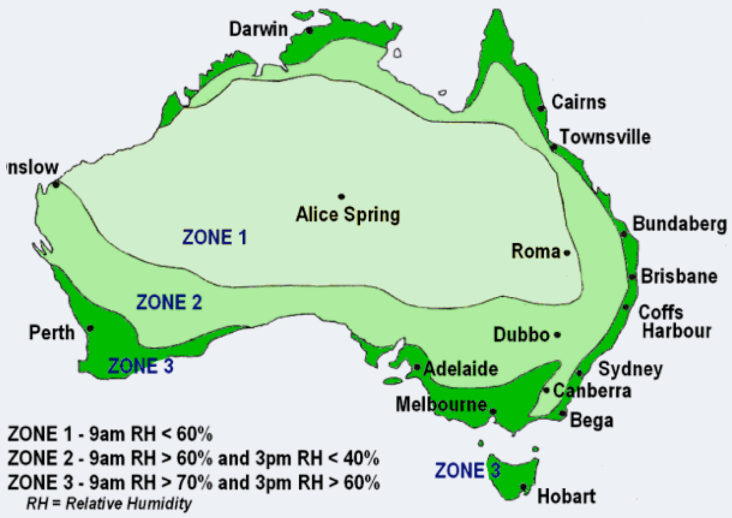


Figure 3.18: Climatic zones based on relative humidity. Source: NCC 2015 Vol 2

NCC Sub-floor Ventilation Requirements CLIMATE ZONE, CONDITIONS & SELECTED LOCATIONS		Min. Sub-Floor Ventilation mm²/m of wall	
		No membrane	Ground sealed with impervious membrane
1	Average 9am RH < 60%	2000	1000
2	Average 9am RH > 60% and 3pm RH < 40%	4000	2000
3	Average 9am RH > 70% and 3pm RH < 60%	6000	3000

Figure 3.19: NCC sub-floor ventilations requirements.

Figure 3.20: For frequently damp soil conditions, the sub-floor ground level can be raised with crusher dust and a polyethylene membrane laid over it.

The ground beneath a suspended floor should also be graded so that no ponding is possible. Where springs or aquifers are present (e.g. exposed by earthworks on sloping sites) and cause water to enter the sub-floor space, a closed drainage system should be installed under the dwelling to remove this water. The ventilation system will not cope with this level of moisture in the sub-floor space.

3.5.3 Ventilation Requirements in New Zealand

Site sanded and coated solid floors in New Zealand should be provided with sub-floor ventilation that meets the New Zealand Building Code. With sub-floor ventilation a balance with insulation requirements also needs to be considered, as too much ventilation can lead to unwanted heat loss. Vents to enclosed sub-floor spaces should be within 750 mm of corners, evenly spaced between and up to 1.8 m apart. The ventilation requirement is 3,500 mm^2 for each square metre of floor area.

Therefore, a building with 120 m^2 floor area would require 120 x 3,500 = 420,000 mm^2 of open vent area. If the building is 10 m x 12 m then install vents no more than 750 mm from corners and spacing up to 1.8 m, each 10 m long walls would require six vents and the 12 m walls require seven vents. The total number of vents is 26 and each vent would need a clear opening of 16,150 mm^2, which is a little over 160 x 100 mm for each vent.

Soil vapour barriers may also be used to reduce soil moisture evaporation into the sub-floor space.

3.6 Considering the Likely Movement After Installation

As outlined above, timber is a natural product that responds to changes in weather conditions with seasonal humidity and temperature changes in the air, causing boards to shrink and swell at different times throughout the year. Similarly, both heating and cooling systems have a significant effect on floor movement and often moderate the more severe conditions outside.

The overall movement occurring in individual boards and the rate of movement will depend on the timber species and growth ring orientation. Small differences in moisture content between boards at the time of manufacture (noting that a 5% range is normally allowed by applicable standards) and variable conditions within the house (e.g. westerly facing room compared to southerly facing) will also cause further variation in board width. Consequently, it can be expected that small gaps will occur at the edges of most boards, particularly during the drier months, and that the actual gap sizes may differ across a floor. In cases where shrinkage occurs after installation, wider boards (e.g. 130 mm) will result in larger gap sizes at board edges than if narrower boards are used.

Some movement usually occurs in timber floors after laying as the floor adjusts to the internal climate and, although floor finishes may retard moisture content changes, they will not prevent this movement. With prefinished flooring, the coating to the upper board surface (multiple coats of UV-cured urethane) is often less permeable than the single coating provided to the lower board surface. Moisture uptake is not even through top and bottom face and care is needed as moisture differential can induce cupping. In applications where greater movement is expected (e.g. from seasonal changes, use of wide boards, more prolonged air-conditioning use), particular care is necessary after finishing site coated floors to ensure that the finish does not act as an adhesive and bond a number of adjacent boards together. This is known as edge bonding and, with subsequent shrinkage, wide gaps between groups of two to eight or so boards may occur or boards may split.

Figure 3.21: Edge bonding can result in wide irregularly spaced gaps at board edges and split boards within the floor.

The way different timber species respond in a floor depends on their moisture content and also on the rate at which they take up and lose moisture, the associated movement and their density. High-density species are extremely strong and those that take up or lose moisture more quickly (such as Blackbutt) will also follow seasonal moisture changes more closely than slower responding species (such as Spotted Gum). Particular care is necessary to be able to accommodate expansion of the higher density species, particularly in warm humid localities. This may necessitate providing small expansion gaps every 6 to 10 boards during installation, in addition to normal expansion allowances, to accommodate this movement. Lower density hardwoods (e.g. Tasmanian Oak, Victorian Ash) and softwoods will, to a large extent, compress at their edges when a floor expands. With these timbers, normal expansion allowance is generally able to accommodate the expansion in more humid climates.

3.7 Installation Moisture Content and Acclimatisation of Strip Flooring

The moisture content of timber is the percentage weight of water present in the timber compared to the weight of timber with all water removed. As previously discussed, moisture content varies with changes in the humidity and temperature in the surrounding air. To minimise the movement of a floor, swelling on moisture uptake and shrinkage on moisture loss due to changes in moisture content, it is important to lay and fix timber floors close to the average in-service moisture content. This can at times be difficult to estimate. Timber flooring is usually supplied at an average moisture content between 10% and 12.5% and most boards can be expected to be within a few per cent of the average. Where the average supplied moisture content of the flooring is near the expected average in-service moisture content, acclimatisation is not necessary.

In areas where higher average moisture conditions persist and where floors are expected to have higher moisture contents, additional allowance should be made for subsequent expansion. Such areas include tropical North Queensland and northern New South Wales, areas of dense bush land, shaded gullies and forested locations, particularly at higher elevations and mountain areas.

Figure 3.22: Acclimatisation can be effective if product MCs and in-service conditions are known.

Installation methods need to be considered to accommodate the difference between the average moisture content on delivery and the average expected in-service moisture content. These can include either providing additional intermediate expansion joints or acclimatising the flooring.

Acclimatisation is simply a process of getting the moisture content of the flooring closer to its expected in-service moisture content, so that shrinkage or swelling of the floorboards will be less after installation. Increasing the average moisture content of the flooring supplied will only be effective if the humidity in the air is sufficient to cause moisture uptake. Care must also be exercised as the rate of moisture uptake differs from species to species. Some higher density species are very slow to take up moisture from the air (e.g. Spotted Gum) while others react more quickly (e.g. Blackbutt and Brush Box). If flooring is to be laid in a dry environment such as western New South Wales or a consistently air-conditioned building, acclimatisation can be effective in reducing the average moisture content of the flooring prior to laying and thereby reducing gap sizes at board edges from board shrinkage. In such climates, future expansion of the floor must be allowed for to accommodate periods of wet weather.

Acclimatisation relies on each board being exposed to the in-service atmosphere, so packs must be opened up and restacked to allow airflow between each board. Acclimatisation can only be effective in an air-conditioned building if the air conditioning is operating at the time or in dry localities during drier periods. The species and period for which it is acclimatised will also influence effectiveness. For some higher density species that are slow to lose or take up moisture, acclimatising may have little effect. Acclimatisation in dry climates does not negate the need to provide for floor expansion during periods of wet weather.

A simple guide to pre-installation considerations is provided in Figure 3.23, which should be referred to in conjunction with the preceding text. Note that, with prefinished strip flooring, some manufactures may have further advice regarding acclimatisation due to coating permeability and tolerance considerations. Also, manufacturers of thinner site sanded and coated overlay flooring often recommend not to acclimatise this thinner floor but to allow it to adjust to the internal conditions for a period after laying and prior to sanding and coating.

Figure 3.23: A guide to pre-installation considerations.

To acclimatise flooring, it is necessary to have the equipment to monitor both the moisture content of the flooring as well as the measuring equipment to assess the change in board width. Some will place 10 short boards together during the acclimatisation period. The average moisture content over the 10 boards (from 10 individual readings) is determined along with the total dimension over the 10 boards. This enables the movement resulting from moisture uptake or loss during the acclimatisation period to be more easily assessed. Moisture uptake is applicable if laying in a humid environment and desiring to increase the average board width prior to laying, and moisture loss is applicable if desiring to pre-shrink the flooring in a dry environment prior to laying. Note that an 80-mm-wide board will shrink or swell by about 0.25 mm for each 1% change in moisture content (proportionately increased for wider boards). Therefore, if the measurement over 10 boards increased during the acclimatisation period from 800 mm to 807 mm then this would reflect about a 3% increase in moisture content that should also be reflected by an increase in the average of the moisture content readings over the 10 boards.

With reference to Figure 3.24, the flooring may have been supplied at an average moisture content of 10% and the desired installation moisture content may be 15%. After a few weeks of acclimatisation, the average moisture content may have increased to 13%. This would be considered sufficiently close to the desired installation moisture content to lay the floor, as the average moisture content is just 2% away from the desired moisture content and not 5% as initially supplied. Also, on average each board would have increased in cover width by 0.7 mm prior to laying. But again it is important to note that acclimatisation does not negate the need to install appropriate expansion allowance. If the moisture content range of the flooring to be acclimatised is too wide (including from poor drying) then the acclimatisation process will result in widely variable board widths. Similarly, with wide boards the variation in board width at the conclusion of acclimatisation can be greater and also with wide boards there will be a greater tendency for board ends to be wider with moisture content increase (or narrower with moisture content decrease) than the centre of the board. Due to this, the provision of additional expansion allowance at installation may be preferred.

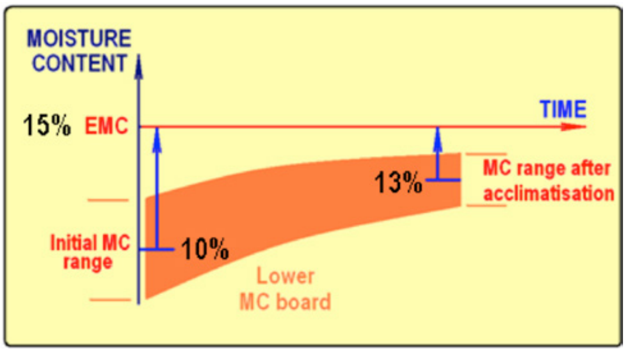


Figure 3.24: Acclimatisation example.

4

Site Sanded T&G Floor Installation: Timber and Sheet Sub-floors

4.1 Installation Practice and Products

This section outlines the recommended practices for laying site sanded and coated timber strip floors over timber and engineered timber joists (it does not include steel joists), structural sub-floors such as plywood and particleboard and over concrete, but does not include direct adhesive fix to slabs, which is provided for in Section 5. The fixing of parquetry is covered in Section 6 and prefinished timber strip floors is covered in Section 7. Note that New Zealand practices may vary to a degree with regard to thickness of sub-floor sheeting and fixings etc.

The process of laying a timber floor is a three-step process that requires: 1) assessment of the product being laid; 2) an assessment of the expected in-service environment; and 3) the laying of the floor by an appropriate method, based on what was determined in the first two steps. Aspects needing to be considered with steps one and two are provided for in Section 3. When laying a timber strip floors over joists, either directly on the joists or on sheet flooring fixed to joists, adequate sub-floor ventilation is essential for the satisfactory performance of the floor. Sub-floor ventilation recommendations as outlined in Section 3 need to be adhered to.

The specified recommendations contained in this Guide are generic in nature and, although they are frequently used, installers with knowledge and experience in a particular locality, or other constraints, may fix a floor in a manner that differs from that outlined here. However, it needs to be recognised that such systems are non-standard and the installation becomes the floor installer's system, rather than an industry recognised system. It is expected that all floor installations will be provided with a robust fixing method and guidance on this can be obtained from the recognised methods outlined in this Guide. When site sanded and coated floors are installed with due provision for movement (expansion allowance and acclimatisation as applicable) it is expected that a floor will be provided that is adequately fixed and without severe board shrinkage or severe expansion related concerns. Consequently, a final appearance complying with the provisions of Section 9, which discusses site sanded and coated floor appearance expectations, should be achievable and expected.

There are also an increasing number of flooring manufacturers who are producing specific products with accompanying installation instructions, and such instructions take precedence over the generic methods outlined in this Guide and should be strictly followed. Such instructions often relate to wider thin overlay boards and standard profile flooring for secret fixing. Other manufacturers recommend that standard profile flooring should not be secretly fixed. If flooring is fixed contrary to the manufacturer's intention for the product, it may also affect possible warranty claims. It should be recognised that specific manufacturing methods may apply to certain products and other similar-looking products of different manufacture may not perform equivalently, even with the same fixing method.

4.2 Consideration of Installation Methods

Due to climatic differences occurring between and throughout each state of Australia and in New Zealand, the fixing requirements of the floor need to be carefully assessed and will differ depending on locality. Applicable fixing requirements differ to some degree across these regions and between locations within each region or within a state in Australia.

Top (face) nailing is a more robust fixing method than floors secretly fixed with beads of adhesive. Top (face) nailed floors can therefore accommodate greater movement and expansion pressure without buckling. Increasing the amount of adhesive used will also provide more robust fixing and some installers elect to bond the floor with a full bed of adhesive. Where greater floor expansion is expected after installation, the method of fixing and associated spacing of fixings or amount of adhesive used requires consideration. With higher density timbers, a full bed of adhesive in humid localities will limit floor expansion but can also contribute to higher pressure at board edges making the floor more prone to peaking, resulting in a cupped appearance (refer to Appendix G – Troubleshooting guide for an explanation of terms).

The installation methods covered by this Guide are used extensively by many installers throughout Australia and form the basis for the industry's recommendations.

4.3 Allowance for Expansion

Site sanded and coated floors require a minimum 10 mm expansion gap between the floorboards and any internal or external wall structures. However, where board ends abut doorways, the gap may be reduced to a neat fit but with a small gap (approximately 1 mm) to prevent rubbing. Where skirtings may only be 10 mm wide, the wall board can be undercut or skirting may need to be replaced.

For floors on joists, battens and over sheet sub-floors where beads of adhesive have been used as part of the fixing method, floors up to 6 m wide (measured at right angles to the run of boards) are not required to have intermediate expansion joints, provided that it is a normal in-service environment. For floor widths over 6 m or where extra allowance for expansion is required (e.g. moist locations) an intermediate expansion joint, or a series of smaller expansion gaps usually every 800 mm to 1000 mm to provide equivalent spacing, or a combination of both is required. If 12-mm-wide cork expansion joints are used, the cork should be 2 mm or so proud of the floor surface when installed. This excess will be removed during the sanding process. However, cork to the perimeter should be installed level with the timber surface. It should be noted that cork to aluminium door joinery can cause the joinery to bow under floor expansion and an aluminium angle as shown in the diagram below overcomes this. This angle may also be inverted and adhesive fixed to the aluminium joinery or, alternatively, a small timber bullnose moulding on flat that may be fixed to the flooring.

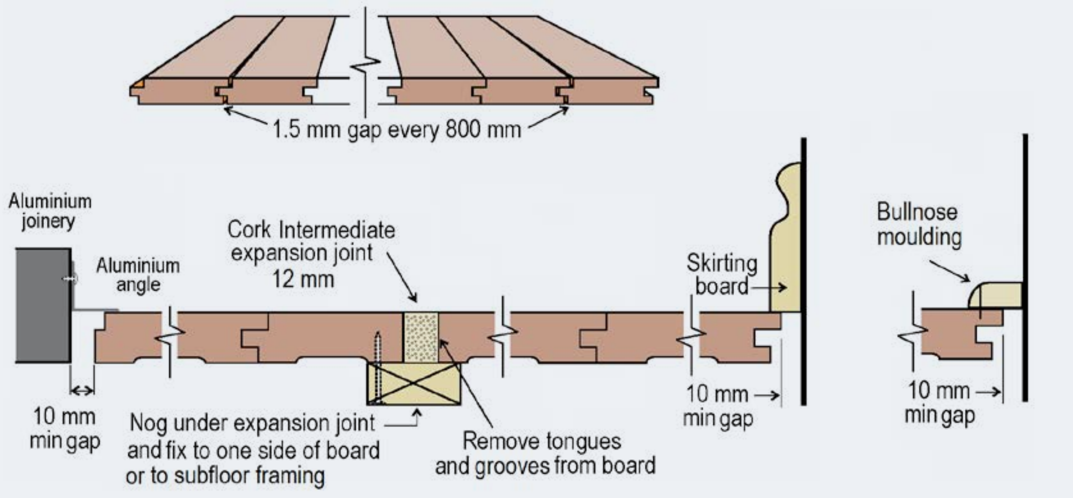


Figure 4.1: Allowance for expansion.

Figure 4.2: Small regular gaps can be used to provide the additional expansion allowance needed, particularly for wide floors or in moist climates. These often close during humid periods.

Figure 4.3: Cork intermediate expansion joints blend in well with timber floors.

When installing floors using a full bed of adhesive, it needs to be considered that the adhesive fixing substantially reduces the degree of expansion in the floor and expansion forces have to be resisted by the sub-floor. Full bed adhesive-fixed floors should be provided with a minimum 10 mm expansion gap between the floorboards and any internal or external wall structures. Similarly, where board ends abut doorways, the gap may be reduced to a neat fit but with a small gap (approximately 1 mm) to prevent rubbing. The need for intermediate expansion allowance in wider floors will vary depending on the density of the timber species being laid. With medium density hardwoods (e.g. Tasmanian Oak) and floor widths over 6 m or where extra allowance for expansion is required (e.g. moist locations) a 12-mm-wide cork intermediate expansion joint or a series of smaller expansion gaps often to provide equivalent spacing, or a combination of both is required. With higher density flooring (e.g. Blackbutt), board edges do not crush on floor expansion to the degree that occurs with medium-density hardwoods. Due to this and the restraining effect of the adhesive, a single cork joint may not provide sufficient movement allowance. In such installations, it becomes increasingly important to have the flooring laid close to the expected average in-service moisture content, and regular small gaps often provide a better solution.

In addition, when laying over a structural sub-floor such as plywood or particleboard and the flooring is of higher density, it is important that the sub-floor fixing is adequate. In moderately humid locations, it has been found that nail and adhesive-fixed sheet flooring has buckled off the joists in some instances, even when fixed in accordance with the relevant nailing requirements of Australian Standards. Screw fixing to the joists provides for a more robust fixing.

Figure 4.4: Buckling of the plywood sub-floor off the joists.

4.4 General Floor Laying Practice

The moisture content, cover width and profile (undercut and T&G tolerance) of the flooring should be checked and preferably recorded (see Section 3) prior to laying. If it is identified that the moisture content is not correct or the boards are outside of expected requirements, or are otherwise not considered to meet the specified grade, the installer should contact the supplier to resolve these issues before commencing laying. Similarly, any board found during laying that is considered outside the grade specification should not be laid.

Top (face) nailing, where used, is to be undertaken uniformly with respect to edge distances and alignment across the floor. Some variation due to batten and joist layout may occur.

When laying over sheet flooring or an existing floor, boards should be staggered to provide the look of a floor similar to that laid over joists. It is good practice to ensure that end joints are at least 300 mm to 450 mm apart and that joints do not cluster together or align. For aesthetic reasons, close alignment of end joints in adjacent boards should generally be avoided.

Installers also need to consider how the boards will be distributed in the floor in terms of length, grade, feature and colour, irrespective of whether this is on joists or other sub-floors. As such, it may be necessary to lay from more than one pack at a time so that the colour range and grade features can be blended throughout the floor. It is also necessary to take care with single boards of highly contrasting appearance and it is best that they are not installed in highly visible locations because, although not necessarily requiring remedial work, it is not seen as good practice.

With some installations, it can be beneficial to reverse the laying direction and this can be achieve by installing a row of boards ‘back to back’ with a slip (or false) tongue.

When only moderate expansion pressure is expected in the floor or the flooring is not of high-density species, the slip tongue is glued (with PVA adhesive) into the groove of the fixed board (that is fully adhesive fixed to the sub-floor), thereby creating a board with a tongue along both edges. The board with the false tongue can then be secretly fixed through the false tongue – noting that the tongue needs to be supported while fixing (usually with an offcut) so that the tongue does not drop. The adjoining board should also be fully adhesive fixed to the sub-floor and with timber and sheet sub-floors also top-nailed into them. In instances where greater expansion pressure is expected or a secretly fixed installation is required, some installers will trim the top shoulders of the adjoining boards to be in line with the bottom shoulders. Again, both boards need to be fully adhesive fixed, with the slip tongue glued into the groove of the fixed board and secretly fixed through the false tongue. With this second option, board widths will be a little narrower. Note that a slip tongue is more appropriate to flooring at least 19 mm thick, and with overlay flooring a double tongue board is sometimes used.

If a slip tongue is not used and boards are not fixed in this manner, the floor may tent with floor expansion at this location. Figure 4.5 shows the slip tongue methods described and the photo illustrates the consequence of not using a slip tongue.

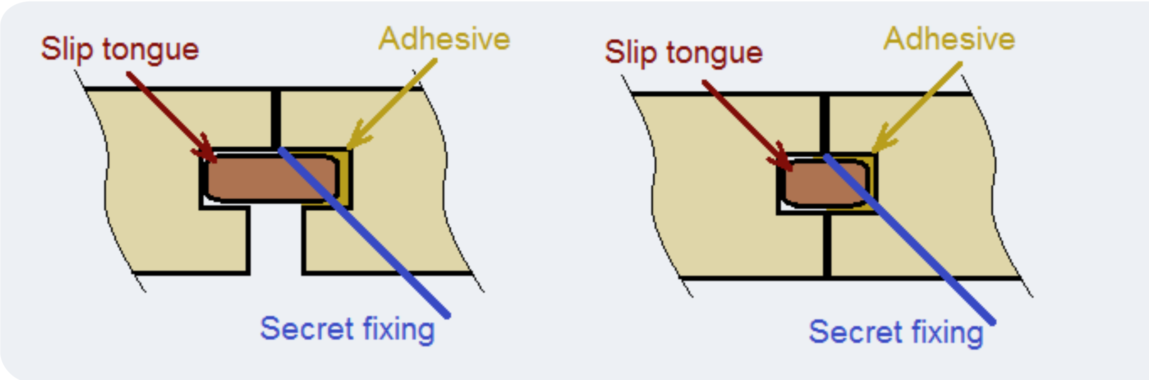


Figure 4.5: The slip tongue methods described.

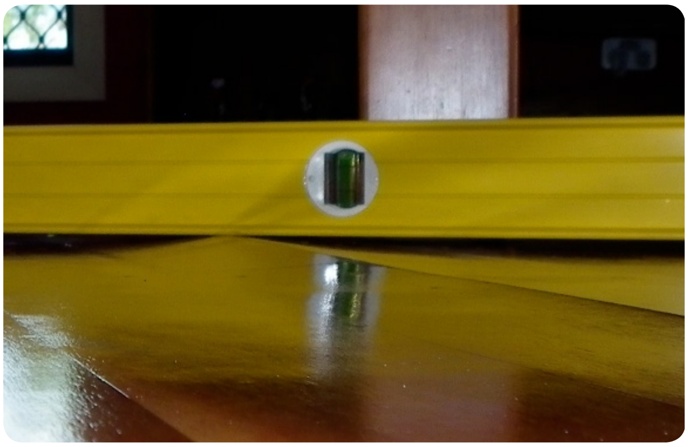


Figure 4.6: Possible consequences of not using a slip tongue and not fixing these boards correctly.

4.5 Installation Direct to Joists

4.5.1 Construction Method

Where the timber floor is to be sanded and polished (i.e. a feature floor), fitted floor construction needs to be used. With this method, the timber flooring is installed after the roof cladding and external wall cladding are in place and the house is weathertight. This prevents initial degradation due to water and sunlight exposure and reduces damage from trades during construction.

4.5.2 Sub-floor Framing – Bearer Size, Floor Joist Size and Flooring Spans

The size of timber members used to support the flooring boards can be determined from AS 1684 – Residential timber-framed construction, and in New Zealand NZS 3604 – Timber-framed buildings. This Standard should also be referred to with regard to board spans, etc, and fixing requirements for flooring installed in New Zealand.

In Australia, for end-matched flooring profiles, joists with a minimum thickness of 35 mm may be used. Where plain end flooring is butt-joined at floor joists, 45 mm or 50 mm thick joists are recommended to reduce splitting problems at butt ends.

Figure 4.7: Timber floors are successfully laid over a range of solid timber and engineered joist systems.

If installing a secretly nailed floor over joists, the joists need to be seasoned timber or Cypress, as secret nailing cannot be re-punched. If the joists shrink away from the floor, movement of boards on the fixings is likely to cause excessive squeaking.

Top (face) nailed floors may be fixed into either seasoned or unseasoned joists. Unseasoned joists are now less common and the joists need to be of a species not exhibiting high rates of shrinkage and to be of a single species or species with similar shrinkage. Species exhibiting high tangential shrinkage rates or prone to collapse or distortion should not be used unless seasoned. The potential effects of floor frame shrinkage require assessment prior to specifying or ordering unseasoned floor framing, and due allowance made in the building design and detailing. Similarly, after installation, the effects of both shrinkage and possible nail popping need consideration.

The joists must be sufficiently flat to accept the timber floor and to provide a finished floor appearance that also appears flat. The allowable span of timber flooring is dependent on the timber species, density, grade, thickness and whether or not the flooring is end-matched. The following table gives the acceptable joist spacing and maximum spans for various flooring products when fixed to timber joists. Maximum board span (the distance between where the timber is supported) needs to be considered in installations where flooring is at an angle to the joists, as this increases the board spans.

Table 4.1: Allowable joist spacing and maximum span of floorboards for Australia.

Species Group	Grade	Thickness (mm)	Acceptable Species, Grade and Joist Spacing 450 mm End-matched	450 mm Butt-joined	600 mm Butt-joined	Maximum Span End-matched	Butt-joined
Hardwood	AS 2796						
All hardwood species listed on page 5	Select Grade	19	✓	✓	✓	500 mm	630 mm
	Medium Feature (Standard) & High Feature Grade	19	✓	✓	✗	450 mm	570 mm
Cypress	AS 1810						
	No. 1	19	✓	✓	✗	410 mm	510 mm
	No. 2	20	✓	✓	✗	410 mm	510 mm
Softwood	AS 4785						
Slash Pine	Select & Standard Grades	19	✓	✓	✗	410 mm	510 mm
Other pinus species	Select & Standard Grades	19	✗	✓	✗	350 mm	470 mm
Araucaria (Hoop Pine)	Manufacturers Grades	20	✓	✓	✗	410 mm	510 mm

4.5.3 Installation Directly to Joists

In most instances, when laying over joists, boards are to be supported on at least three joists. However, there will be instances where some boards may not be (i.e. floor edges or the occasional shorter board within the floor), but this should be kept to a minimum. Flooring should be laid in straight and parallel lines. Butt-joined boards must be cut to join over floor joists and joints in adjacent boards should be staggered. End-matched joints in adjacent boards should not occur within the same span between joists. It is essential that boards are in contact with the joists at the time of nailing, particularly when machine nailing is used, as this type of nailing cannot be relied on to pull the board down to the joist.

It is generally recommended that not more than 800 mm of flooring is cramped at any one time, however, this may be varied by the installer, depending on the flooring used and conditions in which the floor is laid. The pressure used to cramp the boards together will differ from one floor to another, depending on the moisture content of the flooring at installation, the air humidity and the average moisture content conditions for the location. As a general rule, cramping should be sufficient to just bring the edges of adjoining boards together while maintaining a straight line.

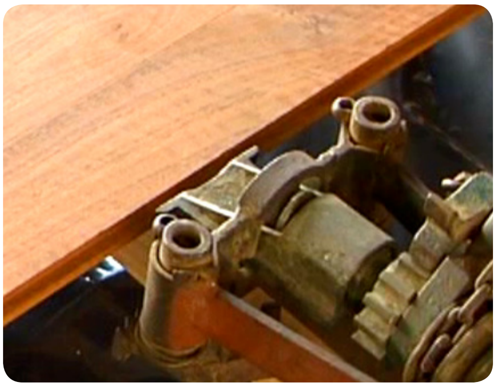


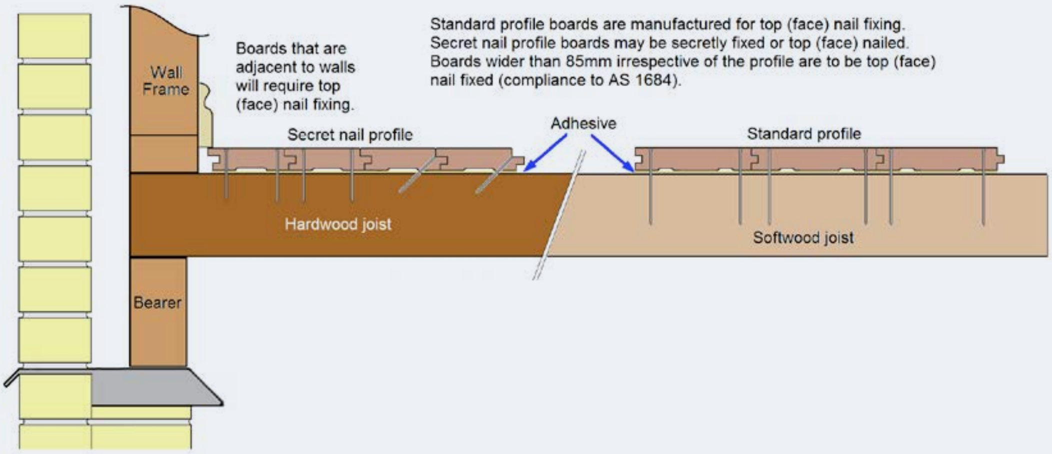
Figure 4.8: Cramping should be sufficient to just bring the edges of adjoining boards together.

4.5.4 Top (Face) Nail and Secret Fixing Directly to Joists

Boards for top (face) nailing and cover widths up to 65 mm are top (face) nailed with one or two nails at each joist. Boards for top (face) nailing and a cover width over 65 mm and up to 135 mm wide should be top (face) nailed with two nails at each joist. Boards wider than 135 mm are often top (face) nailed with two or three nails.

Figure 4.9: Buckling of 80-mm-wide Spotted Gum boards secretly fixed to pine joists in a humid locality.

Top (face) nailing is to be undertaken uniformly with respect to edge distances and alignment across the floor. Some variation due to joist layout may occur. Boards up to 85 mm wide can be secretly fixed with a staple or cleat at each joist and require a good coverage of flooring adhesive to the joist. In humid and moist localities, additional care is required to cater for possible greater expansion. Consideration should be given to board moisture contents, providing for expansion, the species, joist material and fixing method. In some locations, top (face) nailing will be the preferred option. Fixing sizes commonly used for 19 mm to 21 mm thick boards are provided in Figure 4.10.



Fixing specifications

For all installations in conjunction with mechanical fixing, apply 6 mm to 10 mm beads of flooring adhesive to the battens in a tight zigzag pattern.

Top (face) nailing into hardwood, Cypress, softwood, LVL and I-Beams
For all board widths 50 x 2.2 or 50 x 2.5 T-head machine-driven nail or 50 x 2.8 bullet head hand-driven nail

Secret fixing into hardwood and Cypress joists
For all board widths 45 x 15 gauge staple or 45 x 16 gauge cleat

Secret fixing into softwood, LVL and I-Beams
For all board widths 50 x 15 gauge staple or 50 x 16 gauge cleat.

Figure 4.10: Secret and top (Face) nail fixing structural 19 mm thick flooring directly to joists.

The recommended minimum edge distance for nailing at butt joints or board ends is 12 mm. All nails, including machine nails, should be punched a minimum of 3 mm below the top surface. During fixing, the joint between floorboards and the top surface of floor joists should be checked to ensure that gaps are not present. If gaps are present, nails should be punched to draw boards tightly onto the joists.

Figure 4.11: It should be checked that boards are tight on the joists.

Figure 4.12: Secret fixing is recommended for boards up to 85 mm in cover width.

4.6 Installation over Existing Timber and Sheet Floors on Joists

4.6.1 Assessing the Existing Floor

Timber T&G flooring may be laid over an existing T&G floor or sheet floor (plywood or particleboard). Where the existing floor is structurally sound, either overlay flooring (generally up to 14 mm thick) or structural flooring (generally 19 mm to 21 mm thick) can be laid. Wider 19mm thick boards (130 mm or wider) and thicker boards (to 21 mm) are generally top (face) nailed fixed through the sub-floor into the joists. Narrower 19mm thick boards (85 mm or less) and overlay flooring is usually secretly fixed into the sub-floor. With 19mm or thicker boards, either beads or a full bed of flooring adhesive is used in conjunction with the mechanical fixing and, with overlay flooring, a full bed of adhesive provides for a more stable floor and is recommended.

In instances where there is doubt over the structural adequacy of the existing floor, either:

a) remove the existing floor and use structural flooring laid at 90° to the joists, and fix into the joists

b) replace the defective boards or sheets to make the existing floor structurally sound (structural or overlay flooring may then be used); or

c) if the existing floor is not made structurally sound, use structural flooring at 90° to the joists and fix through the existing floor and into the joists.

The new boards may be fixed at an angle (other than 90°) to the joists in options a) or b) above, provided that the thickness of the new boards is appropriate to the increased span between the joists (as a consequence of the angle). Top (face) nails in existing flooring should be re-punched where necessary. The existing floor should be rough sanded to provide an appropriate surface over which the new floor is to be fixed. Adhesives require a clean, structurally sound floor free from surface moisture, loose particles and contaminants. This includes removal by sanding of the waxed surface layer of particle board floors. In some instances, sheet sub-floors (substrates) can sag between joists and require levelling as the sagging, if not attended to, will show through to the new floor.

It is necessary to check that the existing floor moisture content is appropriate to accept the new floor. The cause of any excess moisture (wetting during construction, leaks, inadequate sub-floor ventilation, etc) needs to be addressed prior to installation of the new floor. Moisture meters are unpredictable in sheet flooring and this may necessitate oven dry moisture content testing. Prior to laying, the new floor should be of similar moisture content (within about 2%) to the existing floor.

Figure 4.13: Before laying over existing floors, the moisture content and structural integrity needs to be assessed.

Squeaking present in an existing T&G floor may be reduced by providing a bead of flooring adhesive to fill any gaps between the underside of flooring and tops of joists (caused by cupping, shrinkage, etc). Further reductions may be achieved by fixing a seasoned batten (approximate dimensions 35 mm x 45 mm or 19 mm x 60 mm) to the underside of flooring (mid-span between joists) and parallel to the joists, fixed with a full length bead of flooring adhesive and screwed at approximately 450 mm to 600 mm centres to hold the batten in place until the adhesive is set. This, however, requires that there is access to the underside of the floor. Squeaks can also occur from sheet sub-floor fixings and at times the joist fixings, particularly if they are in line with the bearers. Checking for sub-floor squeaks prior to laying the T&G floor can prevent concerns arising later on.

4.6.2 General Installation Recommendations

The secret fixing of boards requires one staple or cleat at the appropriate spacing. For (top) face nailing of boards through the sub-floor and into the joists two nails per board are required at each fixing for boards exceeding 65 mm cover width.

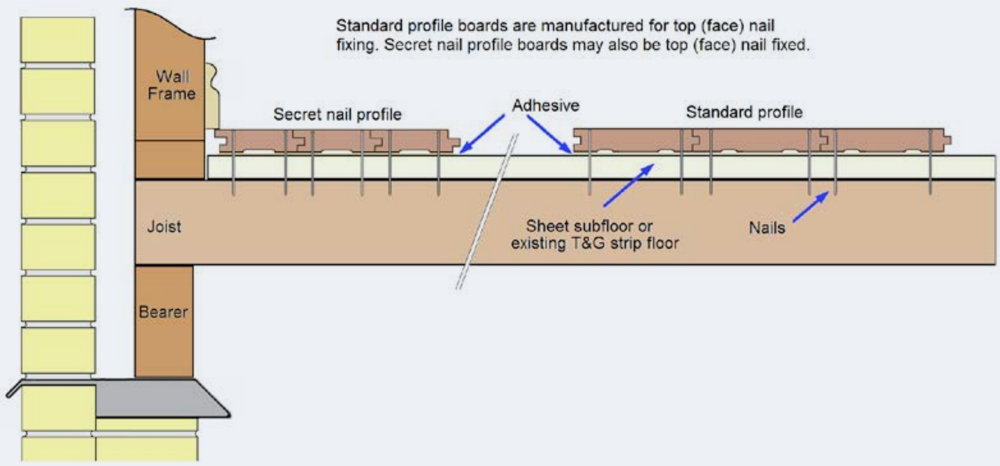
In humid and moist localities, additional care is required to cater for possible greater expansion. Consideration should be given to board moisture contents, providing for expansion, board size, and the species and fixing method. In some locations top (face) nailing with 19 mm or thicker boards may be the preferred option or a full bed of adhesive used. Overlay flooring can be more reactive to changes in environmental conditions that may be induced not only by conditions beneath the floor but also by sun exposure through large windows above the floor. For these reasons a full bed of adhesive is recommended. Some manufacturers do not recommend that their 130 mm x 19 mm or wider boards be secretly fixed and other manufacturers have specific fixing recommendations providing for the secret fixing of wider flooring that should be strictly adhered to.

Installation of flooring should not proceed until other construction activities (particularly wet trades) are complete and until after the building is roofed and enclosed. It is also preferable that the temperature and humidity are as close as possible to the expected in-service conditions although this is often not achievable as heating or cooling systems are generally not operating at the time of floor installation. Additional care or even delays to the installation should be considered if weather conditions are extreme for the locality (hot and humid, or hot and dry). As detailed above, expansion gaps of 10 mm minimum should be provided at all walls and other fixed obstructions, which are parallel to the run of floorboards.

For floors over 6m in width or where extra allowance for expansion is required (e.g. moist locations), an intermediate expansion joint, a series of smaller expansion gaps often every 800 mm to 1000 mm to provide equivalent spacing, or a combination of both is required. This is particularly so with full bed adhesive fixed floors or floors of higher density species in more humid locations.

4.6.3 Top (Face) Nailing into Joists through the Sub-floor (Substrate)

When structural 19 mm to 21 mm flooring is used, the flooring can be top (face) nailed through the existing floor or sheet floor and into the joists. Nailing is to be undertaken uniformly with respect to edge distances and alignment across the floor. Some variation due to joist layout may occur.



Fixing specifications - **Top (face) nailing**

- Bullet head 65 x 2.8 mm hand-driven or 65 x 2.5mm T-head machine-driven nails
- Boards to 65 mm wide, 1 or 2 nails per board at each joist crossing
- Boards 65 to 135mm wide, 2 nails per board at each joist crossing
- Boards wider than 135 mm, 3 nails per board

A 6 to 10 mm bead of flooring adhesive is applied in a zigzag pattern at the fixing points and midway between.

Board ends adjacent to walls should be adhesive fixed and nailed to the sub-floor.

Figure 4.14: Top (Face) nail nailing 19 mm thick flooring through timber and sheet sub-floors into the joists.

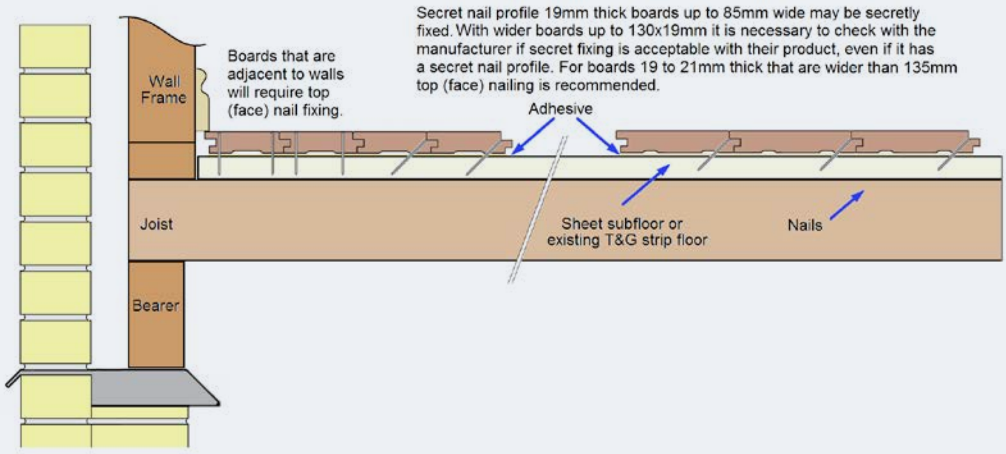
4.6.4 Secret Fixing into Sub-floor (Substrate) Only

When relying on the sub-floor or substrate for fixing, boards should be secretly fixed with the first and last few rows of boards that do not allow secret fixing being, top (face) nailed. When laying over an existing T&G sub-floor, the new flooring may be laid either parallel or at 90° to the existing boards, or at any other angle to the existing boards, providing the sub-floor (substrate) is within the required flatness tolerances and clean for adhesive fixing as outlined above. If there are potential concerns with seasonal movement of a T&G sub-floor affecting the appearance of the overlay floor, an underlay may be used. After the sub-floor is prepared, this can consist of approximately 6 mm thick plywood, adhesive and staple fixed to the T&G sub-floor. This may be achieved by adhesive beads at 100 mm intervals and staples around the perimeter of the sheet, 12 mm in from edges and spaced at 75 mm intervals. Through the main body of the sheets, staple spacing should be at 100 mm. The sheets should be laid in a brick bond pattern with the length of the sheets running at right angle to board length. In New Zealand, underlays are used when fixing over existing T&G sub-floors. Plywood squares approximately 400 mm x 400 mm are often used, which are full-bed adhesive fixed and temporarily screwed until the adhesive cures. With screws removed, a key sand and checking of floor flatness is undertaken. The fixing of the floor may be undertaken relying on a combination of mechanical and adhesive fixing. Some systems rely on mechanical fixing with beads of adhesive, while other systems rely on a full trowel spread bed of adhesive for the fixing. With full-bed adhesive systems, mechanical fixing is still used to ensure close contact between board and adhesive to result in a strong adhesive bond. In addition to fixings at recommended spacings, fixing is also required within 50 mm of board ends, however, if it is too close, splitting at ends may occur and should be avoided by fixing a little further from the ends.

When fixing 19 mm to 21mm thick boards up to 85 mm wide at close centres of approximately 225 mm, beads of adhesive to provide a cushion between the two floors helps to minimise possible squeaks. This is achieved by using a continuous bead of adhesive at 90° to board length midway between fixing points or a pattern ensuring there is adhesive to board edges. Where staples or cleats are spaced up to 450 mm apart, beads of adhesive are used at the fixing points and midway between.

With wider 19 mm thick flooring up to 135 mm, a full bed of adhesive with fixings up to 300 mm apart is applicable. Due to the reliance on the adhesive to provide much of the fixing in this instance, it is important that the adhesive manufacturer's recommendations for using the adhesive are followed. Surface cleanliness, flatness provisions and spread rate are all important. Further information on adhesives is provided in Section 5. Note that 130 x 19 mm and wider structural flooring is often required by manufacturers to be top nail fixed and therefore not recommended by them for secret fixing. Top (face) nailing through the sub-floor to the joist therefore needs to be considered or an alternate product permitting secret fixing of that board width used. With overlay flooring, board widths may be up to 180 mm and thickness generally between 12 and 14 mm. Overlay flooring is adhesive fixed with a full bed of adhesive.

The recommended fixing of the flooring is provided in Figures 4.15 and 4.16 in conjunction with the fixing specifications.



Fixing specifications - Top (face) nailing

Mechanical fixing with beads of adhesive

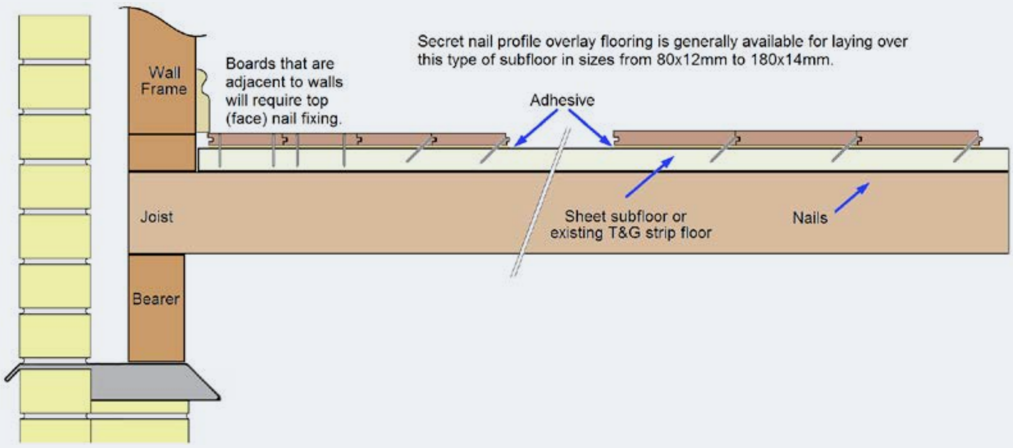
Limited to board widths up to 85 mm wide – 32 x 15 gauge staples or 32 x 18 gauge cleats:

- Either at approximately 225 mm centres and a bead of flooring adhesive (6 to 10 mm) applied in a zigzag pattern midway between the fixing points.
- Or at approximately 450 mm centres and a bead of flooring adhesive (6 to 10 mm) applied in a zigzag pattern at the fixing points and midway between.

Full trowel adhesive bed fixing

For all board widths up to 135 mm – 32 x 15 gauge staples or 32 x 16 gauge cleats at approximately 300 mm centres and with a full trowel bed of adhesive to the adhesive manufacturer's instructions. Note: suitability for secret fixing boards wider than 85 mm is to be checked with the flooring manufacturer.

Figure 4.15: Secret fixing 19 mm thick flooring to timber and sheet sub-floors on joists.



Fixing specifications - Top (face) nailing

Full trowel adhesive bed fixing

For all board widths – 25 x 15 gauge staples or 25 x 16 gauge cleats at approximately 300 mm centres and with a full trowel bed of adhesive to the adhesive manufacturer's instructions.

Figure 4.16: Secret fixing overlay flooring to timber and sheet sub-floors on joists.

4.7 Installation over Plywood or Battens on Concrete Slabs

The methods below are generally suitable for structural 19 mm thick flooring with board widths up to 180 mm wide and overlay flooring from 80 x12 mm to 180 x14 mm. Use structural flooring on battens and either structural or overlay flooring on plywood. The secret fixing of boards requires one staple or cleat at the required spacing.

In humid and moist localities, additional care is required to cater for possible greater expansion. Consideration should be given to board moisture contents, providing for expansion, board size, the species and fixing method. In some locations, top (face) nailing to the battens may be the preferred option or a full bed of adhesive used on plywood sub-floors. Overlay flooring can be more reactive to changes in environmental conditions that may be induced not only by conditions beneath the floor, but also by sun exposure through large windows above the floor. Some manufacturers do not recommend that their 130 x 19 mm or wider boards be secretly fixed and other manufacturers have specific fixing recommendations providing for the secret fixing of wider flooring that should be strictly adhered to.

4.7.1 Assessing the Concrete Slab

Timber floors may be laid on battens or plywood over a concrete slab, or by direct fix. Direct fix to the slab (as outlined in Section 5) is a more specialist field and, if considering this method, appropriate flooring contractors specialising in this field should be consulted and used. The following information covers installation of T&G flooring on plywood over concrete or on battens over concrete. Prior to installation, it is necessary to ensure that the concrete is sufficiently level to accept the system. Where there is a deviation of more than 3 mm below a 1.5 m straight edge (or, in New Zealand, 3 mm below a 3 m straight edge), a concrete topping (levelling compound), grinding or packing should be used. Slabs on ground should be constructed with a continuous under-slab vapour membrane to applicable AS or NZS standards. Timber floors should not be installed until the concrete slab has been assessed in accordance with Appendix C3. Generally, the slab will need to have cured for a period of at least three months after the roof and walls are in place and the building is enclosed. However, if due to moisture assessments or age of a slab it is considered to be near ready to accept a floor, applied moisture vapour retarding barriers can provide the necessary protection from slab moisture. These would need to be input from the particular company supplying the product.

Figure 4.17: Methods to lay timber floors over concrete slabs include battens, direct adhesive fix and over plywood. Direct adhesive fix should be undertaken by professional floor installers.

4.7.2 Installation

With floors fixed over a plywood sub-floor, overlay or structural flooring may be used but, structural flooring (19 mm or thicker) is required with battens. The plywood sub-floor or battens need to be at a moisture content within about 2% of the flooring to be installed at the time of installation.

Installation of flooring should not proceed until other construction activities (particularly wet trades) are complete and the building is roofed and enclosed. It is also preferable that the temperature and humidity are as close as possible to the expected in-service conditions, although this is often not achievable, as heating or cooling systems are generally not operating at the time of floor installation. Additional care or even delays to the installation should be considered if weather conditions are extreme for the locality (hot and humid, or hot and dry).

Figure 4.18: Secret fixing to a plywood sub-floor. A polyethylene moisture barrier has been placed over the slab and both the plywood and flooring are clear of the wall.

For secret fixing to plywood or battens, staples or cleats are used at the required spacing. For top (face) nailing of boards to battens, at each batten crossing, one or two nails are required for boards up to 65 mm wide; two nails per board are required for boards exceeding 65 mm in width and up to 135 mm; and three nails are required for boards wider than 135 mm fixed to battens. Nailing is to be undertaken uniformly with respect to edge distances and alignment across the floor.

As detailed above, expansion gaps of 10 mm at a minimum should be provided at all walls and other fixed obstructions, which are parallel to the run of floorboards. For floor widths over 6 m or where extra allowance for expansion is required (e.g. humid locations), an intermediate expansion joint, or a series of smaller expansion gaps (often every 800 mm to 1000 mm to provide equivalent spacing), or a combination of both is required. This is particularly so with full-bed adhesive fixed floors of higher density species in warm and humid locations.

As an added protection against moisture vapour from the slab (from slab edge effects, beam thickening etc.) or minor building leaks, a 0.2 mm thick polyethylene membrane is recommended. The polyethylene should be lapped by 200 mm, taped at the joints and brought up the walls (or fixed columns etc.) to or above the intended top surface of the flooring. The polyethylene is then covered by the skirting. Fixings of plywood sub-floors or battens through the polyethylene are not considered to reduce the overall effectiveness of the moisture vapour retarding barrier. An applied moisture vapour retarding barrier over the slab may also be used to protect against possible slab moisture (refer to Appendix C – Slab Moisture Assessment).

4.7.3 Fixing Recommendations – Plywood Sub-floors to Concrete Slabs and Fooring to Plywood

In Australia, plywood sub-floors that are non-structural CD grade, 15 mm thick and with a type A bond may be used, when hand-driven ‘spike’ fixed to the concrete slab. Plywood 12 mm thick is also used by floor installers but, with this thickness, greater consideration needs to be given to slab flatness and the possible perforation by fixings of moisture vapour retarding barrier beneath the plywood. Sheets may be installed in a ‘brick’ pattern or at 45° to the direction of the strip flooring with a minimum 6 mm gap between sheets and a minimum 10 mm gap to internal and external walls. In most cases, the plywood is fixed to the concrete. In those cases where for technical or acoustic reasons the plywood cannot be fixed to the concrete, the plywood sheets are laid at 45° to the direction of the floorboards and the end joints of the plywood sheets are staggered.

Various methods of fixing the plywood sheets to the concrete are used, including adhesives and mechanical fixing. In New Zealand, marine-grade structural plywood is generally used and may be mechanically or adhesive fixed to the slab over an applied moisture vapour retarding barrier. Use of polyethylene sheet as a moisture vapour retarding barrier beneath plywood is not practised in New Zealand.

Figure 4.19: Fixing of the plywood sub-floor through the polyethylene membrane and into the slab.

The option detailed below is for hand-driven spikes, which has proven to provide solid fixing to the slab:

- Slabs should be flat, in that there should not be more than 3 mm below a straight edge spanning between two high points in 1.5 m. If not, the effect needs to be assessed and the use of a topping compound prescribed for the purpose or other appropriate measures to provide a satisfactory floor installation should be undertaken.
- Install 0.2 mm polyethylene vapour barrier.
- Fix 15 mm thick plywood sheets through the membrane to the slab with hand-driven 50 mm long by 6.5 mm spikes (‘Powers SPIKE’ or equivalent). A minimum of 20 spikes should be used per 2,400 mm x 1,200 mm sheet, equally spaced (4 rows of 5 spikes down the length of the sheet) and with the outer spikes 75 mm to 100 mm from the sheet edge. If a brick pattern is used, it is preferable that sheets be staggered by 900 mm so that fixings do not line up from sheet to sheet. If 12 mm thick plywood is used, 28 fixings similarly spaced (4 rows of 7 spikes down the length of the sheet) should be used.

Figure 4.20: Adhesive spread prior to fixing.

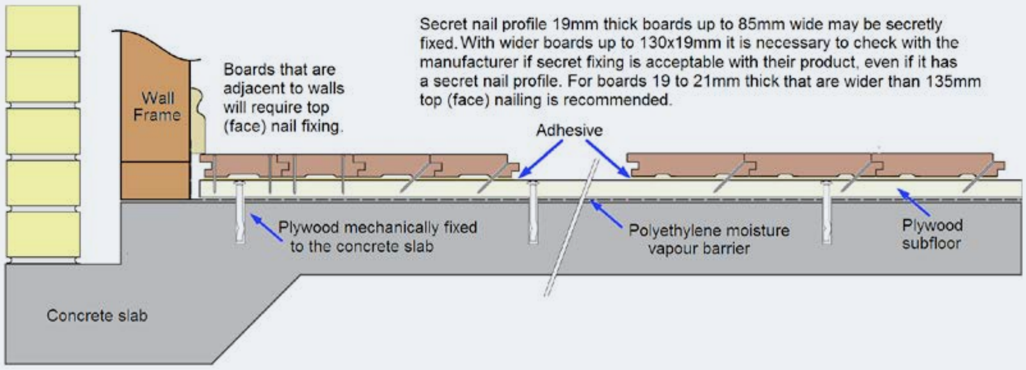
With regard to floor fixing, some systems rely on mechanical fixing with beads of adhesive while other systems rely on a full trowel-spread bed of adhesive for the fixing. With full-bed adhesive systems, mechanical fixing is still used to ensure close contact between board and adhesive to result in a strong adhesive bond. In addition to fixings at recommended spacings, fixing is also required within 50 mm of board ends; however, if too close, splitting at ends may occur and should be avoided by fixing a little further from the ends. When laying over the plywood, boards should be secretly fixed with the first and last few rows of boards that do not allow secret fixing, being top (face) nailed.

When secret fixing 19 to 21 mm thick boards up to 85 mm wide at close centres of approximately 225 mm, using beads of adhesive to provide a cushion between the two floors helps to minimise possible squeaks. This is achieved by using a continuous bead of adhesive at 90° to board length midway between fixing points, or a pattern, ensuring there is adhesive to board edges. Where staples or cleats are spaced up to 450 mm apart, beads of adhesive are used at the fixing points and midway between.

When laying with wider 19 mm thick flooring up to 135 mm, a full bed of adhesive with fixings up to 300 mm apart is applicable. Due to the reliance on the adhesive to provide much of the fixing in this instance, it is important that the adhesive manufacturer's recommendations for using the adhesive are followed. Surface cleanliness, flatness provisions and spread rate are all important. Further information on adhesives is provided in Section 5.

Note that 130 x 19 mm and wider structural flooring is often required by manufacturers to be top nail fixed and is therefore not recommended by them for secret fixing to plywood sub-floors over slabs. Top (face) nailing to battens therefore needs to be considered, or an alternate product permitting secret fixing of that board width used. With overlay flooring, board widths may be up to 180 mm and thickness generally between 12 mm and 14mm. Overlay flooring is generally adhesive fixed with a full bed of adhesive.

The recommended fixing of the flooring is provided in the diagrams below in conjunction with the fixing specifications.



Fixing specifications

Mechanical fixing with beads of adhesive

Limited to board widths up to 85 mm wide – 32 x 15 gauge staples or 32 x 18 gauge cleats:

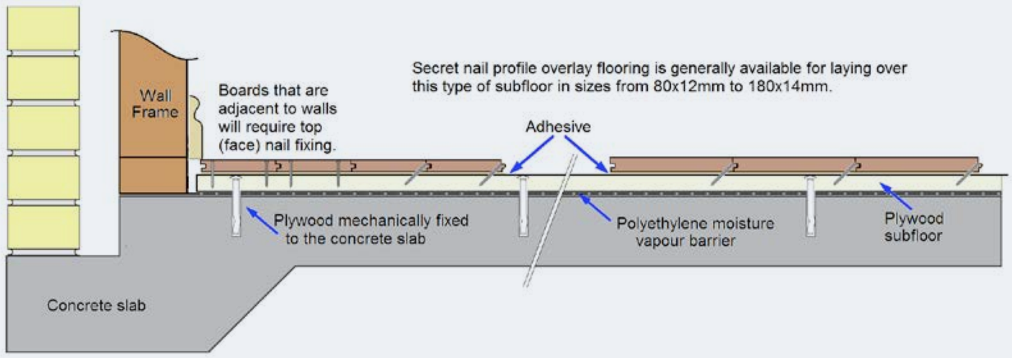
Either at approximately 225 mm centres and a bead of flooring adhesive (6 to 10 mm) applied in a zigzag pattern midway between the fixing points.

Or at approximately 450 mm centres and a bead of flooring adhesive (6 to 10 mm) applied in a zigzag pattern at the fixing points and midway between.

Full trowel adhesive bed fixing

For all board widths up to 135 mm – 32 x15 gauge staples or 32 x 16 gauge cleats at approximately 300 mm centres and with a full trowel bed of adhesive to the adhesive manufacturer's instructions. Note: suitability for secret fixing boards wider than 85 mm is to be checked with the flooring manufacturer.

Figure 4.21: Secret fixing 19 mm thick flooring to plywood sub-floor over a concrete slab.



Fixing specifications

Full trowel adhesive bed fixing

For all board widths – 25 x 15 gauge staples or 25 x 16 gauge cleats at approximately 300 mm centres and with a full trowel bed of adhesive to the adhesive manufacturer's instructions.

Figure 4.22: Secret fixing overlay flooring to plywood sub-floor over a concrete slab.

4.7.4 Fixing Recommendations – Battens to Concrete Slabs and Flooring to Battens

Battens are to be seasoned and may be either hardwood or softwood. Battens may be fixed to the slab using 75 x 6.5 mm gun nails at 600 mm maximum spacing. 'Powers Spike Fasteners' with a minimum embedment of 32 mm or equivalent fastener at 900 maximum spacing or M6 masonry anchors at 900 mm maximum spacing. Batten spacing is dependent on the species and grade of timber flooring used and the spacing shall be up to that for flooring being supported by joists (as provided in Section 4.5 – Installation direct to joists). Where higher expansion forces are expected after installation (e.g. warm humid, rural and coastal environments), batten spacing may be reduced to provide more robust fixing and floors that are secretly fixed. If battens are a minimum of 35 mm in thickness, the spacing between fastenings may be increased up to a maximum of 1,200 mm, provided minimal floor expansion force is expected after installation. Again, where higher expansion forces are expected after installation, a maximum fixing spacing of 600 mm is more frequently used with fixing in each adjacent row offset by 300 mm. This is to reduce the risk of the battens lifting off the slab surface under floor expansion and resulting in small surface undulations in the floor and more frequent hollow sounds or impact noise.

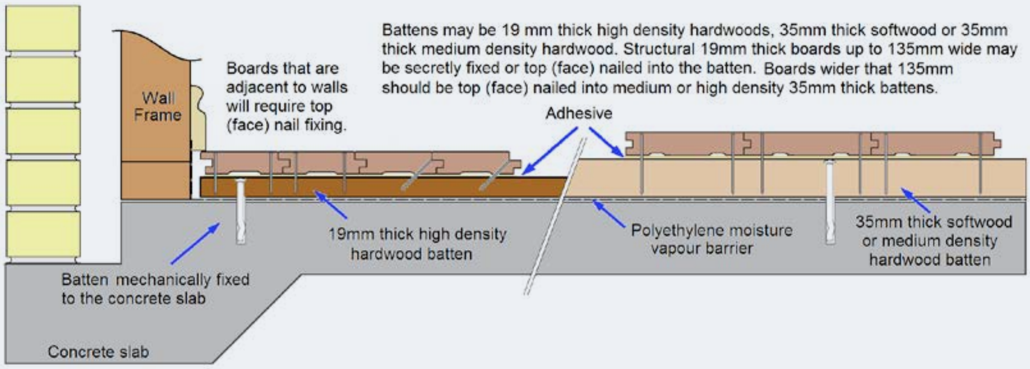
Structural flooring at least 19 mm thick needs to be used. Boards for secret fixing up to 135 mm wide can be secretly fixed with one staple or cleat at each batten crossing. Note that 130 x 19 mm and wider flooring is often required by manufacturers to be top nail fixed and is therefore not recommended by them for secret fixing to battens. Adhesive to the batten with a 6 to 10 mm bead in a tight zigzag pattern is recommended to reduce the risk of squeaking, assist with the fixing strength and ensure boards remain tight on the batten across their full width.

For secret fixing to battens, staples or cleats are used at each batten crossing. For top (face) nailing of boards to battens, at each batten crossing, one or two nails are required for boards up to 65 mm wide; two nails per board are required for boards exceeding 65 mm in width and up to 135 mm; and three nails are required for boards wider than 135 mm fixed to battens. Top (face) nailing is to be undertaken uniformly with respect to edge distances and alignment across the floor.

When fixing into battens, the batten needs to be sufficiently thick. The properties of the batten material used and the board size will govern the size of batten used. If battens are of lower density (including softwood, Cypress and hardwoods less than 750 kg/m^3 in density, e.g. Tasmanian Oak) then battens should be a minimum of 35 x 70 mm. Where high-density hardwood battens are used, the minimum size is 19 x 60 mm. Boards up to 135 mm wide may be secretly fixed or top (face nailed) into either the lower-density 35 mm thick batten or the higher-density 19 mm thick batten. Boards wider than 135 mm should be top-nailed into minimum 35 x 70 mm medium or high-density hardwood battens (such as Tasmanian Oak or Spotted Gum). Secret fixing of boards up to 135 mm wide is permitted with battens over a slab, but not when laid on joists. This is because the floor is not part of the building structure and conditions beneath the floor are more stable than a floor laid on joists that is open or has a closed-in sub-floor space beneath.

In warmer humid or moist localities, additional care is required to cater for possible greater expansion. Therefore, particular consideration should be given to board moisture contents to provide for expansion, board size, the species used and the fixing method.

The recommended fixing of the flooring is provided in the diagrams below in conjunction with the fixing specifications.



Fixing specifications

For all installations in conjunction with mechanical fixing, apply 6 to 10 mm beads of flooring adhesive to the battens in a tight zigzag pattern.

Secret fixing

- Board widths up to 85 mm wide into 19 mm thick battens – 32 x 15 gauge staples or 38 x 16 gauge cleats. For greater fixing strength (e.g. humid locations) or board widths up to 135 mm wide – 38 x 15 gauge staples or 38 x 16 gauge cleats.
- Board widths up to 85 mm wide into 35 mm thick battens – 45 x 15 gauge staples or 45 x 16 gauge cleats. For greater fixing strength (e.g. humid locations) or board widths up to 135 mm wide 50 x 15 gauge staples or 50 x 16 gauge cleats.

Top (face) fixing

- For board widths up to 135 mm wide into 19 mm thick battens – Machine-driven 32 x 2.2mm T-head nails.
- With 35 mm thick battens – Machine driven 45 x 2.2 mm T-head or 45 x 2.5 hand-driven bullet head nails. For greater fixing strength (e.g. warmer humid locations). Machine driven 50 x 2.2mm T-head or 50 x 2.8 hand-driven bullet head nails.

Figure 4.23: Secret and top (Face) nail fixing structural 19 mm thick flooring to battens over a concrete slab.

5

Site Sanded T&G Floor Installation: Adhesive Fixed to Concrete Sub-floors

5.1 Installation Practices

This section outlines the recommended practices for laying timber strip floors by direct adhesive fix to concrete slabs. This is one of three methods of laying a timber floor over a concrete slab and practices within this category differ between Australia and New Zealand and between states within Australia. Timber floors are also regularly laid on plywood or battens over a concrete slab and procedures for these other two methods are covered in Section 4.

When laying a floor by this method, which may include additional pinning (either temporary or permanent), there are aspects to consider in addition to those when laying over plywood or battens. Greater knowledge and understanding of concrete properties, levelling compounds, applied moisture vapour retarding barrier and adhesive performance are all necessary, and such installation should not be attempted without this knowledge and sound experience of general timber floor installation practices. In addition, greater care is necessary with higher density timbers, as expansion pressure in some localities can result in performance concerns (peaking, tenting and buckling). These can occur after adverse wet weather some years after installation. For this reason, floor installers may not recommend this method of installation or may advise it should only be used with thinner overlay products up to a specific board width.

Figure 5.1: Spotted Gum direct stick overlay floor.

One of the advantages of direct adhesive fix is that it can overcome possible height restrictions. The method is also used with parquetry (as covered in Section 6), which is commonly adhesive fixed to concrete slabs. It should be noted that it is not uncommon for direct adhesive fixed floors to have some ‘drummy’ areas and, where occurring, this should fall within industry guidelines.

Concerning practices around Australia, in Western Australia and particularly Perth – with its sandy soils and predominance of slab-on-ground double brick house construction – a particular method of installation has been developed. The majority of all timber floors in that state are laid by direct adhesive fix with supplementary top-nailing into the slab. Adelaide, which has winter heating and dry hot summers, uses direct adhesive fixing methods to slabs, similar to Perth. Some companies also have specific instructions on installing their overlay flooring direct to slabs and those instructions should be followed. Methods differ in other states, and there is a much greater mix of floors being laid by direct stick, over battens and over plywood. It is not uncommon for some individual installers in the eastern states to lay floors over slabs by each of these three methods depending on client preferences, timber species, site conditions and site constraints. Floors will have a different feel and sound when walked on, depending on what they are laid over. In the cooler climate of New Zealand, having significant periods of winter heating, direct adhesive fix systems to slabs are often used with techniques more in line with the practices used in Western Australia.

5.2 Assessing and Preparing the Slab

Slab assessment requirements are defined by most moisture vapour retarding barrier and adhesive manufacturers, and these do differ between product manufacturers –in both content and specific details. Practices used in slab assessment should meet the requirements of the product manufacturer and the assessment may need to go beyond what they require.

Aspects that commonly need to be assessed and what is required to prepare a slab are outlined below:

- Slab Moisture – Details regarding the moisture assessment of slabs are provided in Appendix C and this needs to be referred to. It is imperative that slabs are sufficiently dry to accept a timber floor to avoid cupping, inadequate adhesion and expansion-related issues that may arise from the redistribution of moisture in a slab after the floor is laid. Moisture vapour retarding barriers are often used as an added precaution.
- Surface Contaminants – It is expected that the surface will be clean, dry and free of paint, oil, grease, concrete curing sealers, previous adhesives and loose material, etc. There have been a number of instances where incompatible slab curing coatings that are not visible at the time of floor installation have prevented adhesion. Water droplets on a slab should freely soak into the surface; if not, the presence of a sealer or similar should be suspected. Mechanical removal is considered the most effective means of contaminant removal (grinding and shot blasting, etc).
- Slab Construction and Soundness – It is generally accepted that the new slabs will have been constructed to meet the applicable Australian and New Zealand standards for residential slabs and footings with a steel-trowelled finish, and will be free of floating ridges. Adhesive-fixed timber floors can fail if the slab is not suitably strong and the possibility of weak surface layers or previous patches of lower strength needs to be determined. Where suspected, the surface should be tested for weakness and hollow sounds. Any weak material needs to be removed and repaired.
- Flatness and levelling – Flatness provisions differ between adhesive manufacturers with many indicating a required flatness of 3 mm in 3 m. That is, any deviation is to be not more than 3 mm when the straight edge is placed on the slab, as shown in Figure 5.2. Self-levelling compounds with high tensile strength and rapid drying times may be required to level the slab and high spots may be ground off. When a moisture vapour retarding barrier is applied, it is usually applied beneath the levelling compound and subsequently primed prior to the levelling compound being applied. The primer enhances bond strength but may not be compatible with the adhesive and in such instances care is needed to ensure that all primer is covered.

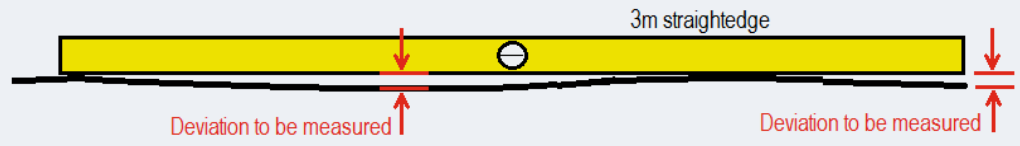


Figure 5.2: Measuring deviation.

- Slab construction joints – It is necessary to attend to slab construction joints before laying the floor. Floors have become moisture affected above joints that have not been sealed, resulting in boards cupping and expanding above the joint. Moisture ingress can be from either moisture vapour or capillary action. An applied moisture vapour retarding barrier to the slab is not going to prevent damage from this source.
- In some situations, and particularly when there is some uncertainty over slab integrity, it has been beneficial to undertake bond testing. This is where half the length of 300 mm long pieces of flooring are glued to the slab and, after 24 hours, are levered up to ensure sufficient strength and appropriate failure. The flooring should not be easy to lift and failure through the adhesive and the timber would be expected with minimal failure from the slab.

Figure 5.3: A slab being ground flat, which also removes contaminants.

5.3 Moisture Vapour Retarding Barrier

Many of the adhesive companies manufacture a compatible moisture vapour retarding barrier or will state what barrier is recommended with their product. Moisture vapour retarding barriers are not mandatory, but may be required by adhesive manufacturers as part of their warranted system. Many installers assess slab moisture and will determine the need to apply one or not. The purpose of the moisture vapour retarding barrier is to reduce any residual moisture migration from the slab to a sufficiently low level so that the timber flooring above is not affected. A moisture vapour retarding barrier is not a waterproof membrane. Requirements differ between products and usually the application of one or two coats is required with application by brush or roller. As with all coating systems, temperature and humidity constraints apply as well as recoating intervals. A curing period applies prior to the application of adhesives or levelling compound and there is often a time window for application of the adhesive, outside of which further preparation is necessary. Aspects relating to surface preparation as applicable, such as soundness and surface contaminants, are outlined above.

In timber flooring applications, it is often necessary to temporarily or permanently pin the floor to the slab. Following clarification on the effect of this from a number of moisture vapour retarding barrier manufacturers and after testing undertaken by these companies, a limited number of nail penetrations was considered by them as being acceptable with their products.

When a fixing is put into a slab and the moisture vapour retarding barrier is perforated, you would expect that there would be some leakage of moisture vapour around the fixing and, if the fixing was removed, there would be even greater moisture vapour transmission. The adjacent diagram illustrates the effects of moisture vapour transmission through a moisture vapour retarding barrier that has perforations from fixings. As indicated, the effects are small.

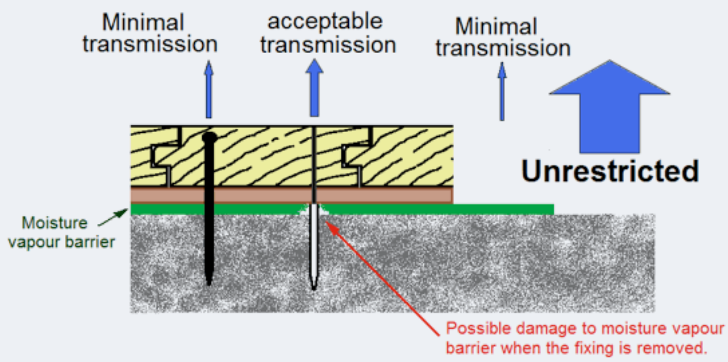


Figure 5.4: Effect of fixings through moisture vapour retarding barrier.

When a fixing is removed, there will generally be some damage to the moisture vapour retarding barrier and consideration must be given to this. Damage can expose a much larger area than the hole size of the fixing. For this reason it is best to leave fixings in place. If temporary fixing is used with clamps or similar for cramping the floor, this may mean grinding off the fixing flush with the sub-floor surface. It is necessary that nails are vertical and hand driven into predrilled holes. Angle fixing, as would occur with secret fixing, invariably chips the concrete surface and comprises the moisture vapour retarding barrier.

Companies that have undertaken testing consider that up to 10 fixings per square metre of a diameter of 3 to 4 mm would not significantly affect the performance of the moisture vapour retarding barrier or the timber flooring above. As such, provided the manufacturers' recommendations are complied with in all respects, this number of penetrations should not affect the manufacturers' warranties. To ensure that warranties are maintained, confirmation should be sought from the specific moisture vapour retarding barrier supplier that this applies to the product being used.

Slabs that are drier naturally present less risk from moisture vapour transmission and it is recommended that all slabs be at or near the recommended levels for timber floors over concrete slabs, prior to the use of moisture vapour retarding barriers (refer to slab moisture assessment in Appendix C).

5.4 Adhesives

Most of the adhesives on the market for direct adhesive fixed flooring are 1-part moisture curing polyurethane products or polymer adhesives. As indicated above, recommendations for the use of these products differ between manufacturers, both in content and specific details. It should also not be assumed that each product is the same in its properties. Some differences such as cured flexibility and foaming characteristics are easily observed; however, other characteristics such as initial hold, curing rate and final strength are not easy to discern. In addition, the polymer adhesives often have moisture vapour retarding and acoustic absorption properties.

All major manufacturers have data sheets for the use of their products and these need to be adhered to, specifically noting that the requirements in particular aspects of use may differ between products.

Aspects to be aware of include:

- Polyurethane adhesives are not designed to be moisture vapour retarding barriers and will not perform this task. Applicable polymer-based adhesives with moisture vapour retarding properties need to meet the conditions and application requirements of the product.
- The adhesive may not be compatible with primers used with levelling compounds.
- The curing rate for moisture curing adhesives will be slower in very dry conditions and can differ markedly between products.
- The working time will differ between products and needs to be adhered to.
- The time required for full curing can range up to about 7 days.
- Cleanup is easier with some products than others.
- Trowel size and the angle at which the trowel is held are both important to obtain the correct spread rate.
- It is necessary that some means of holding boards in place is employed (weighting or pinning) while the adhesive cures.
- Floor sanding is often not recommended to be undertaken for about 3 days.
-

Figure 5.5: Direct adhesive fixed 80 x19 mm Standard Grade Blackbutt.

Adhesives provide significant restraint to board movement (shrinkage and swelling); however, it must be recognised that many of Australia's hardwoods are very dense and the swelling forces generated can exceed the strength of the adhesives. Irrespective of how flexible an adhesive is, a similar amount of movement often occurs with higher density species. In locations where atmospheric moisture uptake causes significant expansion pressure, 'peaking' can also occur. This is a pressure-induced cupped appearance across a floor. Some flooring profiles are more prone to this than others. Profiles with higher levels of undercut or relief (difference between upper and lower cover widths) are generally more prone to peaking. To reduce in-service expansion pressure it is also necessary that the average moisture content of the flooring at the time of installation is aligned as closely as possible to that which the installed floor will attain in-service during humid periods of the year.

5.5 Direct Adhesive Fix Installation

5.5.1 Practices in the Eastern States of Australia

Installers may use a variety of practices to lay floors by this method and the following outlines those more commonly used.

General cleanliness is important and the floor area must be kept clean and free from debris such as stones that could prevent adequate contact between the board and the slab. Similarly, it must be ensured that partially cured adhesive on the trowel does not lessen the required spread rate or height of the adhesive. Adhesive height is particularly important to ensure bonding with variations in slab flatness. The adhesive to be used may be in either sausage form or a pail. If in a pail, any skin formed should be carefully removed to the point where the adhesive is soft below. The adhesive can then be squeezed from the sausage or distributed from the pail onto the slab surface. With pails, the lid should be loosely placed on the pail between applications to reduce the risk of curing in the pail. Care is also necessary to keep edges of the lid and pail clean if overnight storage of a part-used pail is necessary. In such instances, the pail with lid firmly attached is placed upside down.

Generally, for visual and expansion reasons, boards are laid parallel to the longest wall in the room or where boards will run lengthwise down hallways.

From the wall where the floor is being started, a chalk line parallel to the wall is 'flicked' on the floor approximately 800 mm out from the wall. The distance needs to take into consideration the actual board width and an allowance of at least 10 mm for expansion beneath the skirting.

Temporarily fix the 'starting board' with adhesive and concrete nails, often called 'mickey pins', to this line with the tongue facing the 'starting wall'. Ensure that the 'starter board' remains in firm contact with the adhesive until the adhesive has cured. The temporary pins may be removed after the adhesive has sufficiently cured, which is generally at least 24 hours.

At both ends of the floor, the required minimum 10 mm expansion allowance is also to be provided. A piece of timber of the required expansion width, placed along the wall and later removed, can be used to assist in providing an even gap.

Only use sufficient adhesive for the area that will be covered in about 20 minutes, which may be only 3 to 4 boards at a time. Adhesive manufacturers recommend that the adhesive should generally be spread at right angles to the edge of the board. The recommended notched trowel should be used to spread the adhesive, taking care to ensure the appropriate spread rate and height of adhesive is maintained.

Working from the area between the 'starter wall' and 'starter board' (now fixed in place), begin installing the floor left to right from the end wall, maintaining the required expansion gap, and lay the first row of boards away from the 'starter wall' by slotting the tongue of each board into the groove of a 'starter board' and then pressing the board firmly down into the adhesive.

When laying the boards, it is necessary to position the tongue and groove together and press the board into the adhesive as significant sliding action will spread the adhesive more thinly, lowering its height, and this in turn can then result in poor bonding between the board and slab.

In the first row, each board is laid until the wall is reached where the final board will need to be cut to fit, ensuring the required expansion gap is also provided at this wall. A board should be chosen so that the off-cut is long enough to be used at the start of the next row. With each new row, the boards should be gently tapped together, using an appropriate block so as not to damage board edges and to ensure a tight fit.

Continue to lay the floor from left to right. For any direct adhesive-fixed floor to perform, it is necessary that the boards are held down with the adhesive contacting both board and slab while the adhesive cures. Systems generally use the temporary concrete nails (as above) or weights (filled bags, filled pails or railway irons, etc). During the installation, temporary pinning will be required every 800 mm or so or the floor will need to be weighted to ensure a relatively even weight distribution.

It is good practice to ensure that end joints are at least 300 mm to 450 mm apart and that joints do not cluster together or align. This practice provides a floor that is generally considered to be more visually appealing. However, if there are many short board lengths in the flooring this may not be easy or possible to achieve.

When the wall opposite the 'starting wall' is reached the final board should be scribed and cut, again ensuring that the required expansion allowance is provided along the full length of the wall. Note that the walls in the room may not be parallel.

Once the main floor area has been laid, the area near the starting wall can be completed. At an appropriate time all temporary fixings or spacers can be removed.

A number of adhesive manufacturers indicate that floors should not be sanded for at least three days and, with some flooring products, longer periods of 7 to 14 days are considered beneficial.

5.5.2 Practices in Western Australia

In Western Australia, concrete nails approximately 3 mm in diameter provide mechanical fixing through the top surface of the boards, in addition to a full bed of adhesive beneath the floor. The nailing is done randomly throughout the floor, particularly in areas where drummy spots were observed during installation. Careful colour matching of the filler results in the nail penetrations blending in with the floor. The following section outlines performance-based considerations for acceptable practice by West Australian installers. Individual practices will vary to some degree between installers.

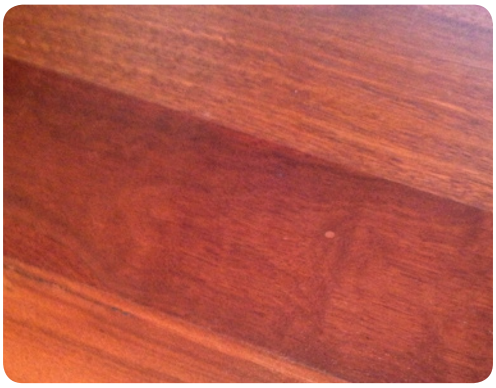


Figure 5.6: The nail penetration is to the bottom left of the photo.

Sub-floors and underlay

Surfaces must be clean and free from substances that may compromise the adhesive bond. The surface is to be in a sound condition and suitable for the purpose, that is, cohesive in structure and able to withstand the forces resulting from possible floor expansion above.

Cementitious screeds or concrete screeding may be required to patch or level sub-floors that are outside the flatness tolerances or to rectify surfaces unsuitable for glue-fixed installations. A sub-floor is generally considered sufficiently flat when no part of the sub-floor is more than 5 mm below a 3 m long straight edge placed at any location on the sub-floor. Screed application should be in accordance with manufacturers' instructions, and primers or bonding additives are recommended to enhance the bond strength of the screed. It is essential that all contaminations such as paint, plaster, old adhesive or PVA sealers be completely removed prior to screeding.

Underlay may be used as a base for glue-fixed timber flooring and common products are wood fibreboard, cement fibreboard and plywood. Underlays should be glue-fixed and nailed to achieve a sound base. Underlay thickness can vary and the installed product must be well bonded and solid.

Removal of old floor coverings such as carpet, vinyls, etc, is often required prior to the placement of glue-fixed timber flooring and the slab may need further work to provide a suitable substrate. If there is doubt about the suitability of a sub-floor for glue-fixed timber flooring, a trial lamination should be carried out to confirm the integrity of the proposed bonding base.

Moisture testing

Moisture testing is required prior to the installation of glue-fixed timber flooring. The moisture testing survey should include the proposed timber flooring and the slab. Where practical, the average relative humidity associated with the installation site should be established, which will assist in confirming the suitability of materials and site conditions. The results of the survey need to indicate that the flooring and concrete slab are suitable to proceed.

Slab moisture vapour retarding barriers

Slab moisture vapour retarding barriers are used to protect timber flooring from contamination via slab moisture that may be present at the time of installation, and as insurance against moisture that may enter the slab during the in-service life of the flooring. Moisture vapour retarding barriers need to be compatible with the proposed adhesive system and installed in accordance with the manufacturers' recommendations.

Adhesives

Adhesive, generally polyurethane or polymer-based, should be applied using a notched trowel as recommended by the manufacturer and the timber flooring should be well adhered to the sub-floor or underlay/sub-floor system, achieving a solid bond with no underfoot movement detectable after adhesive curing. When a board is placed into a bed of adhesive applied to recommended practices, the transfer of adhesive to the underside of the board with contact being maintained between the surfaces should achieve a minimum of 75% coverage. Some drummy boards can be expected in line with industry-accepted limits.

Clamping

Clamping/cramping of glue-fixed T&G timber flooring is carried out to reduce the gaps between boards. The degree of clamping/cramping required will vary with each product and consideration should be given to site conditions and the installer's evaluation of the product. Not all installations are gap free and some gaps are considered normal and acceptable in glue-fixed timber flooring. The filling of gaps is an acceptable practice.

Supplementary fixing

Supplementary fixing is carried out primarily to hold the timber boards or timber sections in place while the adhesive sets. These fixings can be permanent or temporary and can be applied mechanically or manually.

The amount of fixings can vary significantly and are often randomly applied across the floor depending on the flatness of the sub-floor. The amount and type of fixings are determined by the installer and based on site and material conditions. All holes or puncture marks resulting from supplementary fixing require filling.

Expansion allowance

Provision for expansion at walls and around fixed objects is an industry requirement and is normally set between 10 and 12 mm, depending on product and site conditions. Consideration for expansion provision is also recommended in installations which span 6 m or wider. This requirement can vary between products and installation systems and the implementation of expansion voids is often decided in consultation with the home owner or project manager.

5.5.3 Practices in New Zealand

In New Zealand, many floors are laid directly onto concrete slabs and outlined below are general procedures often used. Practices are similar to those used in Western Australia.

Sub-floors requirements and moisture assessment

The sub-floor requirements as outlined above in terms of the concrete slab needing to be dry, sound, clean and level apply. A sub-floor flatness of 3 mm in 3 m generally applies, and concrete slab sub-floors are made sufficiently flat through diamond grinding and use of levelling compounds. Slab moisture assessment is usually undertaken with above-slab relative humidity measurement, although in-slab relative humidity is also used. Above-slab humidity assesses moisture vapour transmission from the slab where checks may be done after a moisture vapour retarding barrier has been applied. Most levelling compound manufacturers require a primer to be applied over the moisture vapour retarding barrier to ensure the necessary adhesion of the levelling compound.

Flooring installation and finishing

The moisture content of the timber flooring is checked to see that it is close to the expected in-service moisture content and laid with a full trowel bed of adhesive. Semi-rigid polyurethane flooring adhesives are often used and need to be applied to the adhesive manufacturer's instructions. Some cramping may be undertaken and masonry nails and weights used to ensure a good adhesive bond. Expansion allowance is generally to the flooring supplier's specification, and may vary depending on wood density and how close the flooring moisture content is to the expected in-service moisture content. Following installation, the flooring is generally left for about two weeks prior to sanding and coating. This enables the flooring to acclimatise to the in-service conditions and undergo possible small shape changes prior to sanding, which will increase the likelihood of a flat floor.

6

Parquet and its Installation

6.1 Acceptable Appearance

The product is referred to as parquet prior to laying (refer AS 2796), and a parquetry floor after installation. This section provides information on block parquet, which is the main parquet flooring manufactured in Australia, as well as the now less common mosaic finger parquet. Block parquet consists of square edge blocks (as opposed to some imported parquet that has tongue and groove edges and ends) and is often of larger piece sizes. This section includes specific installation instructions, as well as information on manufacturing requirements, pre-installation considerations and pattern design names.

The specified recommendations contained in this Guide are generic in nature and although they are frequently used, installers with knowledge and experience in a particular locality, or other constraints, may fix a floor in a manner that differs from that outlined here. However, it needs to be recognised that such systems are non-standard and the installation becomes the floor installer's system rather than an industry recognised system. It is expected that all floor installations will be provided with a robust fixing method, and guidance on this can be obtained from the recognised methods outlined in this Guide.

When parquetry floors are installed with due provision for movement (applicable expansion), it is expected that the floor will be adequately fixed and without severe block shrinkage or severe expansion-related concerns, and will have a surface without obvious cupping.

6.2 Block Parquet Manufacture and Standards

The manufacture of parquet in Australia is governed by AS 2796 Timber – Hardwood – Sawn and milled products. It covers the manufacture of both block and finger parquet in Australia.

The Standard indicates that block parquet is to be manufactured 'square' dressed with a rebate, chamfer or groove machined to the underside to accommodate surplus adhesive. The Standard also indicates that 10 mm is the minimum thickness, even though a thickness of 14 mm to 19 mm is more commonly produced. The minimum wear thickness is half the block thickness.

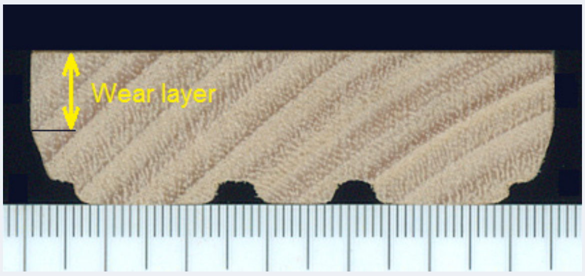


Figure 6.1: Typical 65 x 19mm block parquet profile.

The Standard indicates that the block length is to be a whole number multiple of the width and that the width-to-length tolerance does not exceed ± 0.5 mm, although manufacturers generally ensure that the multiple of block widths do not exceed block length. This small but important allowance ensures that block widths fit just inside the block length for the likes of a 'square on square' pattern.

Figure 6.2: Standard grade parquet.

In terms of moisture content, the range stated in the Standard is from 8% to 13%; however, as parquet is often manufactured from T&G flooring offcuts, the manufacturing range is more likely 9% to 13%. This variance makes no significant difference in practical terms. The Standard provides for the three grades for T&G timber flooring: Select Grade, Medium Feature Standard Grade and High Feature Grade. However, due to the small block size, a parquet floor with many blocks to Select Grade can appear higher in feature than a Select Grade T&G floor. A parquet Clear Grade (still with some feature) was included in the Standard to compensate for this. The Standard dates back many years, however, and we are not aware of any parquet Clear Grade currently being produced. Parquet in line with the other grades in the Standard is produced, but may fall under manufacturer grade names.

A common size of parquetry block is 260 mm x 65 mm, providing a 4:1 ratio. However, other block sizes may be 300 mm x 60 mm; or 400 mm x 80 mm (both providing a 5:1 ratio).

With mosaic finger parquet, the fingers are pre-adhered to a backing sheet and it is required that the sheet is sufficiently open to permit 75% adhesive contact when laid. The minimum finger thickness is 6 mm, with 8 mm and 9 mm being the more common thicknesses. Most mosaic finger parquet is a 'square on square' pattern with a 5:1 ratio and 120 mm finger length and a sheet size that can vary between manufacturers from single to groups of square panels. Ratios such as 6:1 with a 133 mm finger length and a 7:1 ratio with 145 mm finger length are also used.

The available Australian species are likely to be the northern and central coast New South Wales hardwoods, the southern Ash species and Jarrah.

6.3 Block Parquet Patterns

Figure 6.3: With parquet, a variety of patterns can be produced.

One of the attractions of a parquetry floor is the variety of patterns that can be achieved. Many of these patterns have standard names and are used extensively. However, patterns can be generated that are less standard or a distinct appearance can be achieved by using a combination of species, or creating borders to the room. More intricate patterns are used in residential work as well as commercial work.

Some of the patterns that can be achieved are illustrated in the diagram below. It shows the simpler patterns that are used more often, as well as more complex patterns that can be created. Some of the complex patterns are inspired by floors that can be found in European palaces.

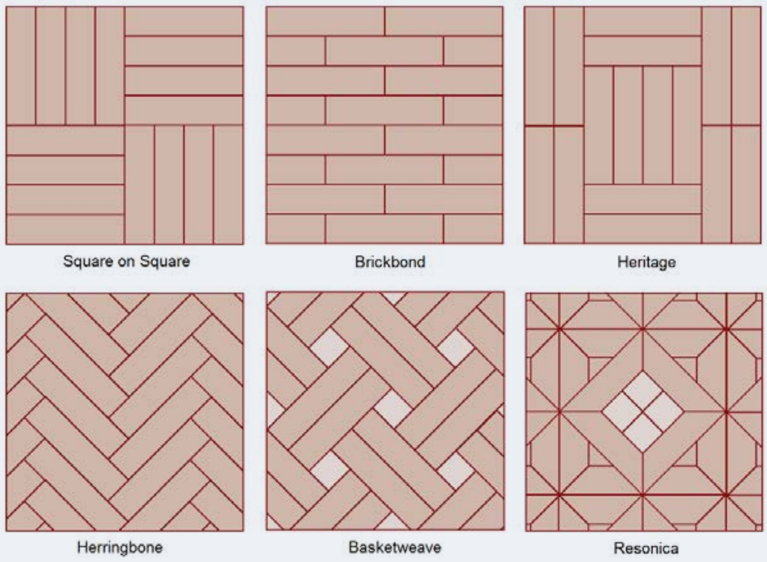


Figure 6.4: Parquet patterns.

Figure 6.5: Parquet at the Palace of Versailles, Paris.

6.4 Product Assessment

The products are usually packed into cardboard boxes after manufacture for ease of handling and, although often not provided with installation instructions, they are traditional products and subject to relatively few marketplace concerns.

When parquet boxes are received on-site, they should be checked for water or other damage. The product should be stored in a weathertight dwelling in an area away from external walls and direct sun exposure. If stored over a concrete slab, the boxes should be supported on gluts clear of the slab surface.

Before laying the flooring, it should be checked and should generally meet the following:

- Grade – Block parquet is to be supplied to the specified grade, which may be a manufacturer's grade. If a manufacturer has given a specific name to a grade, the product may be similar to one of the grades contained within an Australian Standard, but it is likely to differ in some respects. This may or may not be important to customers and should be resolved prior to supply. With imported product, grading applicable to the country of origin may apply and it may differ to that within the Australian manufacturing standard.
- Moisture content –The moisture content range for parquet is 8% to 13%, however, as block parquet is often manufactured as a by-product from strip flooring production, a range between 9% and 13% is more common.
- Block or finger moisture contents should be checked and recorded. Resistance moisture meter readings must be corrected for species and temperature, and may be affected by other factors. Corrected readings are estimates only. If in doubt, confirm results by oven-dry tests. Water marks or a significant increase in block width may be indicative of the blocks having been moisture affected.
- Block width should be checked and it should be noted that the check has been made. This is a simple test to ensure that, depending on the ratio, the number of blocks on edge do not exceed the length.
- Mosaic finger parquet should be checked and it should be noted that the check has been made. Again, this is a simple test, with the Standard indicating that the sheet is to be within ± 0.5 mm of the ordered size in both directions.

Any concerns relating to the above should be addressed prior to laying the floor. Although installers have a responsibility to check product before laying, suppliers have a responsibility to ensure product is adequately cared for, usually during transport and storage, and manufacturers have a responsibility to supply product meeting the relevant manufacturing Standard.

Figure 6.6: Imported product from a location where grading rules permit light-coloured sapwood. As this is infrequent, it is prudent to check that this meets client expectations.

6.5 Parquet Installation

6.5.1 Pre-installation

Aspects relating to pre-installation as outlined in Section 3.4 to 3.7 need to be considered for parquet flooring, although it is recognised that parquet provides a more stable floor than a T&G strip floor in the same location. These sections indicate that the site and installation environments need to be assessed and the sub-floor conditions need to be appropriate. Ensuring the sub-floor and sub-floor conditions are correct is particularly important. Acclimatisation is generally not appropriate because of the small piece size and also because it is important to maintain that the number of blocks on edge do not exceed the length. This is particularly necessary for many of the patterns used with block parquet. With moisture uptake, the block and finger width will expand but the block and finger length will not, therefore acclimatisation processes could be problematic.

With mosaic finger and many block patterns, pieces are laid at right angles to each other and – although this introduces expansion in both the width and length of the floor – it also halves the expansion that would be experienced from a solid timber strip floor. Attempts to acclimatise will also bring about variation in block width due to differences in block moisture contents and cutting pattern. This effect becomes more apparent with wider blocks. Parquet is also full-bed adhesive fixed, and this too limits the degree of expansion that occurs. Experience has shown that problems seldom occur due to expansion in parquetry floors, unless the floor has been moisture affected.

6.5.2 Allowance for Expansion

Parquetry floors require a minimum 10 mm expansion gap between the floorboards and any internal or external wall structures. Where skirtings may only be 10 mm wide, the wall board can be undercut or skirting may need to be replaced.

In many instances other than when the laying pattern is edge on edge, such as the brick bond pattern, parquetry in domestic floors does not generally require intermediate expansion allowance. If the pattern is edge on edge, then expansion allowance as for solid strip floors should be provided for block parquet (see Section 4.3). However, at times it will be necessary to separate one floor area from another, and this is more often in, for example, a doorway separating two larger floor areas. In such instances, cork expansion joints have been used with block parquet. Around doorways and architraves, the blocks can be trimmed to a neat but not tight fit. A cork expansion joint is generally used with other hard floor surfaces.

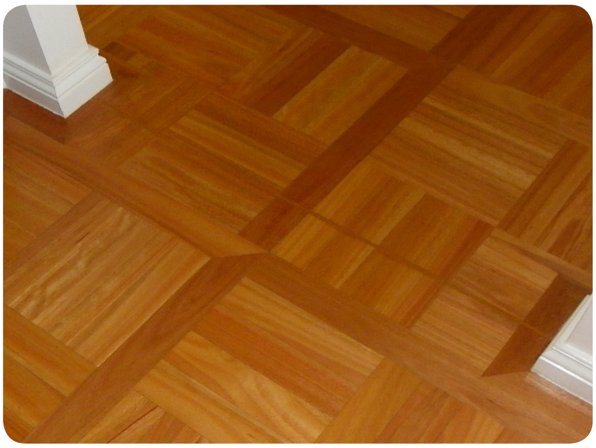


Figure 6.7: Cork expansion joint separating larger floor areas between two rooms.

6.5.3 Installation Procedures for Block Parquet

Parquet blocks are adhesive fixed to the sub-floor, which includes concrete, sheet flooring (particleboard and plywood) and existing timber floors. As such, the sub-floor assessment and preparation is the same as for site sanded and coated timber floors. For the assessment of concrete slabs, see Section 5 and Appendix C. For the assessment and preparation of sheet and timber floors, see Section 4. Note that in New Zealand a flatness tolerance of 1.5 mm beneath a 3 m straight edge is adhered to. When parquetry is laid over an existing timber floor, it may be necessary to provide a plywood underlay over the existing floor to prevent seasonal movement of a T&G sub-floor affecting the appearance of the parquetry floor. In New Zealand, it is standard practice to install a plywood underlay. The installation of underlays over T&G sub-floors is covered in Section 4.6.4. Masonite is sometimes also used. All timber and sheet sub-floors should be level sanded to remove any surface irregularities and to provide a clean surface.

Provided below are the general aspects involved in the set-out and installation of parquet floors, including consideration for borders. However, due to the wide range of patterns available, specifics will be determined by the flooring contractor who will also need to consider the layout of the dwelling.

Setting out

Within the room to be laid, it is usual for two chalk lines at right angles to each other to be made from the centre of the room, that are also near as possible to being parallel with the walls. A right angle can be determined by using the 3-4-5 rule and measurements of 900 mm, 1200 mm and 1500 mm. When one chalk line is made, the intersection of two arcs – one 1200 mm long from the room centre and the other 1500 mm long from the point 900 mm from the room centre – will provide the point where the line at right angles can be made. This is shown in Figure 6.8.

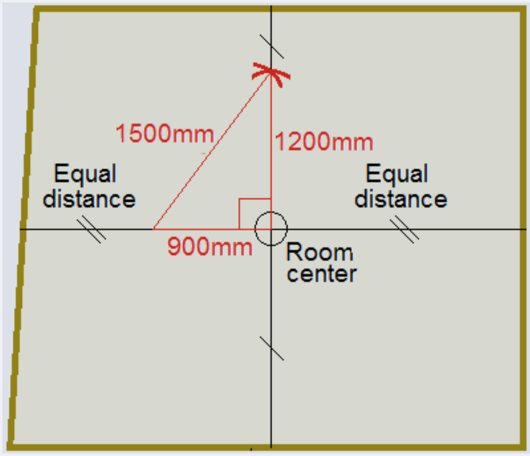


Figure 6.8: Setting out a parquet floor.

When a border is included, chalk lines are made parallel to and in from the walls, by the width of the border and the perimeter expansion allowance. When laying the blocks, adhesive is only applied up to these lines.

From the centre of the room, the block pattern is laid to the right and then to the left and this is then repeated throughout the body of the floor, with the perimeter of the floor being completed at the end. This process helps to maintain a consistent and square pattern throughout the installation. The process is shown in Figure 6.9.

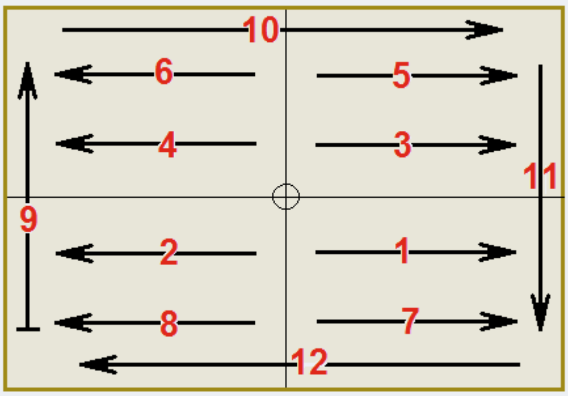


Figure 6.9: Including a border.

If a border is involved, the blocks from laying the body of the floor will overlap the border lines but, in the area of the border, they will not be bonded. After the adhesive has cured sufficiently (about 24 hours) the border lines can be remarked and, with the saw set to the correct depth, the excess can be cut off and removed to leave the main body of the floor up to the border edge. The border can then be completed.

Fixing practices

Water-based adhesives have been largely replaced with polyurethane adhesives, and some polymer adhesives are also entering the market. As some of the polyurethane adhesives foam on curing, some installers prefer to not use this type.

A full trowel bed of adhesive is applied to the slab, working from the centre and spreading about 1 m2 at a time before laying the blocks into the spread adhesive. Care is needed with the trowel to ensure the full height of adhesive is maintained as required by the adhesive manufacturer. To provide a more even distribution of colour and grade features, blocks should be laid from several boxes at one time (with a mix of manufacturing dates) and the blocks are then laid into the adhesive. During laying, it is important to keep to the string lines and also to ensure the pattern remains tight and even. Some variation in block sizes will occur due to timber properties, and such variations must be accommodated at the time of laying. If any creep occurs it cannot be corrected so, for this reason, centre and reference lines as well as the sequence of laying is important. For more intricate patterns, floors laid on the diagonal and the likes of herringbone patterns, additional reference lines are needed. A rubber mallet and timber block may be used to tap the blocks into the adhesive and reduce any mismatch at block edges. The floor is laid in a sequence as indicated in the diagram. During laying, stand or kneel on the sub-floor to ensure the blocks do not shift or slip after laying. When the perimeter of the floor is laid, blocks will need cutting – remembering that perimeter expansion allowance must be catered for. As outlined above, if a border is being installed then the blocks are cut back to the border line before working on the border. Expansion allowance at the floor perimeter is to be covered by the skirtings which need to be of sufficient thickness. The adhesive is then allowed to cure before sanding and coating as outlined in Section 8.

Parquet may also be laid on acoustic underlays and it is important that the correct underlay is used. More flexible underlays can result in blocks depressing under foot pressure once the floor is laid. To avoid this, underlays more specific to parquet are used, which are often cork and rubber composites.

Figure 6.10: Tallowwood 5:1 herringbone parquetry floor.

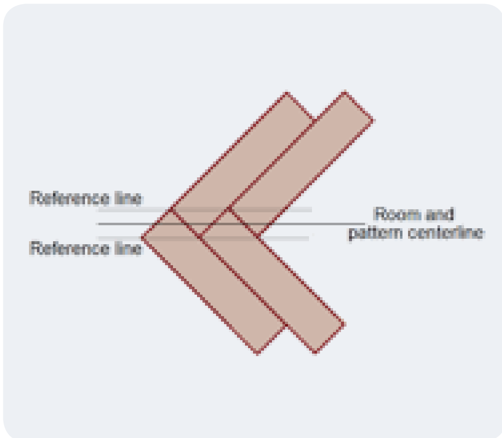


Figure 6.11: Centre and reference lines with herringbone pattern.

6.5.4 Installation Procedures for Mosaic Finger Parquet

The mosaic finger sheets are adhesive fixed to the sub-floor which includes concrete, sheet flooring (particleboard and plywood) and existing timber floors. As such the sub-floor assessment and preparation is the same as for site sanded and coated timber floors. For the assessment of concrete slabs refer to Section 5 and Appendix C. For the assessment and preparation of sheet and timber floors refer to Section 4. When parquetry is laid over an existing timber floor, it may be necessary to provide a plywood underlay over the existing floor to prevent seasonal movement of a T&G sub-floor affecting the appearance of the parquetry floor. This is covered in Section 4.6.4. Masonite is sometimes also used. All timber and sheet sub-floors should be level sanded to remove any surface irregularities and to provide a clean surface.

The sheet can be laid with a similar set out and procedure to block parquet (as above) with a full trowel bed of timber flooring adhesive being used. Some may also choose to lay the sheets at 45° to the walls, which can significantly change the look of the floor.

7

Prefinished T&G and its Installation

7.1 Installation Practice and Products

This product type is currently imported into Australia and New Zealand and is available in both Australian and exotic species. As a prefinished product, it should not be seen as being manufactured to the same specification as site sanded and coated solid Australian T&G flooring. Some product entering the country will be manufactured to the requirements of markets in perhaps Europe or the USA, while other products – often in Australian species – will be manufactured more suited to the Australian installation environment. As the product is imported, there is no Australian Standard that covers the manufacture of the product, so care is needed and checks on the product are required prior to installation. Flooring that is a minimum of 18 mm thick and at least meeting the grading requirements applicable to raw solid timber flooring (noting that flooring free of feature would comply with Select Grade) can be regarded as a structural floor.

Product is manufactured in a range of board widths up to about 130 mm wide and can include edge-laminated two strip boards. For transport and packaging in boxes, lengths up to about 1.8 m to 2.4 m are available to suit the box length. 'Nested' lengths with two or three pieces making up the box length can be expected and boards are end-matched. The maximum and minimum length will vary between manufacturers. Flooring is generally 18 mm thick and with a UV multilayer coating system to the exposed face. Boards are generally bevel edged and this will range from a micro bevel to bevels that are more pronounced. Although most flooring can be produced to be very straight, some boards will be more prone to some warping (bow, spring and twist) after manufacture. These effects become more apparent in longer length boards.

Figure 7.1: Pyinkado 127x 18 mm prefinished floor.

As this product type is more highly manufactured than site sanded and coated flooring, it should be expected that the products will be provided with accompanying installation instructions. These instructions should be strictly followed, as they take precedence over the generic methods outlined in this standard. If flooring is fixed contrary to the manufacturer's intention for the product it may affect possible warranty claims.

Laying a timber floor is a three-step process that requires: assessment of the product being laid; assessment of the expected in-service environment; and laying the floor by an appropriate method. This includes assessing that the sub-floor is also suitable to be laid over.

The specified recommendations contained in this Guide are generic in nature and although they are frequently used, installers with knowledge and experience in a particular locality, or other constraints, may fix a floor in a manner that differs from that outlined here. However, it needs to be recognised that such systems are non-standard and the installation becomes the floor installer's system rather than an industry recognised system. It is expected that all floor installations will be provided with a robust fixing method and guidance on this can be obtained from the recognised methods outlined in this Guide.

When prefinished solid floors are installed with due provision for movement (applicable expansion allowance and acclimatisation as applicable), it is expected that a floor will be provided that is adequately fixed and without severe board shrinkage or severe expansion-related concerns, and which has a surface without obvious cupping.

Provided below is further information about the products and their characteristics, including how they differ from raw solid timber boards, along with aspects that should be checked prior to laying and an outline industry-accepted installation practice.

7.2 Product Characteristics

As prefinished timber flooring is manufactured, it is important to realise that the coating to the upper face is UV-cured, multi-layered and often has aluminium oxide in one of the coats to increase wear resistance. The boards are also coated to edges and underside, often with a single coat of polyurethane.

As this flooring does not require site sanding and coating, it must also be considered that, as opposed to site sanded and coated boards, any slight cupped appearance or other movement effects cannot be sanded out.

In addition, the permeability of the coating on the upper exposed surface is generally lower than that through the coating to the underside of the board. This affects the rate of moisture transfer through the boards and any acclimatisation processes used may not be balanced, with preferential moisture uptake into the lower board surface and the potential to induce some cupping. However, once laid and over a dry sub-floor, moisture uptake through exposed UV-coated finish will generally be less than a site sanded and coated floor. As such, this reduces seasonal movement and provides for greater product stability. It is also important that the flooring is protected from possible moisture from beneath the floor as the products are usually more prone to cupping from moisture from beneath. The flooring should preferably be manufactured close to the expected average in-service moisture content, which for most of floors in major Australian cities is about 9 to 11%.

Therefore, the manufacture of the product is particularly important, and as there is no Australian Standard covering the manufacturing, it is also important that the product is assessed prior to laying. Although board profiles will vary from one manufacturer to another, is a typical board profile with associated features identified is provided below.

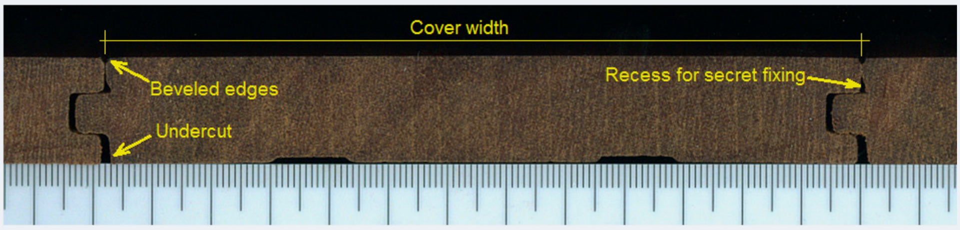


Figure 7.2: Typical board profile.

Most products have bevelled edges and ends which define the boards' outline in the floor. Any mismatch causing one board to be a little higher than an adjoining board will not result in sharp edges when boards are bevelled. Sharp edge boards can also be prone to splintering at their edges. The size of the bevel will vary between manufacturers and it ranges from a micro bevel, resulting in the boards being less defined in the floor, to a more distinct bevel.

Some products have a high level of undercut and care is necessary if higher density boards are laid in humid environments, resulting in higher expansion forces after laying. This can lead to the floor peaking, which results in a pressure-related cupped appearance.

The following aspects need to be checked and considered at the time of laying.

Figure 7.3: Peaking due to expansion pressure.

7.3 Product Assessment

When timber flooring is received on-site, it will usually be in plastic-wrapped cardboard boxes and it is necessary to ensure that the boxes have not been water or otherwise damaged. Product should be provided with installation instructions; however, this will not always be the case. The product should be stored in the weathertight dwelling in an area away from external walls and direct sun exposure. If stored over a concrete slab, the boxes should be supported on gluts clear of the slab surface.

Prior to laying, the flooring it should be checked and should generally meet the following:

- Grade – Product from exotic species is generally free of feature. With Australian species, it may be free of feature or may be to one of the Australian grades used for site sanded and coated timber floors. It should be established that the boxes are marked with the appropriate grade that was ordered.
- Moisture content – This should be in the range of 9% to 14% with the average moisture content for all pieces approximately 10 to 12%. There have been concerns resulting from product containing a significant number of boards at moisture contents below the lower limit of this range, and this has resulted in expansion-related problems after installation. Also, some product may have boards high in moisture content resulting shrinkage after installation. It is therefore important that a broad sample of boards are moisture content tested prior to laying. With some imported species, moisture meter correction may not be easily attainable. The flooring supplier has a responsibility to provide this information if not provided in AS 1080.1 Timber – Methods of Test – Method 1 – Moisture content. Moisture contents should be checked and recorded. Resistance moisture meter readings are to be corrected for species and temperature. Corrected readings are estimates only; if they are either high or low the supplier should be contacted and it may be necessary to confirm moisture contents by the oven-dry test method.
- Cover width of strip flooring – This should be checked and recorded. For prefinished strip flooring, there should not be more than 1 mm difference between one board and another. Cover widths should generally be within 0.5 mm of the nominal cover width. (If in excess of this, it can reflect changes to board dimensions that can occur after milling and prior to installation, and therefore be outside of manufacturing limits).
- Bevelled edges and mismatch – Most prefinished solid flooring is manufactured with the upper board edges bevelled (that is, the sharp edge at adjoining board face and edge removed). This to compensate for any mismatch in the machining and variance in board machining tolerance. When boards with bevelled edges are laid the mismatch is not to exceed 0.5 mm.
- Warping – Boards should not be visibly cupped prior to laying and any warping (bow, spring and twist) should be minimal so as not to prevent boards from being able to be flat when fixed and without gaps or lipping greater than 0.5 mm due to warping.
- Tongue and groove tolerance in strip flooring – Generally, this should not be less than 0.3 mm or greater than 0.6 mm. Boards should slot together to form a ‘snug’ fit. The fit should not be loose and sloppy or overly tight. A tighter tolerance may apply to some prefinished flooring, particularly if edges are not bevelled.

- Undercut in prefinished flooring – this is the difference between the upper and lower cover width of the boards. In Australia, it is appropriate for the undercut to be about 0.5 mm for an 80-mm-wide board, and a little more as board width increases. If the undercut is large and there is significant expansion pressure after installation, significant 'peaking' (pressure-related cupped appearance) can occur. The smaller the undercut, the less the effect. If imported prefinished flooring has been supplied with undercut significantly wider than that recommended here, should peaking occur, the manufacture of the product is often considered a contributing factor.

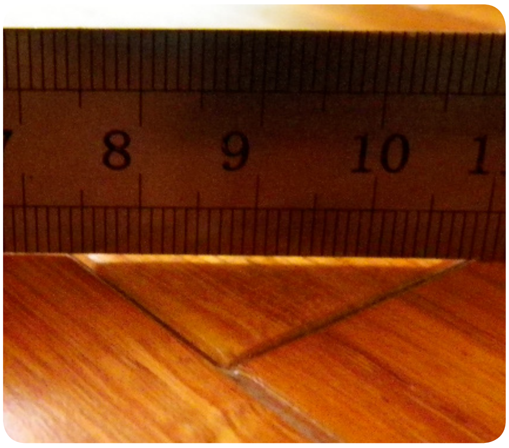


Figure 7.4: The effect of bevelled edges minimising mismatch effects.

Any concerns relating to the above should be addressed before the floor is laid. Although installers have a responsibility to check product prior to laying, suppliers have a responsibility to ensure product is adequately cared for, usually during transport and storage and manufacturers have a responsibility to supply product meeting the above points and that is fit for laying. Installation instructions should also be provided with the product or be available through the supplier of the product.

7.4 Prefinished Solid Installation in Australia

7.4.1 Pre-installation

Aspects relating to pre-installation as outlined in Section 3.4 to 3.7 are applicable to prefinished solid timber flooring. These sections indicate that the site and installation environments need to be assessed and that the sub-floor conditions need to be appropriate. As indicated above, proper acclimatisation may be more difficult to achieve with this product type and there is a need for the average manufactured moisture content to be close to the expected average in-service moisture content.

7.4.2 Allowance for Expansion

Prefinished solid floors require a minimum 10 mm expansion gap between the floorboards and any internal or external wall structures. However, where board ends abut doorways, the gap may be reduced to a neat fit but with a small gap (approximately 1 mm) to prevent rubbing. Where skirtings may only be 10 mm wide, the wall board can be undercut or skirting may need to be replaced.

Due to the flooring being prefinished, it is not appropriate to use cork expansion joints for intermediate expansion allowance. However, intermediate expansion allowance through a series of small regularly spaced gaps (2 mm gaps every 1 m to 1.5 m) can be used. The use and spacing of these gaps will depend on the initial moisture content of the floor and humidity levels within the installation environment. This allowance should be considered for all floors, but also recognising that many floors will be assessed as not needing intermediate allowance. When floors are provided with intermediate expansion allowance the gaps provided will often close at the time of the year when higher humidity conditions prevail. In some instances, a caulked joint will be used in doorways to segment one floor area or room from another. While such joints provide for some movement, it is on the proviso that the flooring will be near its average installation moisture content when laid.

Figure 7.5: Caulked joint used to relieve potential expansion pressure through a narrower doorway linking two larger floor areas.

7.4.3 Installation Procedures for Prefinished Solid Flooring

Prefinished flooring is generally manufactured up to a board width of 130 mm and, for product up to this width, secret fixing over a plywood or particleboard sub-floor is the preferred method of installation. It is necessary that the sub-floor is flat with deviations of not more than 3 mm below a 1.5 m straight edge. The surface also needs to be clean and free from any debris or protrusions from the sub-floor, as this can show through to the floor surface.

Prior to laying, as with other prefinished flooring products, boards should be checked for any faults to the surface or coating and any possible higher levels of warping. With some floors, there may also be grade considerations. Any boards that would be considered to visually depreciate the appearance of the floor from a standing position should not be laid.

As discussed above, the product is more susceptible to moisture from beneath. For this reason, if the flooring is laid on plywood over a concrete slab, a plastic sheet is to be laid under the plywood or a moisture vapour retarding barrier is to be applied to the slab, for all installations. Black polyethylene 0.2 mm thick should be lapped by 200 mm, taped at the joints and brought up the walls (or fixed columns, etc) to or above the intended top surface of the flooring. The polyethylene is then covered by the skirting. Note that fixings of plywood sub-floors through the polyethylene are not considered to reduce the overall effectiveness of the moisture vapour retarding barrier. An applied moisture vapour retarding barrier over the slab may also be used to protect against possible slab moisture (refer to Appendix C – Slab Moisture Assessment).

Prefinished floors may at times be laid on sheet or existing timber sub-floors to joists that are over an open or enclosed sub-floor space. In such instances, the prefinished flooring will be more susceptible to variable conditions that can occur beneath the floor and, prior to lifting, carpets may have trapped higher levels of moisture in the sub-floor. Before laying the prefinished flooring, it is necessary to ensure that the sub-floor space is dry and well ventilated and meeting the requirements set out in Section 3.5. However, as an added precaution, it is often necessary to lay black 0.2 mm thick polyethylene over the sheet or timber sub-floor to prevent possible moisture in the sub-floor from transferring to the prefinished flooring after it is laid. Joints in the polyethylene are similarly lapped by 200 mm and taped. Note that the sub-floor sheet can still breathe through the lower surface.

The preferred method of installation is closely spaced 32 x 15 gauge staple fixing at 250 mm centres, attached directly to the sheet sub-floor to provide a secretly fixed floor. The fixing may be through the polyethylene sheet over the sheet sub-floor. If fixing is direct to the sheet sub-floor, then beads of adhesive midway between fixing points should be used to minimise possible squeaking between the floor and sub-floor. With the closely spaced staples, this should be regarded as a mechanically fixed floor. Note that attempts to direct adhesive fix to slabs without mechanical fixing, and with higher density timbers in warm humid localities, has resulted in expansion-related failures.

Close to walls where the nailing gun cannot reach, the flooring may be top-nailed and an appropriate filler colour used to fill nail holes. Nails are to be punched 3 mm below the surface. The nailing gun with some clamping action minimises any gapping at board edges due to spring in the boards (lengthwise curvature) and assists to remove minor twist (one corner is raised when the board rests on the floor). If boards longer than 1200 mm have noticeable spring or twist then they may be cut back to this length to minimise any gapping of unevenness that may show once the board is fixed in place.

An alternate method is to adhesive fix the flooring to the sheet sub-floor with a full trowel bed of flooring adhesive. As the sheet sub-floor is without a moisture vapour retarding barrier, this method is not suited to installation on sheet or timber sub-floors on joists with either open or enclosed sub-floor spaces. The surface of the sheet sub-floor needs to be within the required flatness tolerances for an adhesive fixed system, and to be sound, dry and providing a clean surface for adhesive fixing as further detailed in Section 4.6. For adhesive fixing, the flatness tolerance as provided by the adhesive manufacturer is tighter than for mechanical fixing. If this method is used, it needs to be recognised that both spring and twist cannot be removed during laying and that, with no mechanical fixing, sub-floor flatness becomes increasingly important. As such, the flooring needs to be free from any warp that may result in concerns with the floor's appearance (e.g. wider gapping at some board edges, lipping at board ends due to twist) and the floor needs to be weighted until the adhesive has cured. Taking this into consideration, fixing by this method is more suited to shorter length boards under about 1200 mm in length. Consequently, the preferred method of installation is by mechanical fixing, as that method negates some of these potential concerns.

Laying practice also need to be considered as, in many instances, owners will be expecting a floor that has the appearance in terms of board layout that is similar to a site sanded and coated floor. Regular patterns of board ends and very short boards in the main body of the floor should be avoided. Board ends in adjacent runs should not be within two board widths and regular patterns such as a 'step' or 'H' pattern should be avoided. Also ensure that if boards of, say, three lengths are provided, that these also do not form a regular pattern. If this occurs, it does not necessarily mean that remedial work is necessary to correct it, but it is not considered to be good practice.

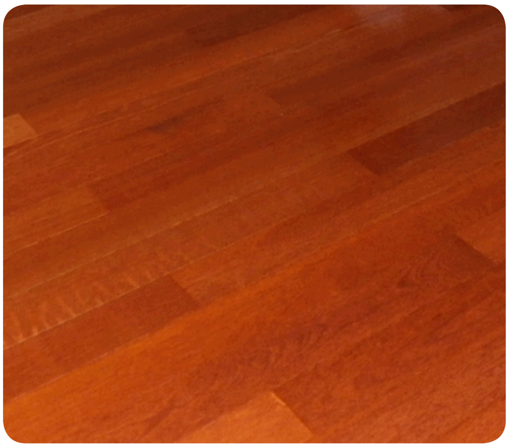


Figure 7.6: A regular pattern where every second board end lines up should be avoided.

On completion, the appearance of the floor should be checked and any minor chipping or damage that may occur at some board ends or edges may be filled with coloured hard wax. As a natural solid timber flooring product, it will be subject to small differences in movement (expansion and shrinkage) between boards. Minor gaping at some board edges may therefore be present after installation and could benefit from a colour-matched filler applied to the base of the bevel. Infrequent minor splits or checks in the coating particularly at features can occur, and are generally not detrimental.

8

Sanding and Finishing

8.1 Sanding and Finishing Practice

The sanding and finishing process is particularly important to the overall performance and appearance of the timber floor and offers a wide array of methodologies and coating systems. The practices outlined are those employed broadly throughout the industry; however, variations on sandpaper grades and procedures are common. The aim in all cases is to provide a smooth surface with the desired surface coating suitably applied to give an even level of sheen across the body of the floor. It is important that when the floor is being sanded and finished the floor is not walked on by anyone, unless under the supervision of the sander and finisher. Simple things such as fly spray, silicone sealer, boots and bare feet can detrimentally affect the floor finish. Generally, floors are out of bounds to everyone until the finisher indicates that they can be walked on.

This section aligns with *AS 4786.2 Timber Flooring – Part 2: Sanding and finishing* but has some aspects updated.

8.2 Assessing the Floor Prior to Sanding

Prior to sanding the condition of the floor should be assessed to ensure that it is suitable for sanding. This may include assessing vertical movement at board or end-matched joints, an appraisal of the overall condition and appearance of the floor (e.g. degree of cupping in boards, gapping at board edges, signs of moisture). If there are signs of abnormal moisture content, it should also include taking and recording moisture contents and moisture gradient of the installed floor. This ensures a complete history of the floor, should issues arise in the future. Any issues should be provided in writing to the applicable person (e.g. principal contractor, owner) and an appropriate course of action taken. In the case of newly installed floors, it is good practice to let the floor 'settle' for a period, which may be 3 to 14 days before the sanding process takes place, ideally in conditions that are the same as, or close to, the in-service conditions that will exist after completion. This period assists in allowing the installed floor to adjust to the internal environment where boards may undergo small shape changes prior to being sanded, and may also be necessary for curing of adhesives. This assists in obtaining a floor that exhibits minimal shape change after sanding.

Figure 8.1: Prior to sanding, the floor should be assessed to ensure that it is in a condition suitable for sanding.

8.3 Preparation for Sanding

8.3.1 Punching Nails and Filling Nail Holes

Before the sanding process can begin, ensure that all nails are punched a minimum of 3 mm below the surface of the boards. Any nail that is not suitably punched will potentially damage the sanding equipment and affect the sanding process. It is important to note that secret nailed floors may have been top (face) nailed adjacent to a wall or other areas where access is limited.

The punched nail holes can then be filled with a filler that is compatible to the surface coating (a non-oil based filler). Oil-based fillers may bleed oil into the timber and affect the colour of the wood surrounding the nail hole. In addition, they may not be compatible with various coating products and their use with these coatings is not recommended. The colour of the filler should generally be selected to minimise the visual impact of the filler on the completed floor. Many of these products are sold in colours pre-matched to specific species. In mixed species floors, or where significant colour variations are present, it is usual to mix or select a colour that is slightly darker than mid-range between the extremes of colour. Generally, all fillers are slightly darker and this allows for the boards to deepen in colour following finishing and UV exposure.

Filling can be done at this stage or after the first coat of finish is applied. By filling after the first coat of finish any potential for the filler to impact on the surrounding timber through bleed or moisture is minimised. Filling after the first coat of finish is however not suitable with all coatings and if in doubt refer back to the coating manufacturer. In all cases the filler must completely fill the hole so as not to impact on the finish quality.

Figure 8.2: Nails are to be punched and holes filled.

8.3.2 Cleaning

The floor requires thorough cleaning to make it free from dirt, grit and debris. These particles, if not removed, can cause deep, uneven scratching in the timber surface requiring substantial additional sanding to remove. The floor should be swept and then vacuumed, with particular attention given to areas not effectively cleaned by sweeping, such as gaps underneath the skirting, corners, window sills, etc. The vacuum should have sufficient capacity in terms of both suction and filtration to satisfactorily clean the floor. When sanding existing floors, care needs to be exercised where gapping at board edges is present as accumulated debris can be trapped in the gaps and loosen during the sanding process, causing unacceptable scratching of the floor. The potential problem needs to be recognised at all stages of the sanding process including the cut-back of the finish between coats.

It is important to remove any materials that may affect either the sanding or coating process. Additional care should be taken with silicone-based sealants that may have been dropped onto the floor. These products can be widely spread through the sanding process, affecting the bond between the coating and the timber.

8.3.3 Protection

During the sanding and finishing process, access to the area of the work must be restricted or denied completely. Any trades working in or around the area can potentially generate dust, wet the floor, introduce silicone-based mastics and sealants, walk over the area and generally contaminate it. Clear instructions should also be given to the owner or occupants regarding access, opening windows (which may blow dust over the area) and the time required for coating systems to adequately cure.

8.4 Sanding

The sanding operation will vary based on the condition of the floor and the hardness of the flooring species. Where the floor is being sanded for the first time, the sanding process is made up of a number of separate sanding stages, which generally start with a coarse paper and progress to a relatively fine grade of paper. It should be noted that the sanding process is effectively scratching off the surface of the boards, and the reduction in grades of paper means that you start with a severe scratching action and finish with a more subtle scratching action.

8.4.1 Level or Basic Sanding

The purpose of the level or basic sand is to cut the boards flat, removing any board-to-board inconsistencies. Prior to the removal of any cupping from the floor, it is important to assess the cause of the cupping. If it is related to moisture gradient, the floor should not be sanded as crowning may result at a later date. Sanding typically comprises three passes with the drum or belt sanding machine (often referred to as the big machine). The aim of level or basic sanding is to provide a flat, completely sanded floor, and each of the sanding procedures that follow this step is designed to remove the sanding scratches generated by this initial step and maintain the flatness of the floor. It should be noted that the term ‘flat’ is relative.

Pass 1 (or the first cut) is generally one from a small angle of about 10° up to a 45° angle to the direction of the grain (diagonally). This angle is dependent upon the layout and size of the area to be sanded and the condition of the floor. The paper grit (or grade) selected and the number of passes will vary from one project to another, and each project should be assessed to determine the grit of the starting paper to be used, the angle the floor is to be sanded and the number of passes required. A coarser grit of paper is used depending upon the species and the condition of the boards. That is, the coarser grade of paper may be used to enhance the effectiveness of the sanding process in a floor surface that is very uneven or with hard species such as Turpentine or Ironbark.

The big machine is designed to sand in a particular direction (generally left to right). It is important to understand this principle and use the machine as the manufacturer designed it to be used. An appropriate procedure for sanding a room is as follows; however , as all floors are different, procedures will vary. After the angle of the first cut is determined (appropriate to project specifics), sanding commences near a wall with the path of travel at the chosen angle to the run of the boards. The machine is started, ensuring that the drum is not touching the boards and with the operator walking slowly forward, the drum is slowly lowered onto the boards. A slow walking pace and consistent pressure is maintained. At the end of the pass, the drum is raised smoothly off the floor and then, with the operator walking backwards and pulling the machine, it is eased back onto the floor for the return pass. The machine should travel so that it is sanding the same section of the floor as was sanded in the forward pass. The power lead, controlled by the operator, must be kept well clear of the drum at all times.

When the original starting point is reached, the drum is again gradually raised off the floor. The machine is then moved (most often) to the right hand side of the first path ensuring an overlap to the first cut path. Sanding continues in that direction maintaining a similar overlap in each forward pass. When the limit of accessibility has been reached in the corner of the room, the machine is turned 180° and the other half of the room is sanded in the same fashion, ensuring that there is an overlap of around 200 mm between the two sides of the floor. Any area that isn’t sanded with this first pass (that is accessible to the big machine) can be sanded now, or else will be sanded during the second pass. The second pass is carried out on the opposite diagonal to the first pass, using a similar grade of paper.

Figure 8.3: First and second pass of sanding at 45° to board direction.

The third pass cuts the floor in the direction of the boards using a similar grade paper to remove the sanding lines from the action of pass one and two. Typically, the operator should start at a point that enables the sanding to be done in the direction and method a described above.

Figure 8.4: Third pass of sanding in the board direction.

Once a forward and reverse path is sanded, the machine is moved to ensure an overlap to the previous cut and sanding recommences in the same manner. This process is carried out across the room. When the full width of the room is sanded, the operator should turn 180° and sand the un-sanded band of floor.

The sanding drum should never have contact with the floor unless it is moving forward or backward. Doing so will cut a groove into the floor (drum mark), which may not be recoverable. Specialist equipment should be used and manufacturers' recommendations and user instructions should be followed.

At the completion of the level or basic sanding, the boards should be generally smooth and free from cupping and mismatching of surface levels between adjacent boards. If this has not been achieved the floor will require additional passes to achieve this state.

8.4.2 Edging

The big machine will not be able to sand the boards along the edges of the room, in corners or areas of reduced access such as wardrobes, etc. In these areas, the boards need to be sanded flat and generally blended into the body of the floor. For these areas an edge sander is used, and the most commonly used machine for the edging process is the disc sander, which is designed to be easy to manoeuvre. Care is necessary to ensure the operation does not dig grooves into the boards and that the finished edge is level with the body of the boards.

Figure 8.5: Edge sanding requires a smooth action to blend into the floor.

The operator should move the machine in a smooth, even pattern at board ends and across the grain. The pattern of sanding should overlap and blend into the body of the sanded floor. It is important that the machine is held level, as the boards are easily grooved with any uneven pressure. On each movement, the machine should sand a section of un-sanded floor of about 50 mm. The edge sanding machine should be moved smoothly along walls parallel with the boards, going back and forth in the direction of the grain and overlapping some 100 mm into the body of the sanded floor. 'Clocking' the edger is a technique of orientating the edger to the wall being sanded up to. This technique is now often used, as it minimises the visual impact of the scratches left by this part of the sanding process. Finer grit papers are usually sufficient for the purpose of edging on new floors and on old floors that are in good clean condition.

In areas of very limited access or at the corners of the room, hand scraping the floor is necessary. The scraping action should always be in the direction of the grain with the surface being both hand-sanded and machine-sanded with a smaller machine – the orbital sander. With orbital sanders, too much pressure or use of an overly aggressive grade of paper can result in deep swirl marks, which will show up in the finish. Once again, care needs to be taken to blend in these hand-scraped areas with the body of the floor.

This process is repeated following the second sanding process of the body of the floor.

8.4.3 Finish Sanding

This is the process of taking a floor that has been level sanded and bringing it further along the path to the coating stage. The purpose of this stage of the sanding process is to smooth off the coarser sanding marks left by the level or basic sand with finer grade or grades of sand paper. Typically an F60–100 grade paper is used and the floor is sanded in the direction of the grain (board run). The aim is to reduce the depth of scratching and ready the floor for the next stage of the process. Some contractors undertake a second pass with the edger at the completion of this stage of the sanding process with the big machine.

Figure 8.6: The finish sand.

8.4.4 Final Sanding or Hard Plating

After the completion of the finish sanding with the big machine and edger, final sanding or 'hard plating' is undertaken. Some contractors undertake the final sanding process using a finer grade of paper or screenback (100–150 grades) attached to a soft pad using a rotary machine. Others will use a process called hard plating, which enables them to consistently achieve a very flat floor surface. Hard plating is the process of utilising a rotary machine with the sand paper on an inflexible base plate, which not only enables a flat floor surface to be achieved but – if undertaken effectively – will help eliminate minor sanding imperfections left from using the drum or belt machine and edger. With both processes, the sanding should be carried out in the direction of the grain ensuring a smooth action, and applying a balanced control of the machine.

After hard plating, or rotary sanding if hard plating is not used, the perimeter of the floor would normally be sanded with a random orbital sander. The importance of both hard plating and random orbital sanding to obtain a flat floor surface with minimal variations in the appearance of the finished floor, when the perimeter of the floor is compared to the body of the floor, cannot be overstated. Some will also buff with a fine paper after hard plating and orbital sanding to further remove any differences.

The floor must once again be fully cleaned of dust, grit and debris. Any matter left on the floor will invariably affect the quality of the finish.

Figure 8.7: Hard plating with the correct attachment.

8.4.5 Buffing

The final stage is the 'buffing' of the floor. This is often carried out with the same rotary machine used for the hard plating, but with the sand paper attached to a more flexible pad on the base of the machine. This is the final process prior to coating the floor, and it is designed to produce a uniform scratch pattern across the entire floor and is also used as the last process to check the floor, prior to the application of the coating.

The floor is then vacuumed thoroughly and – if required – cleaned with tack rag (cloth designed to remove dust). Special attention should be paid to any potential dust traps in the floor (for example, dig out any dirt or dust and vacuum away). These can contaminate the floor coating system if not cleaned adequately, as the applicator will most certainly pull the dirt onto the body of the floor. It should also be understood that heavy sanding equipment may have the potential to create wheel marks on low-density floorboards. Additional care should be taken in these applications. Each stage of the sanding process is designed to achieve a specific outcome, with the end result being a floor that is flat with a minimum amount of very fine sanding marks and little visible difference between any areas of the floor.

It should be emphasised that the floor should be vacuumed after each sanding to remove loose grit and debris before the next stage of the process is commenced. This simple step will help in the reduction of 'rogue' scratches in the finished floor.

Figure 8.8: Buffing the floor.

8.5 Coating System Application

The following information is a typical application methodology, which might be utilised for the various finish types with minor product-specific variations.

8.5.1 Cleaning

The floor finish will be easily contaminated with any dirt, dust or other extraneous matter left on the floor. It is essential that the area be thoroughly cleaned and vacuumed, paying particular attention to any areas which may have caught dust during the sanding process such as window sills, picture rails, skirtings, power and light switches, light fittings, handrails, etc. The floor needs to be well lit with adequate ventilation. It is important to not have draughts blowing across the floor during the process, as they can introduce contaminates from outside of the working area.

8.5.2 Mixing the Coating

The coating material should be thoroughly mixed so that all the solids are blended through the body of the liquid. Do not to stir too quickly or roughly, as this may introduce air bubbles to the material and affect the coating quality. If there are any additives to be used, ensure they are mixed thoroughly into the coating liquid. Follow the manufacturers' instructions in all cases.

8.5.3 Cutting In

Use a clean, good-quality brush to cut in the finish around the perimeter walls and any other obstructions or areas that may not be accessible to the main applicator. The cutting in should extend out about 150 mm into the body of the floor so that the applicator is not required to venture too close to the skirtings and other limited access areas. If any bristles fall from the brush into the finish, remove them immediately.

Figure 8.9: Cutting in the finish around perimeter walls.

8.5.4 Applying Coating

The initial coat applied to the raw sanded timber may be either a recognised sealer coat as prescribed by the coating manufacturer or the same material to be used as a finish, except when outside the manufacturers' recommendations. Sealers are available in both water-based and solvent-based products. The use of a sealer can enhance the development of colour in the timber floor and can reduce the risk of 'edge bonding'. Penetrating and low rupture sealers are available. In all cases, it is imperative to follow manufacturers' instructions closely.

There are many approaches and methods used in the application of floor finishes and coating systems. The following approach is one such application method, which has generally been accepted by the industry.

The applicator, as specified by the coating system manufacturer (often a 6 mm mohair roller or equivalent), is immersed in the coating contained in a large painter's tray or applicator bucket. These allow the applicator to be lightly squeezed on the shallow portion of the tray to avoid drips. The product should be applied to the boards in a smooth action, starting at one end of the boards and working the product in line with the grain of the timber boards. The finish should be feathered off at the outer edge to minimise any build-up of coating at that point. This process should leave a 'wet edge' so that each successive section of application blends into the previous section without any ridging, which can occur if the material skins or dries off before the next application strip. The application process should continue in the same manner, working from one end of the area to completion. An even, wet look should result without any dry patches.

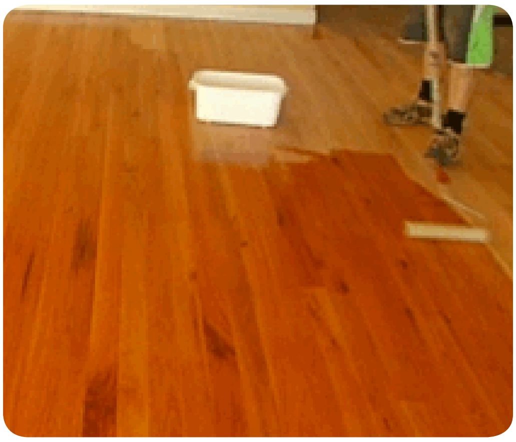


Figure 8.10: Application of the initial coat.

8.5.5 Filling/Stopping

When coating parquetry floors, it is recommended that filler be trowel applied following the first coat. This aids in reducing the phenomena known as 'quilting', where the finish does not flow across joints at board or parquetry edges. Filling of parquetry floors may be carried out prior to or following the application of the initial sealer or first coat, and is at the discretion of the floor sander. It is not a recommended practice to fill tongue and groove timber floors.

When the coating system is dry, any nail holes not previously filled and any cracks or other open faults should now be filled with a suitable filling compound that is compatible with the finish type. Generally, a non-oil based filler is best, which is colour matched to the timber.

The filler should be installed with a clean bladed applicator. Ensure the filler slightly overfills the hole and has been fully pushed into the void. If the material does not completely fill the void, it could come loose in service. Clean off any filler that is spread over the floor around the hole. Any excess will be sanded away in the light sanding between coats.

8.5.6 Sanding between Coats

The floor will typically have a slightly rough feel to it after the first coat of finish, depending on the system used and the degree of grain raise of the timber created. It is normal for more open-grain timbers to exhibit a higher degree of initial grain raise than denser close-grain species. The floor requires a light sand after the first coat to remove this roughness and also to key the surface for the next coat of finish. A 150 or finer grit paper or screenback is used at this stage with a rotary sander or similar. The sanding must not expose the timber, as this will create further raised grain. The sanding process is required to smooth off the roughness in the coating, not the timber. Edges must be hand or orbital sanded to a similar smoothness. It is important to follow the coating manufacturer's instructions as to the type and amount of sanding required, as different products often require slightly different techniques.

8.5.7 Cleaning between Coats

All dust should again be thoroughly removed from the floor along with any potential dust traps as previously described. Ensure that there are no draughts blowing through the area that could contaminate the final coat(s). In addition it may be prudent to use a tack rag over the floor to remove any dust missed by the vacuum. This will ensure that the floor is as clean as possible for the final coat(s).

8.5.8 Second Coat

The floor should again be edged with a clean brush coming out some 150 mm or more into the body of the floor. The application process is as per the first coat, with the applicator being worked along the full lengths of the boards and lightly feathered at the outer edge of each strip of application.

Figure 8.11: Application of the second coat.

8.5.9 Additional Coats

Any additional coats should follow the same process of a light sand of the previous coat, thorough cleaning and then application of the subsequent coating. Typically, a three-coat system is utilised, however, all manufacturers' recommendations should be followed with regard to number of coats and sand paper grades, in addition to any requirements of the specifier. Various water-based and oil-based coating systems require a finer grit of paper between coats, compared to the solvent-based products.

8.5.10 Providing the Floor to the Customer

When the floor is completed appropriate information should be provided to the client in terms of using the floor and maintaining it. This should include when the floor can be walked on, when furniture, etc, can be moved in, the care that must be taken with heavy items of furniture and the need for felt or similar protection for furniture legs to prevent scratching. Therefore, aspects relating to the curing time of the coating should be conveyed. Further information with regard to ongoing care with the floor is provided in Section 10.

9

Site Sanded and Coated Floor Appearance Expectations

9.1 Acceptability Considerations

There are no Standards that outline what an acceptable appearance of a timber floor should be. There are Standards that relate to the manufacture of timber flooring and, when recommended sanding and finishing practices are undertaken, there is a general level of acceptance of the finished product in the marketplace. Floors of the same species can differ markedly in their appearance depending on timber source, age of the tree, board cover width, the finish system used and the lighting in which the floor is viewed. Timber is a natural product that will shrink and swell in response to changes in atmospheric humidity. In addition, no one building environment is the same as another, the sanding and finishing is not undertaken in a dust-free factory environment and finishes may darken with time. However, even with these variables, a high standard in the finished floor is achievable.

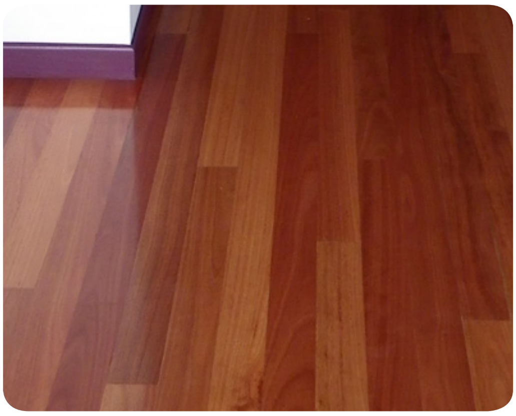


Figure 9.1: A high standard of appearance is achievable.

9.2 Acceptable Appearance Criteria

The following information is a typical application methodology that might be used for the various finish types with minor product-specific variations.

9.2.1 Colour, Species and Grade

The overall colour or blend of colour in a floor is dependent on the species or species mix chosen and the character of the floor. The features present in a floor, such as gum veins, are determined by those features permitted by the grade. Even when a single species is chosen, there can be a wide variation in colour, and it is also possible that a limited number of boards of a different species may be present due to similarity in appearance. It is also important to realise that grading rules do not cover either colour or colour variation. Grade names that do not align with the Australian or New Zealand Standards are likely to be similar to those in the Standards, but clarification should be sought regarding differences.

The grading process is rapid and relies on quick visual assessment where graders must assess the size and extent of a feature without relying on measurement. Due to this, some inaccuracy in grading can occur that may result in a limited number of boards that are outside grade limits. The sanding of a floor can also increase the size of some features or cause features to appear that were not present prior to sanding. Consequently, some boards in a finished floor may not meet the specified grade description. The presence and development of such features needs to be acknowledged by those purchasing timber floors. When viewing a floor, there is generally a clear difference between a floor that is of the incorrect grade and a floor where grade limits have been exceeded in some boards.

Where the number of boards in a floor with features that exceed grade limits, in terms of size and number, are relatively few (less than 5%) and the overall appearance of the floor is in line with the chosen grade, no remedial work is considered necessary.

Figure 9.2: A select grade Blackbutt floor where the backsawn gum vein toward the top right exceeds grade limits but is acceptable within the floor.

Grading also does not account for the distribution of features in boards, between boards within a pack of flooring or within a finished floor. It is a reasonable expectation that the installer, when laying the floor, will provide a relatively even distribution of colour and feature throughout the floor. With regard to colour, however, it must also be recognised that coating a floor highlights colour differences and the extent of the change is at times not easy to discern. Similarly, it can be expected that board lengths will be relatively evenly distributed in the floor and that groups of short boards or board ends will not be frequently clustered together.

9.2.2 Even Timber Surface

The following section outlines some problems that affect the surface of the boards and these should not generally occur in timber floors. However, specific heat sources from appliances or sun exposure through large uncovered windows may induce some cupping of boards in the affected area. Similarly, wide boards or thinner overlay boards may also show some slight cupping or peaking in certain house environments. It should also be recognised that the actions or inaction of owners can contribute to or even cause these to occur.

- Cupping – boards with their edges either higher or lower that the centre of the board. Heat in a specific location or a very dry environment above the floor may result in cupping. Moist sub-floor spaces can also cause boards to cup. Cupping is more likely to be observed in overlay flooring and standard thickness boards that are wider than 100 mm. To some degree, a small amount of observable cupping may occur in some locations within a dwelling (e.g. sun-exposed floor) where these types of flooring are used.
- Peaking – this has the appearance of cupping but is the result of expansion pressure in the floor.
- Tenting – two adjacent boards, where the adjoining edge has lifted above the level of the adjacent flooring. This is often associated with high moisture beneath the floor and can be from many causes.
- Buckling – a section of flooring containing a number of boards that is raised above an adjacent section.
- Crowning – floorboards that are flat on their lower surfaces but where the upper surface has edges lower than the centre of the board. This may occur if a floor is cupped (board edges up) at the time of sanding (see Figure 9.5). Crowning does not become apparent until some months after finishing.

Note: Floors exposed to heat sources after occupancy (e.g. from lack of curtains, fireplaces, vents from appliances, houses closed up for extended periods) may cause boards to cup. Cupping and shrinkage from such sources may be the owner's responsibility.

Figure 9.3: Boards ends should be spaced out and preferably 450 mm or more apart.

Figure 9.4: Cupping – Board edges higher than the centre of the board, but which is barely visible in the floor.

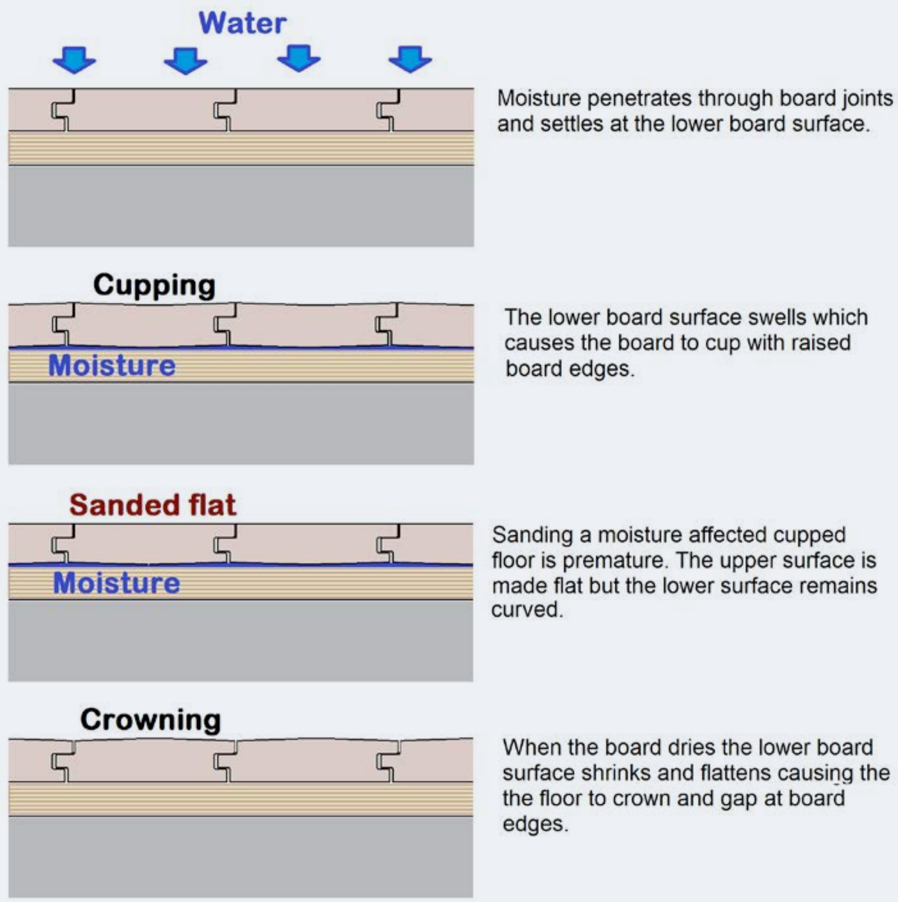


Figure 9.5: Crowning in timber floors.

9.2.3 Relatively Even Gapping Between Boards in Areas Not Exposed to Specific Heat Sources

With solid timber strip flooring, shrinkage gaps over 10 boards can average 0.75 mm for an 80-mm-wide board floor under drier internal conditions. For wider boards, proportionally wider average gapping can be expected. The appearance should indicate gapping between most boards and be free from irregularly spaced wide gaps associated with edge bonding. The provision of expansion gaps as part of the installation process and evident throughout the life of the floor is acceptable.

Figure 9.6 shows gapping near the upper limit, where the average gap size was 0.75 mm, which is considered acceptable. Figure 9.7 shows gapping that is not considered acceptable, where the average gap size was 1.8 mm. Note that this is the average gap size over 10 boards, so some gaps are greater than the average and others are less than the average.

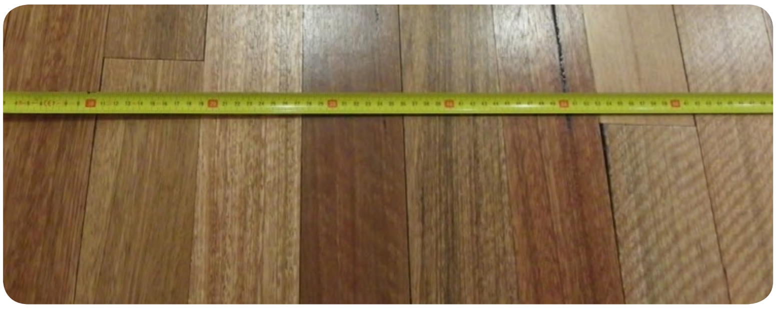


Figure 9.6: Gapping that is considered acceptable.

Figure 9.7: Gapping that is not considered acceptable.

9.2.4 Limited Vertical Movement at T&G Joints

Flooring is manufactured with the board tongue narrower than the groove. This is necessary so that boards will fit together during installation. When floorboards are laid over joists, in particular, some differential vertical movement may occur between adjacent boards, when a load is applied to an individual board. This is due to the clearance between the tongue and the groove. The clearance should not exceed 0.6 mm.

9.2.5 Minimal Squeaking

A small amount of noise can be expected from most timber floors, when walked on. Noises can occur from movement of one board edge against another or from boards moving on nails. A floor is often more noisy during drier weather, due to loosening at the joints. If squeaking is present in main trafficable areas then remedial repairs should be considered.

9.2.6 Indentations

Timber strip floors can be expected to show some indentations depending on the hardness of the species used, volume of traffic and footwear worn.

9.2.7 A Finish with Minimal Contamination and Sanding Marks

A finish similar to that of fine furniture should not be expected. Sanded and polished timber strip floors are not finished in a factory environment and different pieces of flooring will sand differently. The home environment is also not dust free. However, the finished floor can be expected to have an even appearance free from heavy sanding marks, blooming or frequent air bubbles in the surface. A minimal level of contaminants, minor sanding marks and small depressions of the finish at board edges and in nail holes, etc, may be visible. The perimeter and other hard to get at places are more likely to contain these irregularities. Due to this, a mirror finish is an unachievable expectation. Some finishes will also yellow with time and, if rugs are moved, a contrast in the depth of colour can be expected.

When floors are inspected for imperfections, the inspection is to be carried out during daylight hours with lighting on. The overall assessment of the floor is from a standing position with the floor viewed from positions that are usually occupied by people. Internal and external reflections in areas not usually covered by furniture should be assessed. Acceptability relies on judgment that takes into consideration the effect of lighting on noticeable surface imperfections as well as the initial wear of the floor, which can cause some imperfections to significantly lessen or disappear. A floor is subject to much heavier wear than furniture and, although a good-quality finish can be expected, an equivalent finish quality to furniture should not be expected.

Some imperfections that could be expected to some degree in a floor but that should also be assessed include: sanding quality; gloss variation; dust, insects and debris; bubbles and gel particles; and coat levelling.

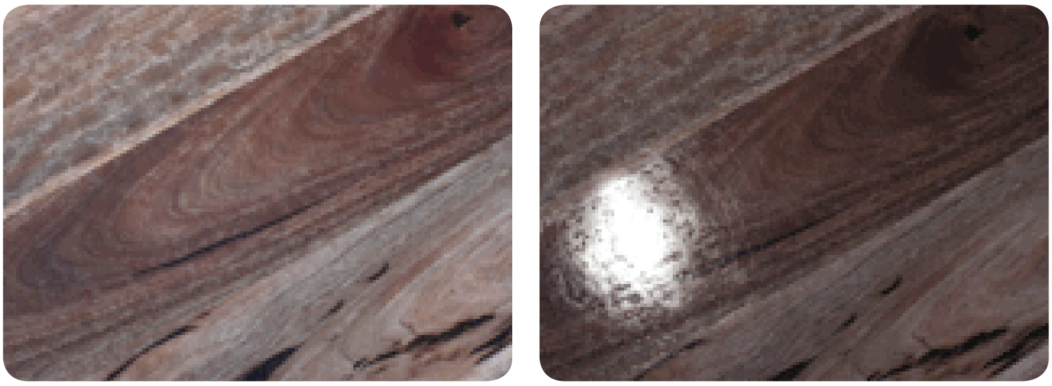


Figure 9.8: The same area of flooring, but with downlights on in the second photo. Downlights highlight sanding imperfections and dust, some of which can be considered acceptable.

10

Care and Maintenance

10.1 General Considerations

Timber floors vary in ease of maintenance depending on the type of coating used and the severity of use. They always greatly benefit from regular care. In doing so, the life of the floor finish and floor are greatly enhanced. However, at some stage the floor will need to be rejuvenated, and this usually requires buffing back and re-coating. Some of the softer floor finishes can also benefit from application of metallised polish, which provides an additional wear surface. It is important that maintenance aspects are passed on to home owners to assist in ensuring ongoing customer satisfaction.

10.2 A Newly Finished Floor

Although a floor may be walked on after initial curing or hardening of the coating, some precautions are necessary with a newly finished floor until the coating system has fully hardened. This may take up to two weeks. Use of the floor before the full cure has been realised can result in increased tendency for scuffing and scratching. It is recommended that rugs are not laid until after the floor finish has fully hardened. Additionally, rugs with rubber backings should never be used, as these may stain or otherwise affect the applied coatings. While light furniture can be replaced and used during this period, it should be ensured that furniture protection felt pads are attached to the feet of tables and chairs, etc, and furniture such as chairs should be lifted and not slid across the floor. Similarly, it should also be ensured that heavy items such as fridges are moved carefully into position – at no time should they be dragged over either newly finished or fully cured floors. Consideration should also be given to chairs with castors, as they can indent softer timbers and also cause premature wear of the coatings they are in contact with. Barrel type castors are less likely to damage a floor than ball castors. Again, these should not be used until the finish has hardened. Avoid walking on wood floors with cleats, sports shoes and stiletto heels, which can easily indent floors.

Figure 10.1: Timber floors are easy to maintain and greatly benefit from regular care.

10.3 Ongoing Care and Maintenance

10.3.1 Ingress of Grit and Direct Sunlight

There are some things that are enemies to timber floor finishes, and one of these is sand or grit that can be brought into the house with footwear. These small particles act like sandpaper, resulting in scratches in the floor. Mats placed both outside and inside external doors provide a simple and effective means of significantly reducing grit from entering the house. Similarly, in high-wear areas, carpet runners and rugs can be effective and can also add to the décor of the house. The kitchen floor generally experiences high wear and therefore a floor rug in this area can be particularly beneficial.

Another aspect that should be considered is the amount of direct sunlight that is reaching the floors. Direct intense sunlight can contribute to gapping and possible cupping of boards. It will also cause the colour of both boards and finish to change with time. Some floor finishes are more prone to darken with age and direct sunlight accelerates this process. Filtered sunlight through sheer curtains or blinds provides an effective means of slowing the colour-change processes and is also effective in controlling gap width at board edges and possible cupping of floorboards. In some instances, it may be decided that window coverings will not be used and, if sunlight has not been controlled by patio roofs or awnings, floors rugs can be used.

10.3.2 Maintenance Plan

Establishing a regular cleaning program will help keep floors in pristine condition. There are many aspects that affect how often the floor requires cleaning and these include the degree of grit present (particularly from children and pets), type of exterior and interior matting used, the level of foot traffic, the types of footwear and the general condition of the area outside the house. Spills should be mopped up when they occur and any leaks must be attended to immediately. Failure to attend to leaking pipe work can result in severe damage to timber flooring, particularly when laid over sheet flooring or directly adhered to a concrete slab. Scuff marks or stubborn stains may be removed with light rubbing using a timber floor cleaner. As some cleaners can attack certain types of coating, where possible, use the cleaning regime specified by the floor coating manufacturer. Alternatively, always test rub an isolated area of floor to verify compatibility of the cleaner used with the coating.

For regular cleaning of domestic floors, an antistatic mop provides an effective means to collect dust and grit. Continual walking on a dirty floor will quickly damage the finish. If a vacuum cleaner is used, the condition of the brushes should be regularly checked. If they have worn thin, contact of the metal head with the floor surface can result in scratching. Hard head vacuum cleaners should not be used as they will invariably cause fine scratches on the floor.

Steam mops are not recommended on polished floors as they can cause damage to certain types of coatings. Most timber flooring and coating manufacturers do not recognise this as an acceptable method, even when it is advertised by the steam mop manufacturer as being suitable. Coatings can become cloudy or opaque, or can peel after steam mop use.

On a fortnightly to monthly basis, floors can benefit from damp mopping. Providing the mop is only damp and the finish is in good condition, mopping carried out correctly will not affect either the finish or the timber. Damp mopping provides an effective deep clean and should be undertaken with a neutral pH wood floor cleaner or product recommended by the finish manufacturer. Harsh detergents or abrasive cleaners are to be avoided, as is the use of methylated spirits and vinegar, as they can chemically attack some types of coatings, e.g. waterborne coatings and penetrating oils. After wetting the mop, it should be wrung out until it is moist before mopping. Using clean water, a final mopping with a mop wrung out until it is ‘dry’ may be used to further remove excess moisture on the boards. Periodically, the protective pads on furniture legs should also be checked to ensure they are clean of grit and to see if they need replacement.

10.3.3 Re-coating

Timber floors are subject to different wear patterns and it is in areas of higher wear that there will initially be signs that the floor requires re-coating. It is important to ensure that excessive wear has not occurred if a total re-sand and re-finish is to be avoided. The finish should be inspected in the high-wear areas. If a few drops of water bead on the surface, the finish is still intact and may require cleaning rather than re-coating. If, however, after a few minutes the water begins to soak in and the timber colour darkens, then the finish is partially worn and re-coating should be undertaken. It is important that the details of the original coating system can be made available to the sander and finisher to ensure compatibility between coats.

A

Appendix A – Moisture Content and Timber Movement

A1 Water in Wood

In all common applications, timber contains moisture. Even timber that has been in service for 100 years will contain similar amounts of moisture to seasoned timber that has just been put into service. The reason for this is that the moisture in the air (humidity) maintains a certain level of moisture in the wood. The moisture present in freshly sawn (i.e. green) timber, straight from the log, is much higher and as a consequence of this, the air absorbs moisture from green timber until a balance is achieved.

A2 Moisture Content

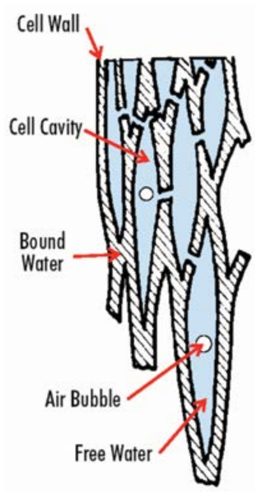
For timber products such as flooring, the amount of moisture present or its moisture content is defined as the mass of water present in the timber divided by the mass of the timber with all water removed, expressed as a percentage. The mass (measured in grams or kilograms) of water present can be determined from the difference in the mass of the timber with water (initial mass) to the mass of timber with the water removed (oven dry mass). The following equation is used to determine the moisture content of timber:

$$\%\ mc = \frac{\text{“mass of water present”}}{\text{“oven dry mass”}} \times 100\%$$

$$= \frac{\text{“initial mass”} - \text{“oven dry mass”}}{\text{“oven dry mass”}} \times 100\%$$

The structure of the cells in timber can be likened to a number of drinking straws glued together. If the straws were full of water, it could be expected that the mass of water contained in the straws would be greater than the mass of the drinking straws alone. In such a case, the moisture content as calculated above would exceed 100%. In a tree, the moisture content may be as low as 40% but can be as high as 180%. Green off-saw timber could therefore have moisture contents of 180%, which means the timber contains 1.8 kg of water for every 1.0 kg of dry timber that was present. In softwoods such as radiata pine and Araucaria, the average moisture contents of 180% or more often occur. In many of our common hardwoods, the moisture content may be no greater than 70%. Cypress, a softwood that grows in drier areas, may only have average moisture contents of 45%. There can also be sizeable variations in moisture content between the outer sapwood of a tree to the inner heartwood.

Figure A1: Timber cell structure.



A3 Drying of Timber for Flooring

Seasoning or drying is the process by which moisture is removed from timber and green timber (i.e. freshly cut boards) may be either air dried or kiln dried or a combination of both. The drying process for flooring often includes more than one stage. Timber is initially stacked to allow air movement between each layer of timber and in this state it can be either air dried by leaving it out in the open for some months, or placed in a low temperature pre-dryer to gently reduce its moisture content under controlled conditions, prior to drying being completed at higher temperatures in a kiln. Some hardwoods are kiln dried from green but many operations use initial air drying or a pre-dryer followed by kiln drying. Softwoods are generally air dried or kiln dried from green.

When we refer to seasoned timber, we are usually referring to timber that has moisture contents within the range of 9% to 14%. This range has been chosen because timber in coastal Australia will usually remain within this moisture content range when used internally. Whether timber is dried by the air or in a kiln, there is always a small variation in the moisture contents of individual boards (usually about 5%). Due to these variations, some boards will take up moisture from the air after being put into service, while others may lose moisture. When timber takes up moisture it expands and when it loses moisture it shrinks. The small moisture variations present at the time of flooring manufacture therefore translate into small differences in board widths as board moisture contents adjust to be in balance with the humidity in the air.

A4 Movement in Timber with a Change in Moisture Content

The cell structure of wood has been likened to a number of drinking straws that are glued together. With regard to this, water in wood resides both within the 'straws' (called free water) and in the walls of the straws (bound water). As indicated above, the moisture content in living trees will vary greatly depending on the species, age of the tree and location in which it is grown. However, no matter what the initial moisture content is of the wood in the trees, shrinkage in timber is minimal until the moisture content reaches approximately 25%. At this level, much of the free water has been removed and it is from this point (called the fibre saturation point) that there becomes a significant reduction in the bound water tied up in the cell walls. Associated with this, the cell walls begin to shrink and we observe shrinkage in timber. This relationship is shown diagrammatically in the graph in Figure A2.

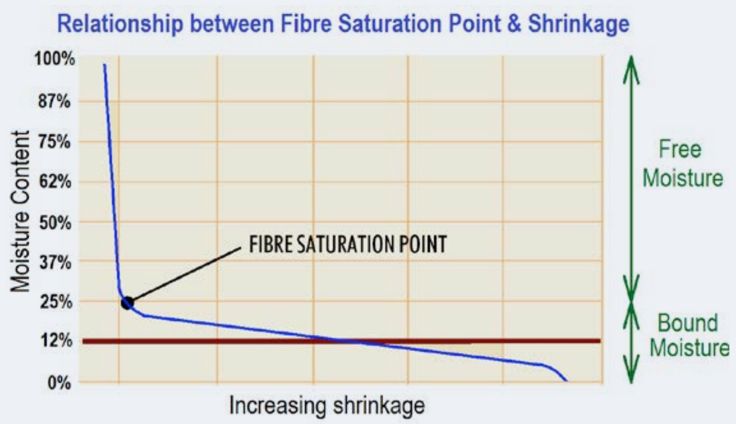


Figure A2: Relationship between fibre saturation point and shrinkage.

Within the sawmilling industry, boards are referred to as being either backsawn or quartersawn and the movement characteristics of each are quite different. In a backsawn board, the angle of the growth rings on the end section to the widest face is less than 45°. In quartersawn boards, this angle is greater than 45°. Backsawn boards are often valued for the 'figure' that appears on the surface of the timber flooring and, with backsawing, the amount of usable timber recovered from the tree is also usually greater. However, backsawn boards can be expected to shrink in width more than a quartersawn board and, due to the angle of the growth rings, backsawn boards will have an inherent tendency to cup when they dry.

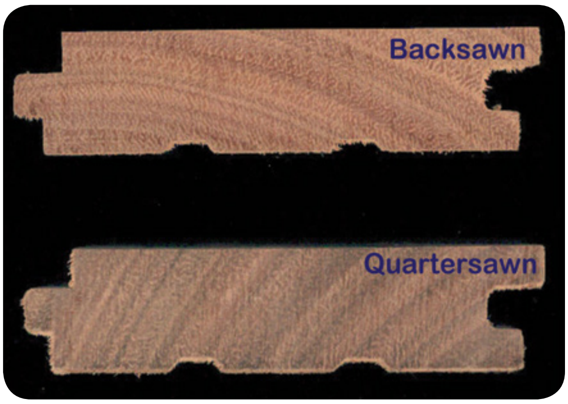


Figure A3: Backsawn and quartersawn floorboards.

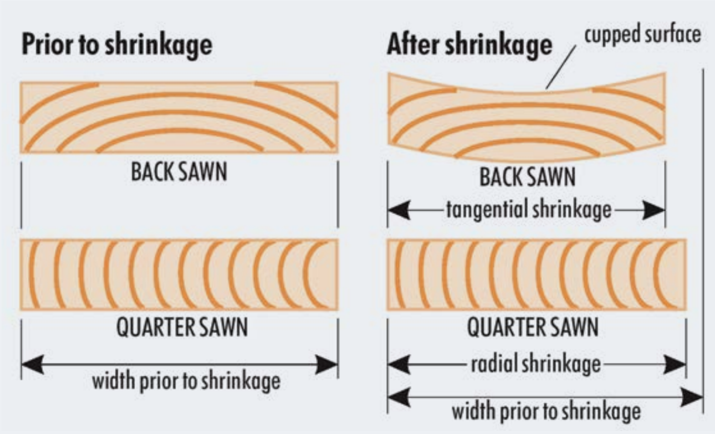


Figure A4: Shrinkage in backsawn and quartersawn floorboards.

The amount of shrinkage that occurs radially (i.e. in a direction that radiates out from the centre of the log) differs from that occurring tangentially (at right angles to the radial direction). Therefore, in a backsawn floorboard the cover width will vary as a result of tangential movement and in a quartersawn floorboard the cover width will vary from radial movement. Flooring manufactured from species grown in Tasmania and Victoria is often quartersawn, whereas species from Queensland, New South Wales and Western Australia are predominantly backsawn.

A useful measure of movement is what is termed the unit tangential movement (UTM). This is the percentage dimensional change for each 1% change in moisture content between 3% and the fibre saturation point for the particular species. For example, Brush Box has a UTM. of 0.38. Therefore a 3% increase in moisture content could on average be expected to cause an 80-mm-wide backsawn floorboard to increase in size by:

$$0.38 \times 3\% \times 80/100 = 0.9 \text{ mm}$$

When dealing with seasoned timber, the UTM can be used to estimate anticipated movement, however, actual movement is often less than the estimate. This is due to the presence of quartersawn material as well as some compression of the timber, which often occurs with regard to applications such as flooring. Therefore care is necessary when applying these figures. Tables of UTM are available from state timber organisations.

A4.1 Flooring Response to Changes in Humidity

A relationship exists between the air temperature, relative humidity of the air and the moisture content that timber will try to attain. This relationship is shown in Figure A5 and it can be seen from this that humidity has the predominant influence over moisture content. As an example, if timber is in a room at 25°C and the relative humidity is 65%, then the timber will in time try to reach approximately 12% moisture content.

Obviously, humidity and temperature will change on a daily basis as well as on a seasonal basis. Because of the relatively slow response rate of timber, we are usually more concerned with seasonal changes. The effects of seasonal changes may be observed in a polished timber floor by the opening and closing of gaps between adjoining boards at different times of the year.

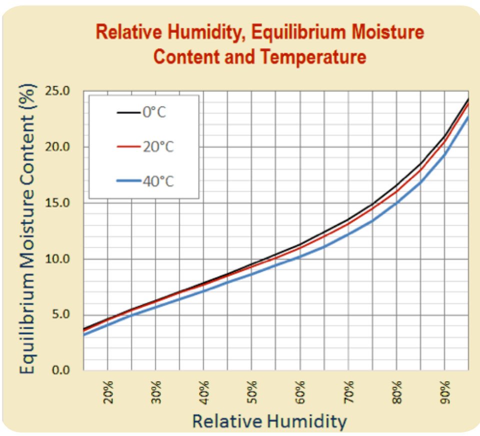


Figure A5: Temperature, RH and EMC.

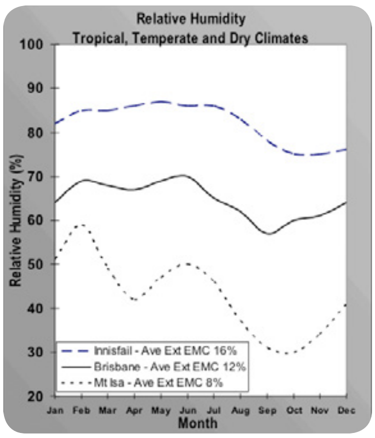


Figure A6: Climatic effects on timber floors.

Weather data provides information on the changes in relative humidity that can be expected in a particular locality, and this is particularly important if installing a floor in a location that differs from the one that you are used to. There can be significant changes over short distances,for example, between a coastal city and hilly rural environment, a half hour's drive away. Examples of different climates, seasonal humidity fluctuations and average moisture contents are given in Figures A5 and A6.

Although these graphs link timber moisture content to surrounding environmental conditions, they do not show the response rate of different species to these changing conditions. The response rate of softwoods such as Hoop Pine or Radiata Pine is more rapid than that of the denser hardwoods such as Spotted Gum. However, even within the hardwood or softwood groups, response rates can also vary quite markedly. Indicative response curves from one trial for Spotted Gum when placed in a very humid environment (18% EMC) followed by a dry environment (8% EMC) are shown in Figure A7. The first graph shows moisture content changes and the second graph the change in cover width. Clearly this illustrates the variability that can be present. Blackbutt, although a dense hardwood, takes up and loses moisture quite rapidly.

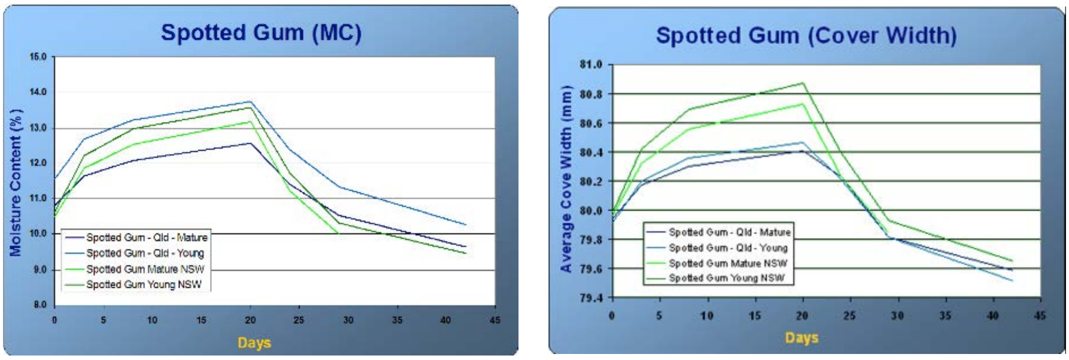


Figure A7: Results from the FWPRDC Research on Timber Flooring undertaken by Timber Queensland Ltd. The graphs show averages of 10 pieces of Spotted Gum flooring from different sources placed in a conditioning chamber at 18% EMC for 21 days followed by 8% EMC for 21 days.

The species that more quickly take up or loose moisture will generally follow seasonal changes more closely. The graphs also indicate that the rate of moisture uptake, which may result from a relatively quick and sustained change in weather conditions, can initially be quite rapid, but the rate of increase then slows over time. This aspect is also reflected in timber floors. Floor installers sometimes comment that a floor may have shrunk a lot in the first week or so after laying, but that it hadn't moved much since then.

As a guide, provided below is a table that outlines the density of the species, whether the flooring is predominantly backsawn or quartersawn and an indicative measure of the species response rate to moisture uptake and loss. In locations where floors are likely to expand after installation, particular care is necessary to adequately accommodate the expansion that will occur (i.e. intermediate expansion joints, loose lay and acclimatisation). This is particularly so with higher density timbers and particularly those higher density timbers that respond quickly to seasonal humidity changes.

Table A1: Characteristics of different species.

Species classification	Density classification	Cutting pattern	Movement in response to humidity changes
Radiata Pine	Low	Backsawn	Low
Tasmanian Oak	Medium	Quartersawn	Medium to high
Victorian Ash	Medium	Quartersawn	Medium to high
White Cypress	Medium	Backsawn	Low
Jarrah	Medium to high	Backsawn	Medium to high
Rosegum	Medium to high	Backsawn	Medium
Blackbutt	High	Backsawn	High
Spotted Gum	Very High	Backsawn	Low to medium
Grey Ironbark	Very high	Backsawn	Medium

Appendix B – Measuring Moisture Content of Timber and Sheet Products

Checking the moisture content of timber flooring prior to installation is important to provide a check on the product supplied, evaluate the need for additional expansion allowance and to ensure that subsequent movement (shrinkage and swelling) remains within accepted bounds. This appendix outlines the various methods used to test the moisture content of timber. Also included in the appendix is a method to evaluate the moisture content compliance of packs of flooring.

B1 Moisture Content Measurement

Figure B1: Moisture content measurement.

Initial mass 32.63 gm

Oven dry mass 29.49 gm

$$MC = \frac{32.63 - 29.49}{29.49} \times 100\% = 10.65\%$$

B1.1 Moisture Content

Moisture content is simply the mass of moisture present in wood divided by the mass of the wood with no moisture in it, expressed as a percentage. What is important about the moisture content in timber is that the board width will increase with increasing moisture content and will decrease with decreasing moisture content. At the time of machining, cover width variations are usually minimal and subsequent variations that occur in board widths are usually due to changes in moisture content. It is often the current and future variations in board width that are of primary importance, and one important purpose of moisture content testing is to indicate what future movement can be expected.

By simply looking at the end of a pack of flooring that may be a month or so old, it is often possible to obtain information about the moisture content of the timber within the pack, even without using a moisture meter.

For example in a three-month-old pack of flooring, some moisture changes are likely to have occurred. If the nominal cover width of was 80 mm and:

- board widths measure between say 79.6 mm and 80.4 mm, then the material is likely to have been dried to within narrow moisture content bounds and should perform well in service.
- board widths range from say 78 mm to 81 mm and some boards are cupped, then the material is likely to have been dried to quite wide moisture content bounds and the floor is likely to show some wide gaps at board edges along the length of the board and near end matched joints.
- board widths range from say 80 mm to 84 mm, then some of the material may have become wet after manufacture.

It is therefore important when considering moisture content to also take the board widths into consideration. Australian Standards that cover the moisture content of flooring vary in their limits as this depends on the species. Table B1 provides some information on species types, the number of the applicable Standard and the moisture content ranges applicable to flooring.

Table B1: Moisture content bounds.

Species Group	Moisture Content Bounds (moisture content anywhere within a board)	Number of the applicable standard
Hardwood	9% to 14%	AS 2796
Softwood	9% to 14%	AS 4785
Cypress	10% to 15%	AS 1810

B2 Methods of Measuring the Moisture Content of Timber

B2.1 How Moisture Content is Measured

Moisture content is determined by the oven dry test method and can be estimated using moisture meters. The two common types of meters in use are the resistance meter and the capacitance meter. Meters use changes in electrical properties caused by the wood and water within it to provide an estimate of the moisture content. Oven dry testing requires a set of scales and an oven from which the moisture content is determined from the change of mass as the sample dries.

Left: Figure B2: Capacitance moisture meter - Measures average moisture – Need to set species density.

Right: Figure B3: Resistance moisture meter - Measures moisture between the pins – Need to correct reading for temperature and species.

B2.2 Measurements by Different Methods

In any piece of flooring, the moisture content is likely to vary to some extent down the length of the piece and from the outer surfaces (case) to the centre (core). With regard to case-to-core differences, some methods of measurement are able to measure this while others can only measure the average moisture content of the board. This can be an important consideration when choosing a measuring method as case-to-core variations or the difference between upper and lower case may need to be determined. At other times, it may be important to gain many measurements quickly to gain an appreciation of the average estimated moisture content. In cases of dispute, accuracy may be of prime importance.

Resistance meters measure the highest moisture across the exposed ends of the pins, whereas capacitance meters measure an average through the piece. Oven dry testing measures the average moisture content of the sample placed in the oven but by cutting the sample up into applicable smaller pieces, case and core moisture contents can also be determined.

The three common methods of measurement, including their application, benefits, limitations and accuracy are outlined below.

When is it used

- Oven dry testing is often carried out where variations in moisture content in the final product can have a significant effect on the performance of the product.
- It is used where accurate results are required or meter readings are known to be inaccurate, which can include some timber species but also particleboard and plywood sub-floors.
- In case of disputes, Australian Standards generally refer to this method as it provides measurements that are more accurate and reliable.
- Manufacturers of board products often undertake oven dry testing in the manufacture of their products.
- Some timber organisations also have the appropriate testing equipment and contract out these services.

Figure B4: Oven dry testing – Provides the most accurate moisture content test.

Testing equipment and facilities

- The equipment required is an accurate balance or set of scales and a laboratory oven that is able to maintain a temperature of 103°C ± 2°C.

Sampling from a pack

- The samples need to be representative of the timber in the pack being tested and capture the variation present. This may therefore include some outside boards as well as some from within the pack.
- If cupping is present or there is variation in the cover width by more than 1 mm, samples should be provided which include two boards that are cupped, two with wider cover widths and two with narrower cover widths. (Packing pieces are not to be provided as samples.)
- If boards are not cupped and there is little variation in cover width throughout the pack, five boards should be chosen. (Packing pieces are not to be provided as samples.)
- The samples from which test pieces will be cut should be taken not less than 400 mm from the end of a board and should be approximately 300 mm long.
- If the sample is from a board on the top, bottom or edge of the pack, it should be marked as being an outside board.
- The samples should be individually wrapped in 'Glad Wrap' or similar to reduce moisture content changes during transport.
- The samples should be stored in a cool place and delivered to the testing facility within 24 hours.

Figure B5 : Sample selection.

Testing procedure

- From the 300 mm long pack samples, test pieces are cut with a length of between 15 mm and 30mm so that the required mass is achieved to suit the accuracy of the mass measuring equipment. If the equipment measures to 0.1 g, a test sample of at least 50 g is required. The sample may be less than 50 g if the equipment measures to 0.01 g.
- The initial masses of the test pieces (and usually the cover widths) are recorded. The test pieces are placed in the oven for at least 24 hours and then reassessed at four-hour intervals until there is minimal change in mass. For longer samples in denser species, times of 48 hours or so may be required. The mass after drying in the oven (i.e. oven dry weight) is recorded.
- The moisture content is then calculated for each test piece by applying the following equation:

Moisture content (%) = ((Initial mass – oven dry mass)/ oven dry mass) x 100%

For example, if the initial mass is 57.6 g and the oven dry mass is 43.3 g then the moisture content is:

Moisture content (%) = ((57.6 g – 49.3 g)/ 49.3 g) x 100 % = 16.8%

- This method provides the average moisture content for the test pieces. Case and core measurements can be obtained by cutting the appropriate sections out of larger test pieces prior to testing.

Interpreting results

- The sampling method outlined above aims to capture the variation present in a pack of timber and from this it can be assumed that most of the timber within the pack will fall within the upper and lower moisture content measurements.
- In applications where cover width is important, both the cover width and the moisture content should be considered. Often boards of lower cover width are also those of higher moisture content and further shrinkage of this material can be expected.

Benefits and limitations

- The main advantage of this method is its accuracy.
- The method is time consuming, not portable and more expensive.
- The most common error results from insufficient drying, which underestimates the moisture content. If sample masses are small, measuring errors can significantly affect the moisture content calculation.
- Microwave ovens can produce good results and speed up testing, however, there are no formal procedures and there is the risk of evaporating volatile compounds in addition to the water, which affects accuracy.

B4 Electrical Resistance Meter to Estimate Timber Moisture Contents

Principal of operation

The electrical resistance of timber reduces as the moisture in timber increases. These meters measure the flow of electricity between two pins where the timber acts as an electrical resistor between the pins. The scale on the moisture meter is graduated to read moisture content. Wood temperature affects the readings and for this reason wood temperature above or below 20°C, requires correction to the reading. Temperature correction if not already taken care of by the meter is applied before species correction. Species correction is necessary as two different timber species at the same moisture content may not have the same electrical resistance. Meters are generally set up relative to one species, Douglas Fir (Oregon) and species corrections are then applied for other species. There comes a point where the water in timber is so low that the resistance is difficult to measure accurately or on the other hand sufficiently high that the resistance does not change greatly and is prone to greater errors. However, these meters generally provide reliable results between 6% and 25% moisture content.

Types of meters

A wide variety of meters are available. All have two pins that are used to penetrate the timber but the pins may vary in length from approximately 6 mm in length up to 50 mm. The longer pins are often insulated up to the pointed ends to prevent surface moisture effects from interfering with core measurements. Those with longer pins are also usually of the ‘sliding hammer’ type, which provides a means of driving the pins into the timber. The sophistication of the meters varies greatly in terms of features such as inbuilt temperature correction, pre-programmed species calibration and depth indication. Many of the meters now come with a calibration block.

Using resistance meters

- The calibration of the meter should be checked prior to use and this is usually done with a test block that contains electrical resistors that correspond to the moisture contents specified on the test block.
- Measurements are then taken in clear timber at least 400 mm from the ends of boards.
- Some meters require measurements to be taken with the pins running down the length of the board while with others the pins are to run across the width of the board (check with the manufacturer's manual).
- The pins are driven to the desired depth to which the moisture content reading is required. As case and core measurements can be significantly different, use of meters with short pins may require boards to be cut and the pins inserted in the end grain to provide a better estimate. In high density timbers, holes may need to be drilled for the pins.
- The pins need to be in firm contact with the timber, otherwise low readings may occur.
- Readings should be recorded to the nearest 0.5% and read shortly after penetration.
- Each reading is to be corrected for wood temperature first (provided this is not done automatically) and then for species (providing the species has not been set on the meter).
- Refer to Table B2 for temperature correction factors and species correction factors for some common commercial species. Additional temperature and species correction factors are available in AS 1080.1.

Limitations, accuracy and precautions when using resistance moisture meters

When using meters a common sense approach is necessary. Each reading should be evaluated and if not as expected, then the reasons for this should be investigated. The meters generally provide a reasonable estimate of the moisture content to 2% in the measuring range from 8% to 25% and as stated above readings should be recorded to the nearest 0.5%. There are a number of factors that are known to affect meter readings and these are:

- Measurement necessitates damaging the surface of the timber.
- The method is conducive to only taking a relatively small number of sample readings.
- Readings near the board surface can be significantly different from the core.
- Low battery can cause low readings in high moisture content material.
- Uncertainty over species that are being used in can make species corrections difficult.
- Species such as Brush Box have very high species correction factors and are prone to greater error.
- Use for extended periods in high humidity environments can raise meter readings.
- Meters only read wettest part that the exposed surfaces of the pins are in contact with.
- Surface moisture can provide artificially high readings not reflecting wood moisture content.
- Salt water or any preservative treatment salts can affect meter readings and will usually raise them.
- Electrical wiring in walls can affect the readings.
- If meter readings are not in line with what is expected, then this may necessitate oven dry testing to more accurately estimate the moisture content.

B5 Electrical Capacitance Meter to Estimate Timber Moisture Contents

Principal of operation

These meters measure an electrical property called the 'dielectric constant'. An electric field produced by the meter and the presence of the timber on which the meter is positioned, form a 'capacitor' type of arrangement. The electric field can penetrate deep into the timber but meter readings are biased toward moisture in the surface layers. Both the moisture content and the density of the timber affect this electrical property. The effective range of capacitance meters is from approximately 0% to 30% moisture content. The more sophisticated meters can be adjusted for timbers of different densities. Less expensive meters do not have density compensation and for these meters corrections to meter readings must be applied based on the density of the species being tested. Such meters are usually preset to be more suited to softwoods and lower density hardwoods, and this can cause limitations with higher density species (i.e. large correction factors are necessary).

Types of meters

Meters are imported from overseas and range from those with few features to those with a wider range. Features may include settings for timber density (or specific gravity) and timber thickness as well as the ability to store readings and apply some statistics to the results. It is necessary to ensure that the meter is going to meet your specific needs and, if it is being used with higher density hardwoods, timber density (or specific gravity) adjustment must be seriously considered.

Using capacitance meters

- The appropriate meter settings for density and board thickness, etc, should be applied and the meter checked for calibration.
- The density (specific gravity) is often calculated differently for different reasons (i.e. green density, density at 12% moisture content or basic density). Specific gravity is the density of a material divided by the density of water (approximately 1,000 kg/m3). It is necessary to obtain from the meter supplier the relevant figures applicable to the meter being used. Table B3 provides densities at 12% moisture content.
- Measurements are to be taken in clear timber away from knots, etc.
- Some meters require measurements to be taken with the meter in a particular orientation on the board (check with the manufacturer's manual).
- The plate of the meter must be in firm contact with the board before a reading is taken.
- Readings should be recorded to the nearest 0.5%. If no density (specific gravity) settings are available then these meter reading needs correcting.

Limitations, accuracy and precautions when using capacitance moisture meters

Similar to resistance meters, common sense must prevail when using these meters, with readings evaluated and investigated if not as expected. Providing the density is accurately assessed, these meters provide a reasonable estimate of the average moisture content in a board up to approximately 25% moisture content. Again there are a number of aspects that need to be considered when using these meters:

- Readings can be taken very quickly either within a single board or in a number of boards.
- The meters do not damage the surface of the timber that is being measured.
- Within species density variations can be quite high, particularly between mature and young growth material.
- Estimating the correct density adjustment can be difficult, particularly if the meter is being used on a range of different timbers.
- Density (specific gravity) information for Australian species relating to specific meters is not well documented.
- Difficulties with setting density (specific gravity) adjustment often reduce field measurement accuracy.
- If no timber thickness adjustment is provided, thicker pieces at the same moisture content are likely to read high.
- Any gap between the meter and the board (e.g. a cupped surface) will cause a lower reading.
- Framing raises meter readings where exposed timbers cross (e.g. softwood floor over hardwood joists).
- The presence of salts (either from salt water or preservation treatment) will cause readings to be higher.
- Readings are also considered to be less reliable with Brush Box.

Again, if meter readings are not in line with what is expected, this may necessitate oven dry testing to estimate the moisture content more accurately.

B6 Assessing Timber Moisture Content for Conformity

Australian Standard 1080.1 – Timber – Methods of Test – Method 1: Moisture content outlines a procedure for moisture content acceptance testing of timber using a resistance moisture meter. The Standard should be referred to for full details. Provided below is a summary of the procedure:

- Sample at least one pack out of every 10, or one pack out of every five for higher value products (e.g. flooring).
- For each pack assessed (of up to 200 boards per pack), 15 boards are randomly selected and tested.
- The pack is deemed to comply if not more than one test result (after applying temperature and species correction factors) is outside the allowable range. This is providing the result outside allowable limits is not too different from other results.
- This sampling procedure is based on at least 90% of the samples occurring within the allowable range.

B7 Measuring the Moisture Content of Plywood and Particleboard

Meters do not provide an accurate and reliable measure of moisture content in these materials. To determine the moisture content of these materials, the oven dry method should be used.

Table B2: Temperature correction factors for resistance moisture meters.
(Note: This is wood temperature not air temperature)

Meter reading %	**8 %**	**10%**	**12%**	**14%**	**16%**	**18%**	**20%**	**22%**	**24%**
Wood Temperature	Temperature correction to be added to or subtracted from meter reading before applying the species correction factor								
15 °C	Nil	Nil	+1	+1	+1	+1	+2	-	-
20 °C	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	-
25 °C	-1	-1	-1	-1	-1	-1	-1	-1	-
30 °C	-1	-1	-1	-2	-2	-2	-2	-2	-2

Table B3: Species correction factors for resistance moisture meters.

(Note that this only contains some common species – refer to AS 1080.1 and FWPRDC report PN01.1306 for a more complete list. The tabled figures are based on the Deltron Moisture Meter. Figures may differ for other meters - refer FWPRDC report PN01.1306).

Meter reading %	**8 %**	**10%**	**12%**	**14%**	**16%**	**18%**	**20%**	**22%**	**24%**	**Density**
Species	Resistance meters are generally calibrated to Oregon (Douglas Fir). Apply the following species corrections after temperature correction.									**At 12% MC**
Oregon (Douglas Fir)	0	0	0	0	0	0	0	0	0	550
Australian Hardwoods										
Yellow Stringybark (NSW)	+4	+4	+3	+3	+2	+2	+1	+1	0	900
Red Ironbark Broad Leaved & Red (NSW)	+4	+3	+3	+3	+2	+2	+2	+1	+1	1100
Grey Ironbark (Qld)	+3	+2	+2	+2	+2	+2	+2	+2	+1	1105
Forest Red Gum - Blue Gum (Qld)	+3	+2	+2	+2	+2	+1	+1	+1	0	1000
White Mahogany – Honey Mahog.(Qld)	+2	+2	+2	+2	+2	+2	+2	+2	+2	1000
River Red Gum (Vic regrowth)	+2	+2	+2	+2	+2	+2	+2	No data	No data	900
Rose Gum - Flooded Gum (Qld & NSW)	+2	+2	+2	+1	+1	0	0	0	0	750
Sydney Blue Gum (NSW)	+2	+2	+1	+1	0	0	-1	-1	-1	850
Blackbutt (Qld & NSW)	+1	+1	+1	+1	+1	+1	+1	+1	+1	900
Turpentine (Qld & NSW)	+1	+1	+1	+1	+1	+1	+1	+1	0	950
Blackbutt (NSW regrowth)	+1	+1	+1	+1	+1	0	0	0	No data	900
Grey Ironbark (NSW)	+1	+1	+1	+1	0	0	0	0	0	1100
Red Ironbark Narrow Leaved (Qld)	+1	+1	+1	0	0	0	0	0	0	1090
Blackwood (Tas)	+1	+1	0	0	0	-1	-1	-2	-2	640
Myrtle (Tas)	+1	+1	0	0	-1	-1	-2	-2	-2	700
Spotted Gum (Qld Citridora)	+1	0	-1	-1	-2	-3	-3	-4	-5	1100
Shining Gum (Vic)	+1	0	0	0	0	0	0	-1	-1	700
Jarrah (WA regrowth)	0	0	+1	+1	+1	+1	+1	+1	No data	780
Grey Gum (Qld & NSW)	0	0	0	0	0	0	0	0	0	1050
Tallowwood (Qld & NSW)	0	0	0	0	0	0	0	0	0	1000
Alpine Ash (Vic & Tas regrowth)	0	0	0	0	0	0	-1	-1	No data	650
Mountain Ash (Vic & Tas regrowth)	0	0	0	0	0	0	-1	-1	No data	650
Messmate (Vic & Tas regrowth)	0	0	0	0	-1	-1	-1	-1	-2	750
Southern Blue Gum (SA plantation)	0	0	-1	-1	-1	-2	-2	-3	-3	700
Spotted Gum (NSW Regrowth Maculata)	0	-1	-1	-2	-3	-4	-5	-5	-6	1100
Brush Box (Qld & NSW)	0	-1	-2	-3	-4	-5	-6	-8	-9	900
Manna Gum - Satin Ash (NSW)	-1	-1	-1	-1	-2	-2	-2	-2	-3	800
Imported Hardwoods										
European Beech	+3	+3	+3	No data	No data	No data	No data	No data	No data	690
Kwila / Merbau (Malaysia)	+2	+2	+2	+2	+1	+1	+1	+1	+1	850
Sugar Maple (Nth America)	-1	0	+1	+1	+1	+1	+1	+1	No data	740
New Zealand Species										
Kauri	+2	+1	0	-1	-2	-2	-3	-4	-5	560
Matai	+1	+1	0	0	0	-1	-2	-2	-2	600
Red Beech (heartwood untreated)	-	+2	+2	+2	+2	+2	+2	+1	+1	560-740
Rimu (sapwood untreated)	-	+2	+1	+1	+1	0	-1	-2	-3	560
Rimu (truewood untreated)	-	+1	0	-2	-3	-4	-5	-6	-7	560
Tawa (untreated)	-	+1	0	-1	-1	-2	-3	-3	-4	730
Softwoods										
Araucaria - Hoop Pine (Qld & NSW)	+3	+2	+2	+2	+1	+1	+1	0	0	550
Radiata Pine (Vic)	+2	+2	+2	+2	+2	+2	+2	+2	+2	550
Cypress (Qld & NSW)	+2	+1	+1	+1	+1	+1	+1	0	0	700

Note:

1. No correction factors are published for Gympie Messmate, New England Blackbutt or Northern Box. Oven dry testing is the preferred method for Brush Box.

2. Tables for Tasmanian Oak indicate a +2% species correction for meter readings up to 16% and +1% thereafter. Research, as outlined above, indicates that a +0% correction as provided in the table for this species mix of Alpine Ash, Mountain Ash and Messmate to often be applicable with younger material.

Appendix C – Slab Moisture Assessment

C1 Properties of Moisture in Concrete

Concrete is a porous material that is able to hold water and water vapour in small voids or pores within its structure. Similar to the cells in timber, the pores can be saturated and full of water or moisture can also exist inside the pores as a vapour.

It is therefore possible to determine the moisture content of concrete by the oven dry method, similar to timber, but with concrete it is also possible to determine the quantity of moisture vapour held within the pores by measuring relative humidity within a slab.

Another similarity to timber is that water vapour will move in and out of concrete depending on atmospheric conditions and the relative humidity within a slab will remain quite high until the water in the pores has evaporated. At this point, the moisture content of the concrete is near 2%. However, when concrete is near saturation the moisture content is only about 6%.

Referring to Figure C1, it is apparent that once both timber and concrete have lost their 'free water' from inside their cells and pores then under conditions of 75% relative humidity timber attains a moisture content of approximately 14% and concrete about 2%.

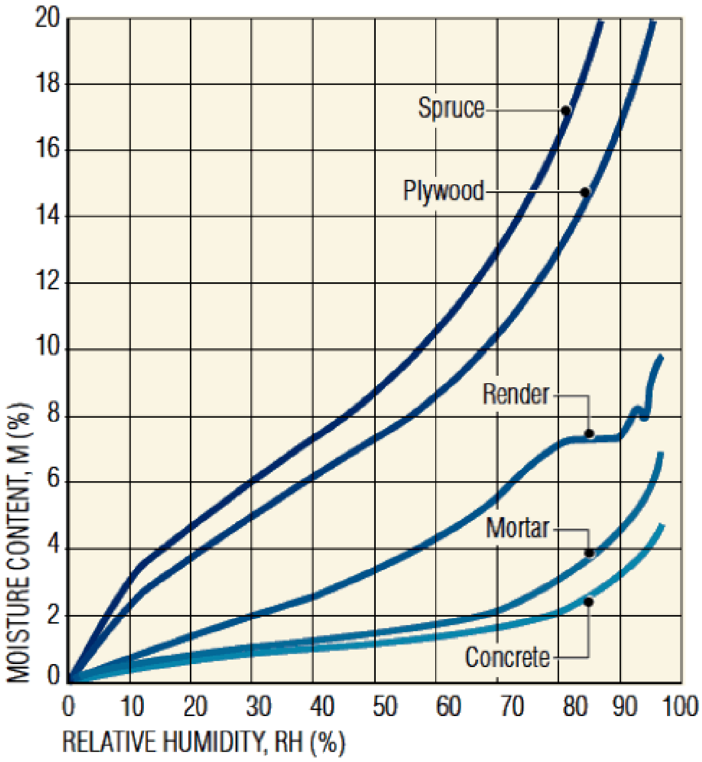


Figure C1: Sorption isotherms. *Source: CC&A datasheet – Moisture in Concrete*

When concrete cures, a hydration reaction occurs that uses up much of the added water. However, even after curing, the pores will contain a significant amount of water, similar to the water within the cells of a board that has been freshly cut from a tree. In both cases, it is from here that drying begins with the lower relative humidity air of the surroundings causing evaporation from the surfaces, and this continues until the 'equilibrium moisture content' is achieved. Similarly, with both materials, the thicker either the board or slab is – the longer it takes to dry.

With timber, we know that density affects the drying rate. With concrete, the water–cement ratio can and does vary and the lower this ratio is, the shorter the drying time. Lower water–cement ratio concrete also results in less permeable higher strength concrete. With a water–cement ratio of 0.5, drying will generally be achieved within three months. Concrete will, however, be slower drying in higher humidity or lower temperature conditions or with higher water–cement ratios.

When measuring the moisture content of an unseasoned timber post, the moisture content soon becomes much lower near the exposed surface than in the core. The same principal applies to a concrete slab. If we were to measure the relative humidity throughout the depth of a slab as it dried, it may initially be close to 100%. Over time, for example, the relative humidity may reduce to 50% near the surface, but toward the lower surface of the slab it may still be well over 90%. In either case, a surface moisture content reading is not going to provide an indication of the moisture held deeper within the post or toward the bottom of the slab. If a timber floor is laid directly over a concrete slab prior to it drying from lower down, then moisture will migrate to the slab surface and affect the timber floor. This is illustrated in Figure C2 for a 100 mm thick slab over a ground moisture membrane.

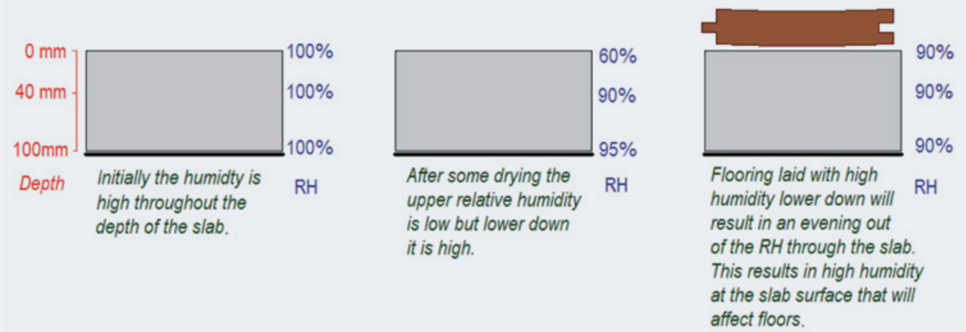


Figure C2: Relative humidity redistribution in a concrete slab as it dries.

From Figure C2, it is evident that surface moisture measurements cannot be relied on to ensure the performance of a timber floor laid above and, for this reason, in-slab relative humidity measurement is gaining in popularity around the world. You will also note in this example that with flooring laid over the slab, the relative humidity at 40 mm or 40% of the depth of the slab is the same at 90% relative humidity prior to and after the flooring was laid. It has been found in slabs that dry from one side only that measurements taken at 40% of the slab depth provide a close approximation to the relative humidity that will occur beneath the floor covering at some later date. If able to dry from both sides, measurements at 20% of the slab depth are applicable.

C2 Timber Floors and Concrete Slabs

Whenever a timber floor is laid over a concrete slab, it is important that the slab is sufficiently dry, irrespective of the method of installation of the timber floor. A polyethylene vapour barrier or slab moisture vapour retarding barrier can be used directly over the top of the slab as an added precaution. It is not recommended that such barriers be used to compensate for slabs where slab age is young and other testing indicates that slab moisture levels are high. A moisture vapour retarding barrier will still permit the transfer of some moisture and the rate is to some degree dependent on the moisture within the slab. In such instances, the flooring could still be affected. Note that not all moisture vapour retarding barriers used on concrete are recommended for use with timber floors. Appropriate measures must also be taken when there are construction joints or where a new slab is added to an existing slab.

It is also important to ensure that slabs have ground moisture membranes beneath them that comply with AS 2870. These membranes separate the concrete from possible sources of moisture that may delay or could prevent the concrete from drying adequately. Provided they are installed correctly, water vapour transmission through them is minimal. It has been shown that such membranes form close contact with the slab preventing lateral moisture movement between the two. Puncturing or gaps in the membrane can result in localised areas of higher moisture, and slab edge dampness also needs to be considered.

With a water–cement ratio up to 0.5, (although likely to be a little higher in house slabs), three to four months drying after the house is enclosed should be sufficient with a 100-mm-thick slab drying from one surface only, or six months for a 150-mm-thick slab and 12 months for a 200-mm thick-slab. If drying from both sides of the slab, then these times are halved. However, relying only on slab age is not sufficient as experiences have indicated that in some instances moisture-related problems have still occurred. At the time of floor installation, you will generally not be aware of what the actual water–cement ratio was (or if water had been added on site), how well the ground moisture membrane was installed or how well the concrete was placed. The presence of beams also needs to be considered. As indicated above, aspects such as weather, including temperature and humidity, also influence drying. Therefore, regardless of the age of the slab, its moisture levels require further assessment prior to laying a timber floor.

C3 Measuring Slab Moisture

There are various methods of measuring the moisture content of slabs and, similar to timber, these include both types of electronic moisture meters. However, there are also other means that measure the vapour emission from the slab. These tests include a simple polyethylene film test, use of a hygrometer to measure the humidity above or within a slab and use of various chemicals.

Preferences of test method vary considerably and each has its limitations. Meters or use of a hygrometer are often preferred as they are relatively quick and easy to use and results may be recorded. However, as with any electrical instrument, the accuracy of the instrument needs to be taken into consideration and periodic calibration checks are necessary. As with all testing, the results need correct interpretation.

It is evident from the above that what is important is the potential amount of moisture that can be released from the slab as well as the rate at which it is released. Test methods and equipment have been developed for each aspect, but each one has its associated advantages and disadvantages.

A qualitative test was developed where clear polyethylene film or glass is fixed over the slab and condensation or darkening of the concrete after 24 hours can indicate a high release rate of moisture from the slab. However, this simple method has been found unreliable as it is temperature dependent, and results at times have indicated that slabs were dry when they were not. In the United States, the moisture vapour emission rate (MVER) has been the standard test for many years. Calcium chloride readily absorbs moisture from the air and this method uses its increase in weight when encased above a slab to determine the moisture release from the slab. For timber floors, 15g/m2/24 hr was deemed to be the upper limit. This method takes a number of days to complete and over the years has been found deficient under certain conditions. It also does not account for moisture deep in the slab. In New Zealand and some other parts of the world, a relative humidity box above the slab has been used. In Australia, moisture meters – either resistance or capacitance – have been used. More recently, in Australia as in other parts of the world, in-slab relative humidity measurements are being taken and this method is becoming increasingly accepted as providing more useful information about slab moisture.

Test methods and considerations relating to moisture meters and in-slab relative humidity are outlined below. However, with any method it must be remembered that the test provides no indication about how slab moisture may change seasonally or that outside moisture sources can affect the flooring system. Although the flooring contractor may not be responsible for such external influences it is expected that the contractor would assess the moisture condition of the slab prior to floor installation.

With regard to this, it would be appropriate to determine quite precisely when the slab was laid and assess moisture contents or relative humidity, within or above the slab, together with the age of the slab. It should also be assessed whether an older slab may not have a moisture membrane beneath the slab. These details need to be recorded for each job and the installer needs to be satisfied with the results before proceeding.

C4 Moisture Meters

Figure C3: Concrete capacitance moisture meter.

Both resistance moisture meters and capacitance meters have been available for some years. Australian Standards such as the pre-2007 version of AS 2455 (Textile floor coverings – Installation practice) specified that moisture contents below 5.5% were acceptable for resilient flooring and it appears that this figure was taken up by the timber flooring industry. In view of the information provided on sorption isotherms in Figure C1, it would appear that this limit is consistent with a saturated slab. There have been many floors laid with readings of, for example, 4.5% where no problems were experienced. In other instances, however, readings of this level have been associated with floor moisture issues. Due to this quandary and the fact that meters and particularly capacitance meters only measure within 25 mm of the concrete surface, their use can provide guidance and be useful for comparative purposes but should only be used as part of the assessment. With one brand of capacitance meter, readings of 6% to 7% have been recorded on a slab that was a few days old and, on a five-year-old slab with no moisture concerns, readings of 1.7% to 2.0%. This is in line with the data shown in Figure C1.

The availability of resistance moisture meters has reduced and that of capacitance moisture meters has increased. The capacitance meter has the advantage of being able to perform many tests very quickly over the slab and therefore, for the purpose of doing a quick survey and comparing different areas, it has significant benefits. Finally, it should be noted that additives as used in some parts of the country may have an effect on meter readings.

C5 In-Slab Relative Humidity

In the United States, the test method is covered by ASTM F2170 'Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs using in-situ Probes'. It simply involves drilling a hole in the slab, inserting a capped sleeve, waiting a period of time and then inserting a probe to measure the relative humidity of the air in the hole in the slab. Some specifics of the testing requirements are:

- The in-service conditions of relative humidity and temperature are to be maintained for 48 hours prior to testing (21°C to 29°C and 40% to 60% RH).
- The depth of the hole is 40% of the slab thickness if drying is from one surface or 20% if drying from two surfaces.
- The hole is sealed for three days to allow the internal relative humidity of the air in the holes to become the same as that of the concrete. The probe must be given time to equilibrate before taking a reading.
- Three tests are required for approximately 100 m2 of floor area.

There has been much discussion about acceptable in-slab RH levels and no clear guidance is available at this stage. In some literature a maximum value of 75% is suggested, in other literature specific to parquetry floors a figure of 60% is quoted. However, in humid climates it may be difficult to achieve 60%. It is also not clear from the literature whether there is a difference between above-slab relative humidity limits and in-slab relative humidity limits. Similarly, companies producing measuring equipment do not provide guidance in this area.

C6 Considerations for House Slab Assessment

When considering house slabs, a check list (see example) can be used to assess the risk. Note that, as there can be differences between the readings of capacitance meters, the limits in provided in Table C1 may differ and need to be determined depending on the meter and locality.

Example check list

If the answer to any of the following questions is 'No' then risks are greater and need to be considered.

1. Is the slab height/floor >150 mm above ground level (including above external patios)?
2. With slab surface testing, was the slab found to be sound, flat and with no hollow sounds under any patches?
3. Do water droplets readily absorb into the slab?
4. Is the slab known to be of an age where an under-slab moisture membrane was a building requirement?
5. Moisture testing (refer to Table C1) – If using a capacitance meter, record at least 20 readings including all internal and external corners and where possible slab thickenings or beams may be present. Are all readings in the moderate-to-low range of the table?
6. If using an in-slab Hygrometer, readings of 75% are indicative of an older dry slab. In Sweden, in-slab relative humidity up to 80% is seen as suitable for timber flooring products to be laid over.
7. If using above-slab relative humidity (as more often used in New Zealand), a RH of not more than 70% is indicative of minimal moisture transmission from the slab or through a moisture vapour retarding barrier.

Table C1: Slab age, moisture content and risk.

SLAB AGE	MOISTURE CONTENT	RISK
< 3Months	-	Very High
3 Months	Up to 5%	High
3 to 6 Months	Up to 4%	Moderate
6 Months - 3 yrs	Below 2.75%	Low
6 Months - 3 yrs	2.75% to 3.5%	Moderate
6 Months - 3 yrs	Over 3.5%	High
> 3 years	Over 3.5%	High

D

Appendix D – Acoustic Performance

Timber floors are used in many multi-storey apartments, both in new construction and renovation work. With new projects, building regulations often apply restrictions to sound transmission between units and in renovation work the noise associated with any replacement floor can often be no greater than the original floor. With regard to sound transmission, timber flooring is similar to other hard flooring surfaces and, in particular, it will freely transfer impact sounds. For this reason, it is necessary to ensure correct detailing and installation measures to provide a floor system with the required sound performance.

D1 Noise Transmission through Timber Floors

Whenever the acoustic performance of a material is being tested, great care is taken to ensure the material is isolated so that only the sound transmission through that material is assessed. When materials are not isolated, as occurs in buildings with floors connected to walls and walls being common to upper and lower-storey units, additional non-direct sound transmission paths or 'flanking' paths are introduced. Sound from a floor above can then radiate from the wall surfaces in the unit beneath and this can contribute considerably to sound transmission between units.

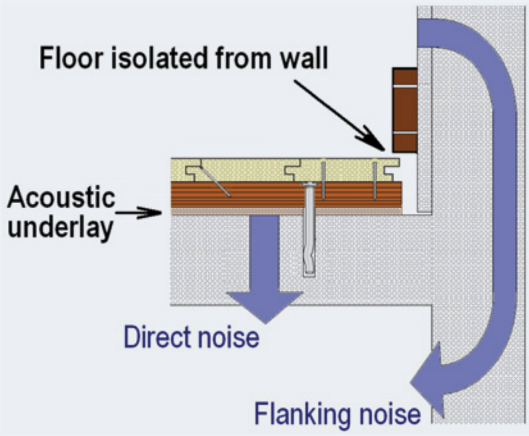


Figure D1: Acoustic underlay and floor isolation significantly reduces direct and flanking noise transmission.

When concrete cures, a hydration reaction occurs that uses up much of the added water. However, even after curing, the pores will contain a significant amount of water, similar to the water within the cells of a board that has been freshly cut from a tree. In both cases, it is from here that drying begins with the lower relative humidity air of the surroundings causing evaporation from the surfaces, and this continues until the 'equilibrium moisture content' is achieved. Similarly, with both materials, the thicker either the board or slab is – the longer it takes to dry.

This indicates that great care is necessary in building design and detailing to provide effective solutions and the system needs to consider providing isolation, absorptive materials and increased mass (i.e. slab thickness). Each of these is important to reduce sound transmission. Timber floors, as with other hard floor surfaces, are particularly affected by impact noise resulting from foot traffic.

D2 Approaches to Improve Acoustic Performance

D2.1 Timber Floors on Battens

Timber floors over concrete slabs are often fixed to battens that are, in turn, directly fixed to the concrete slab. To provide a degree of isolation between each element, resilient pads may be used between the batten and the slab. Fixing of the batten to the slab is still necessary and this will result in some sound transmission. Generally, thicker battens require less frequent fixing and thereby reduce the frequency of direct fixing. With battens at 450 mm centres, 19 mm strip flooring may be used for domestic loading. The flooring may be secretly fixed to 19-mm-thick hardwood batten or top (face) nailed. If top (face) nailing is used the hardwood battens needs to be at least 35 mm thick. For more specific details of floor fixing, refer to Section 4 of this manual.

D2.2 Timber Floors over Sheet Floors

This system uses a complete sheet of acoustic underlay over an existing timber floor or slab. A plywood sub-floor is then laid over the acoustic underlay and fixed to the slab or timber floor beneath. Again, the fixing of the sub-floor will result in some sound transmission. Both 19-mm-thick and overlay flooring may be used in this instance, as the boards are fully supported. Secret fixing with the addition of a polyurethane flooring adhesive is generally used to fix the boards. More specific floor fixing details are provided in Section 4 of this Guide.

D3 Other Important Considerations

D3.1 Selecting the Underlay and Isolation Pads

The purpose of the underlay or pads is to provide isolation of the timber floor from the building elements beneath. Many products are available and each should have test data relating to performance. The products need to fulfil the following criteria:

- Pads need to be sufficiently thick to ensure separation is maintained when the floor is being walked on.
- The product needs to be rigid to prevent compression when the floor is walked on.
- It should provide long-term performance without flattening, particularly under heavy appliances and furniture.

D3.2 Isolation at Floor Edges

It was outlined above that isolation is a key aspect to prevent flanking sound transmission. Gaps need to be maintained between the flooring and all walls, steps, window joinery, etc, and a small gap is also necessary between the skirting and the floorboards.

D3.3 Further Improvements

Improvements in sounds transmission from a floor to a unit below can also be achieved at the design stage by ensuring that the slab is of adequate thickness. An extra 25 mm in slab thickness can make a significant difference to sound transmission. In addition to this, ceiling systems can also be used, which isolate the sound source (i.e. timber floor) from the unit beneath. These systems generally consist of a grid of isolation mounts with furring channels attached. Insulation and plasterboard complete the system. With multi-residential timber framed construction (MRTFC), two layers of fire-rated plasterboard are used. Such systems are effective and are considered to be relatively economical. Finally, rugs, hall runners and mats used in conjunction with timber flooring can not only complement the timber floor but, with their sound absorbing properties, can also reduce noise levels both within and between units.

E

Appendix E – Underfloor Heating

E1 Timber Floors and Underfloor Heating

Timber floors with underfloor heating systems (UFH) are common in Europe and North America. However, they are not common in the cooler southern states of Australia, although public interest is increasing. Due to the limited number of installations, experience in Australia is limited, particularly with the medium and higher-density hardwoods that are available. Research by the Centre for Sustainable Architecture with Wood (University of Tasmania) has recently evaluated the use of overseas practices with the performance of Messmate and Blackbutt. Floors with an underfloor heating system in place in Tasmania were monitored over a period of time, through winter and summer. This Appendix provides guidance regarding the installation of timber floors over underfloor heating systems and is relevant to the southern states of Australia.

E2 The Climate Experienced with Heating Systems

Temperature and relative humidity are the two key factors that influence the internal climate or environment within a dwelling. An increase in the temperature inside the dwelling will cause a lowering of the relative humidity and, with this, the drying capacity of the air increases. Low relative humidity will result in timber flooring releasing some of its moisture to the air, thereby reducing in moisture content and shrinking. As such, the moisture content of a floor is affected by changes in the heated environment. The term equilibrium moisture content (EMC) is often used. EMC can be thought of as the moisture content that timber will attain under set conditions of relative humidity and temperature. Therefore, if the conditions inside a dwelling are maintained at 20 C and 60% RH, the flooring – depending on its current moisture content – will either take up or lose moisture to try to attain a moisture content of about 11%.

The external EMC can be calculated from weather data, and Figure E1 illustrates how this varies seasonally for the southern states. The external RH during winter is high and in summer it is much lower. When cooler external air is then heated, as in an internal environment, the RH and therefore the EMC drops significantly. The Tasmanian study calculated the effect of EMC values resulting from heating to 20°C for the period from May to September, and this is shown in the lower graph.

As can be seen from Figure E1, the effect is dramatic and suggests that the conditions associated with a heated internal environment will result in EMCs between 8% and 9% during the heating period. Both graphs are based on external relative humidity values and a less extreme variation would be expected inside a dwelling. Even so, the flooring needs to be able to cope with very dry conditions during the heating period over winter and moderate rises in moisture content over summer. While this can be catered for, there is an obvious concern if the UFH system was not to operate for a significant period over winter, as this could create expansion that was greater than would occur over the summer months.

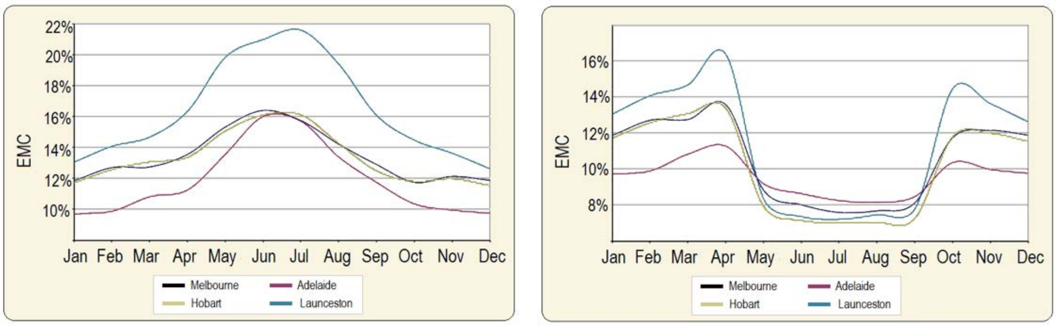


Figure E1: Seasonal variation of EMC for the southern states.
Source: FWPA Project PN07.104 – Advanced Research into Floor Performance Issues – University of Tasmania, 2008.

E3 Choice of Timber Flooring

Two species were chosen in the Tasmanian research: Messmate, a medium-density hardwood; and Blackbutt, a higher-density hardwood. Both species are known to be relatively responsive to moisture uptake and loss from the air, however, under-floor expansion the Blackbutt would tend to crush less at board edges and result in greater expansion forces. Blackbutt is also usually backsawn, whereas Messmate is usually quartersawn. For the same increase in moisture content, a backsawn board will swell more than a quartersawn board. The cover width of the 19-mm-thick flooring used in the research was 85 mm for Tasmanian Oak and 80 mm for Blackbutt.

In the United Kingdom, recommendations are to limit board width to 75 mm with underfloor heated applications. However, with American Oak, a cover width up to 130 mm has been found to give good results. It is not recommended that board widths in Australia exceed 130 mm and the preference is for 80 mm or 85 mm boards in these applications to minimise gapping and the potential for a cupped or crowned appearance.

The Tasmanian research indicated that 19-mm-thick flooring was considerably more robust to effects of cupping than 12-mm-thick overlay material. It must be considered that in times when heating is not on and floor expansion occurs, then the thinner boards will be more reactive and the risk of cupping is very high. For this reason a board thickness of 19 mm is recommended.

Figure E2: Sydney Blue Gum floor with underfloor hydronic heating.
Source: FWPRDC project PN07.104

Concerning the moisture content of the flooring, AS 2796 indicates a normal manufacturing range of 9% to 14%. However, research has indicated that 8% to 9% – which is near the middle of the expected internal seasonal range in Australia's southern states – is more appropriate. Overseas, an average of 8% is often recommended. In Australia, it is unlikely that manufacturers will produce specific batches of flooring at these low moisture contents. Much of the flooring is, however, produced to the lower end of the 9% to 14% range of AS 2796 and flooring packs with boards averaging 10% are likely to be available. To obtain this, close liaison between manufacturer or supplier and the installer would be necessary.

To determine suitability, the proposed flooring would need to be sampled and oven dry testing undertaken to determine exact moisture contents. This can be expected to add some cost but is considered important. Also, great care of the lower moisture content flooring needs to be taken to ensure minimal change in moisture content prior to laying. Irrespective, some gapping at board edges after installation can be expected as a result of the underfloor heating.

E4 Heating System Considerations

Heating systems used with solid timber floors range from hydronic heating, where warm water is piped through a concrete slab beneath the floor, to electric heating systems beneath the floor. It is necessary that the client makes available to the floor installer full installation and operating instructions of the system that is in place, and that the system or proposed system is considered by the heating system manufacturer to be compatible with solid timber floors.

Even heat distribution is vitally important, as hot spots can cause greater board movement (shrinkage or cupping) in some areas of the floor compared to others. Pipes within a slab set at different heights can be the cause of this, and the installer should make the client aware of this possibility.

Figure E3: Blackbutt flooring (130 mm wide) with electric underfloor heating in Adelaide.

The client should also recognise that with seasonal operation of the system some gapping and change in board shape (slight cupped or crowned appearance) is likely, and particularly so if the client has chosen wider boards.

The client also needs to be made aware of the constraints to the system with regard to operating temperature and the need to avoid abrupt changes when adjusting floor temperature. Small increments of 2°C per day are appropriate and underfloor temperatures should not to exceed 27°C.

E5 Typical Installation Procedures

Installation procedures in countries that more regularly lay floors over underfloor heating are relatively consistent, but can vary in certain details.

A typical procedure is provided here for guidance only, as Australian experience is limited. It involves the following steps:

1. **Site conditions**
   The site should be free from all wet trades, be in a state where the dwelling can be lived in and with the heating system fully commissioned. The sub-floor should also have been levelled if necessary to accept the timber floor.
2. **Pre-heat the sub-floor prior to laying to remove excess sub-floor moisture**
   The heating system needs to be operated for a period of two weeks prior to floor installation to lower the moisture content of the sub-floor, particularly if it is a slab, to remove further moisture. The possibility of higher levels of humidity in the room during this process should be checked for and ventilation provided as required. When conditions are sufficiently dry, the flooring should be stored in the installation location in a manner that does not interfere with the drying of the sub-floor. During and particularly toward the end of this period, the room conditions regarding temperature and humidity should be checked and the relative humidity should be in the range of 45% to 60% at a temperature of about 20°C. This equates to an EMC of 8.5% to 11%. The moisture content of the flooring to be laid should have already been thoroughly checked prior to supply to ensure that boards are generally 9% to 10% moisture content, and this should again be checked prior to laying. Similarly, the sub-floor should be checked to ensure it is suitable for accepting a timber floor. The sub-floor temperature should not exceed 27°C with in-slab heating. (With hydronic heating, water temperatures may be 45°C or so to attain an underfloor temperature up to 27°C.)
3. **Turn off the heating and follow this by a non-heating period**
   The period of time that the heating remains off is generally about two days.
4. **Lay and fix the floor**
   If the floor is laid direct to a slab, an elastomeric polyurethane adhesive is used. As this may differ from those used with normal floor installation, advice should be obtained from the adhesive supplier. For other types of sub-floor, normal fixing practices apply. Following installation, the heating is to remain off for a further two days.
5. **Gradually increase the UFH to normal expected temperature**
   The heating should be increased in stages from a low level to the desired room temperature over a period of about 10 days, incrementing by no more than 2°C each day, and should then maintained for a further two weeks.
6. **Sanding and finishing**
   Recommendation vary, with some indicating that it should be carried out about three days after the heating was turned back on, while others indicate that the heating should be turned off and the floor sanded two days after the floor has cooled.
7. **Turn the heating system on**
   The system with installed and finished floor can then be operated, but again the temperature should be raised gradually to the desired operating temperature. With an UFH system in place, the optimum relative humidity range is between 45% and 60% year-round with room temperatures of about 18°C to 24°C.

Appendix F - Installation Checklist

Assessing Packs of Timber Flooring

Flooring Manufacturer:

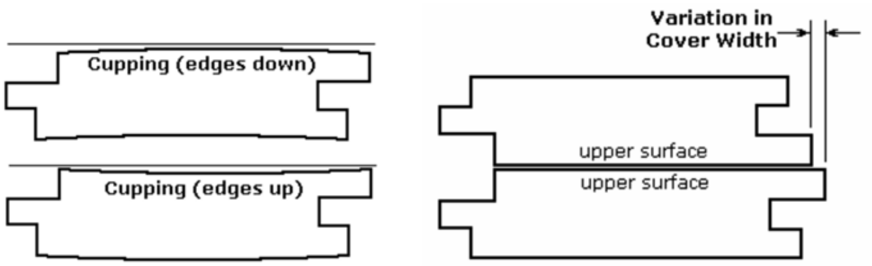
Pack Nos.

Species/Species mix: Cover width: Grade:

Wrapping is in good condition and there are no signs of the product getting wet. ☐ Yes ☐ No

Boards should be checked for:-

- **Cupping** (Use a steel rule or similar)
- **Cover width variation** (Should not vary by more than 1mm between boards)
- **Tongue and groove tolerance** (Snug fit to slightly loose)



Note: Cover width variation exceeding 1 mm, sloppy T&G fit, signs of moisture or cupping may indicate possible problems.

Records

Widest Boards	Moisture Content	Cover Width	Cupping
1			
2			
3			

Narrowest Boards	Moisture Content	Cover Width	Cupping
1			
2			
3			

Note: Ensure that the appropriate moisture meter corrections have been applied. Moisture contents should be between 9% and 14% (average between 10% and 12% is common).

Site Conditions and Installation Environment

Site location

Average 9am RH Average ext EMC

Note: If the external EMC is greater than 2% higher or 1% lower than the estimated average moisture content then additional provision for future expansion or shrinkage needs to be considered (refer Section 2).

If applicable, are sub-floor conditions dry, ground levels beneath dwelling not lower than external ground and graded to prevent ponding, ventilation to recommendations and ground sloping away from dwelling?

☐ Yes ☐ No

Note: If 'no' then these issues may need to be attended to or other measures taken prior to installing the floor.

If the floor is laid on joists ensure the joists are sufficiently level.

If the floor is over a concrete slab or sheet sub-floor, are the sub-floors adequately level, dry and in good condition?

Slab moisture contents or checks undertaken with the following results:

Slab level checked and within ± mm in 1.5 m throughout (plywood or batten system).

Note: Maximum is ± 3 mm

If sheet sub-floors have become wet prior to or during construction and may not have sufficiently dried then moisture contents need to be checked. Moisture contents are as follows:

Note: Plywood and particleboard moisture contents need to be determined with oven dry testing. Sheet sub-floors should be within 2% of the timber flooring moisture content being laid over it. Slab moisture assessed in accordance with Appendices A3.

If the floor is over a concrete slab then check it for construction joints and determine whether it has a moisture barrier beneath the slab.

Note: If construction or similar joints are present in slabs then possible moisture penetration from capillary action needs to be considered. Older slabs may not have moisture barriers beneath the slab and are more prone to seasonal moisture fluctuations that can affect timber floors.

The following slab moisture barrier as applicable has been applied to or over the slab:

Expected Movement after Installation

If wide board flooring is being used greater shrinkage can be expected during dry times.

In moist localities high levels of expansion can be expected *(Ensure adequate additional expansion allowance).*

Is the building design such that the floor will experience high levels of sunlight or has heating/air-conditioning systems? *(Drier in-service conditions can be expected at certain times of the year and shrinkage gaps will be more likely.)* Is the underside of the floor is exposed to dry winds or mist? *(Sealing or protection to the underside of the floor needs to be considered to assist in controlling both expansion and shrinkage.)* Is the floor an upper storey floor *(Drier in-service conditions can be expected – shrinkage gaps are more likely.)* or below grade in shady conditions? *(Wetter in-service conditions can be expected – ensure adequate expansion allowance – refer Section 3.)*

Installation Moisture Content and Acclimatisation

Based on the expected in-service movement the following pre-installation procedures have been undertaken:

Note: Acclimatisation (flooring stripped out or loose layed) or provision of additional expansion allowance, etc, should be recorded.

Method of Installation

This floor is being laid by the following method:

Choice of Finish System

Based on the movement expected and condition of the floor at the time of sanding and finishing some floor finishes are more appropriate than others. (Possible issues such as wear, grain raise, edge-bonding and white lines need to be considered).

The finish system used on this floor is:

(Note: The above is provided as a guide only. Additional testing may be necessary or there may be the need for other considerations.)

G

Appendix G - Troubleshooting Guide

G1 Performance of Timber Floors

In most instances, timber floors perform well in a range of localities and with a variety of installation practices, depending on the sub-floor type. There can, however, be instances where the performance or appearance of the floor can be affected and the major contributing factors are:

- The manufacture of the product does not meet Australian Standards.
- Recognised installation and finishing procedures are not followed.
- There is moisture ingress directly (e.g. leaks) or indirectly (e.g. seepage into sub-floor space).
- The owner has not paid adequate attention to some aspects of the floor.

The table below outlines some of the performance issues with timber floors, common causes and how they appear in the floor.

Table G1: Common performance issues with timber floors.

Performance Issue	Common causes	Appearance in the floor
Cupping	• Moisture from beneath the floor • Dry conditions above the floor • High moisture contents in boards at time of manufacture	• Boards cup throughout the floor and the floor is tight • Boards cup throughout but gaps are present at board joints • Some boards in the floor will cup in the floor but not others
Crowning	• Moisture uptake and the floor sanded and finished in this condition	• During dry periods the floor gaps at board edges and develops a washboard look
Peaking	• High pressure on the upper shoulder of the board often resulting from atmospheric moisture uptake • Board tolerances and MC differences between supply and in-service also contribute.	• The joints at board edges are raised. This can have the appearance of cupping
Tenting	• High expansion. • May be directly related to high humidity or other moisture issues. • May relate to inadequate expansion allowance, poor ventilation or inadequate fixing	• Adjacent boards in the floor rise at the joint above the level of the floor
Buckling	• High expansion • May be directly related to high humidity or other moisture issues • May relate to inadequate expansion allowance, poor ventilation or inadequate fixing	• A group of adjacent boards lift off the sub-floor
Wide or irregular gapping	• The finish gluing adjacent boards and the floor shrinking • High moisture contents in boards at time of manufacture • Boards inappropriately stored and have taken up moisture prior to laying • Wide boards and dry conditions	• Loud cracking noises, irregularly spaced wide gaps and splits through boards • Gaps at board edges associated with narrow cover width boards. • Frequent gapping. The measurement over sections of the floor is inconsistent. • Regular wide gaps

Figure G1: Tenting resulting from atmospheric moisture uptake.

Figure G2: Wide gaps due to high moisture contents at the time of machining.

G2 Sanding and Finishing Imperfections

A high standard of sanding and finishing can be expected when the floor has been completed; however, some sanding and finishing imperfections can be expected. The degree to which imperfections are apparent depends on many factors, including timber colour and use of downlights, both of which can highlight such things as sanding marks and dust in the finish. Consequently, it is difficult to provide objective measures of finishing imperfections. Even so, it is known that a high standard of workmanship also provides an equally high standard of customer acceptance and satisfaction. When the appearance of a floor is being assessed, the assessment should be carried out in daylight hours with lights on and curtains or blinds in their usual position. Imperfections should be viewed from a standing position a few meters away and also from various directions. If the imperfection is difficult to discern, the appearance is generally satisfactory. It should be noted that viewing any imperfection directly toward light sources – such as toward uncovered sliding external doors – will always exaggerate imperfections, and this needs to be considered when evaluating the floors appearance. In addition to this, aspects to be considered should include whether the imperfection is in excess of what would generally occur, whether it is likely to covered by furniture or floor rugs and whether the imperfection will decrease in time with foot traffic. The table below outlines some of the sanding and finishing imperfections with timber floors, common causes and how they appear in the floor.

Figure G3: Rejection and contamination in the finish.

Table G2: Common imperfections in timber floors.

Appearance Issue	Common causes	Appearance in the floor
Rejection	• Contaminants leaching out of the flooring affecting the curing of the finish	• Ranges from a change in a localised gloss level to an 'orange peel' appearance
Delamination	• Movement of the timber at board joints or at the end of the board. • Inappropriate sealers	• The finish peels at board joints or board end
Quilting	• Surface coatings flow into the joints between boards	• A lack of consistency of the coating over board joints highlighting the joints and giving a 'bed quilt' appearance
Contaminants	• Floor not clean • Windy external conditions • Dust in gapped boards or under skirting	• Small specks or insects in the finish which is often worse near poorly sealing external doors
Ghosting	• People walking on the floor at the time of sanding and finishing with certain types of boots and footwear or bare feet	• After a period of 12 months to two years the appearance of a foot or boot print appears in the floor as a lighter colour
Pimples	• Fine air bubbles occurring during coating application	• Popped bubbles in the finish
White lining	• The rapid stretching of waterborne finishes when boards gap	• White lines appearing along board joints.
Edge bonding	• Finish flowing into gaps at board edges and gluing boards together • Thinned finish used as a sealer and penetrating fine joints between boards	• Wide irregular spaced gapping at board edges • Splits in boards
Gloss variation	• Weather conditions • Surface evenness of the boards	• Shiny and dull patches in the finish
Swirl marks	• Rotary sanding particularly at the edges of floors	• Circular swirling scratch marks
Chatter marks	• Vibration in the floor • Sanding technique	• Undulations running across several boards

For further information on the floor inspection process and many of the more common problems refer to the Australasian Timber Flooring Association (AFTA) publication *Problems, Cures and Remedial Measures*.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Timber Windows and Doors

Technical Design Guide issued by Forest and Wood Products Australia

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Introduction

Timber is mainly atmospheric carbon assembled by natural processes into a versatile and attractive building material.

Why Choose Timber?

The building design and construction communities are increasingly aware of the need to consider thermal performance and environmental impact in the design and construction of buildings. This has increased demand for high-performance windows and doors that limit energy use in service and reduce greenhouse gas emissions associated with material production, fabrication and building construction (embodied carbon).

The use of timber windows and doors responds to environmental concerns as well as having many other desirable characteristics. Key benefits of using timber windows and doors are include:

Sensory attributes

Timber is a visually expressive, natural and tactile material ideal for applications that are seen and touched.

Flexibility

Timber is easy to cut, form and shape. It is available in a wide range of products, species, sizes, colours and textures. Timber allows design innovation and creativity.

Thermal performance

Timber in windows and doors can help reduce operational energy over the life of a building when it is part of a well-detailed and designed system, because of timber's low thermal conductivity.

Longevity

Timber is resistant to heat, frost, corrosion and pollution. The timber elements of a door or window will perform satisfactorily for the service life of any building if protected from moisture. Timber windows and doors perform well in extreme external environments with careful design, correct specification of species and finishes and regular maintenance. Timber windows and doors are resilient to degradation and wear associated with regular contact on internal surfaces if properly detailed and specified.

Renewable resource

Timber is a sustainable material obtained from trees which can be grown, harvested and regrown on a continuous basis.

Carbon storage and lower emissions

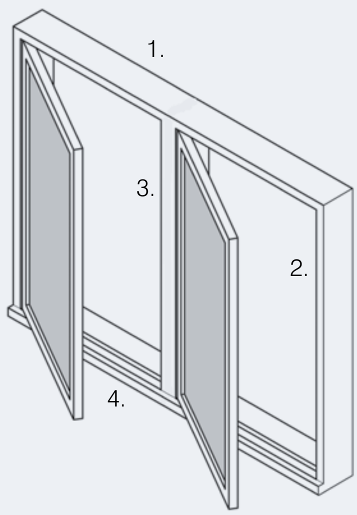
Growing trees store atmospheric carbon that remains sequestered in the timber throughout its service life. Using timber instead of materials that require significantly more fossil fuels in their production avoids substantial greenhouse gas emissions.

Window and Door Basics

A window is an opening in a wall or other surface of a building that allows the passage of light and transmission of varying amounts of air and sound. Windows consist of a frame, sashes, and panes of glass (or other transparent or transluscent material), intended to fit an opening in a building envelope. Windows influence the quality of the internal environment by admitting light and ventilation, excluding wind, rain and draughts, and mitigating noise transfer.

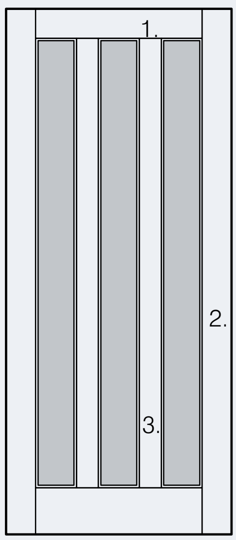
A door is a movable barrier, either solid or glazed, used to cover an opening or entrance way in a wall or partition of a building, or piece of furniture. Doors permit access and admit ventilation and light when open. A door can be opened and securely closed using a combination of latches and locks. Doors are used to provide access to a space and influence the physical environment within by creating a barrier. Doors mitigate noise transfer and are significant in preventing the spread of fire between spaces.

The terms used to describe the major components of windows and doors are common to both windows and doors. The frame is the assembled components that enclose and support the window sashes or door leaves. Frames are fixed to the surrounding building envelope.



The frame consists of:

1. Head – top horizontal component
2. Jambs – vertical side components
3. Mullions & transoms – intermediate vertical and horizontal elements (respectively) between sashes
4. Sill – bottom horizontal component.



Window sashes or door leaves are the moveable components of the unit supported by the frame. They consist of:

1. Rails, top rails and bottom rails – horizontal members of a sash, door leaf or screen
2. Stiles – vertical edge pieces
3. Muntins – intermediate elements of a sash or leaf.

1

Materials

Only carefully selected pieces from certain species will match the performance requirements of durability, stability and appearance required for windows and doors.

1.1 Introduction

Careful selection and combination of glass type, hardware type and timber species is required to create timber windows and doors that meet performance requirements and satisfy the design intent.

1.2 Timber

Timber is a natural, variable, non-homogeneous material that is susceptible to degradation and moves with changing moisture content. Understanding these characteristics will help the designer with the specification of timber windows and doors.

1.2.1 Timber Quality

Window and door joinery generally requires timber with straight-grain, seasoned to a consistent moisture content, and dimensionally stable throughout. Timber used in the external envelope should be relatively durable or be treated to be durable.

Solid timber suitable for windows and doors generally comes from large logs of slowly grown trees. Timber from smaller logs of more quickly grown trees tends to be less stable, more variable, and may also be less durable than older, more slowly grown material of the same species. Laminated sections of timber can be suitable for windows and doors if the timber elements to be laminated are well matched, stable, and if the timber is naturally durable, treated to be durable, or used internally.

Timber elements will deviate from the desired dimensions because of machining tolerances and timber's tendency to move with changing moisture content and with cutting, which relieves locked-in growing stresses. *AS 2047-1999 Windows in buildings – Selection and installation* applies constraints on the bow, spring and twist of particular elements for windows. The allowable limits are shown in Table 1.

Table 1: Allowable bow, spring and twist in timber for windows.

	Head, Jamb, Mullion and Transom					Sash	Sill			
Length	**Bow**		**Spring**	**Twist**		**All**	**Bow**	**Spring**	**Twist**	
Board width	**t=<(2/3) w**	**t>(2/3) w**		**100**	**150**				**100**	**150**
1.2	2	1	2	1	1	0	2	2	1	1
1.8	3	2	3	1	1	0	6	3	2	2
2.7	6	3	6	1	2	0	13	6	2	3
3.6	11	6	11	2	2	0	22	11	3	4

Source: AS 2047-1999 clause 3.2.2

1.2.2 Moisture Content and Stability

Timber is a hygroscopic material, which means it absorbs moisture and expands, or loses moisture and contracts, to achieve moisture equilibrium with its surrounding environment. The amount of expansion and contraction varies with the species, direction of the wood fibre, the way in which the timber is converted from a log, and the speed of growth of the tree. The most stable section will be from species with low percentage moisture movement, straight grain, growth rings perpendicular to the section, and from a slowly grown tree. It is essential that the movement associated with moisture content changes is limited and accounted for, because where windows and doors form part of the building envelope and feature moving parts, unanticipated expansion or contraction can lead to gaps opening or elements becoming jammed.

Timber to be used in a door or window would generally be fully seasoned with a moisture content complying with *AS 2796 Timber – Hardwood – Sawn and milled products* or *AS 4785 Timber – Softwood – Sawn and milled products.* Both AS 2796 and AS 4785 require a moisture content between 9% and 14%. *AS 2047 –1999: Windows in buildings – Selection and Installation* requires that moisture content of the timber is between 10% and 15% at the time of fabrication and delivery of the complete assembly.

Controlling the moisture content of the elements to be fabricated is important. Moisture content of all the elements in the door or window unit should be equal at the time of fabrication, delivery and installation, and should match the anticipated moisture content in service. The moisture content should be even throughout each element, because the timber can distort when it is moulded or as it dries out further if the inner core is wetter than the outside section. In-service moisture content for timber windows and doors built into an external envelope is likely to be as described in AS 2796 and AS 4785. However, the in-service moisture content of elements used internally will be as low as 8% for air-conditioned spaces and may be above 15% for naturally ventilated buildings in areas of high humidity.

The unit should be acclimatised to the final service environment before final assembly and installation if the equilibrium moisture content in service is likely to be significantly different to that of the timber during manufacture. Acclimatisation takes about three weeks for unpainted elements, but will vary depending on timber moisture content, species and target moisture content. A door or window may tend to continually bow or distort if the outside of the unit is continually wetter or dryer than the inside.

1.2.3 Feature and Colour

Features such as uneven grain, minor gum vein, colour variation, and small, tight, knots are part of timber's natural appeal and do not affect a piece's ability to satisfactorily perform. Features such as large or loose knots and major gum veins or voids can reduce durability and should be excluded. AS 2047-1999 constrains the features allowed in windows. These are presented in Table 2. Excluding material based on unreasonable appearance expectations can increase costs and waste material. Features can be confined to concealed surfaces or areas that are to be filled and painted if the appearance of the timber is critical.

Table 2: Features and characteristics permitted in windows in accordance with AS 2047-1999.

Element	Allowable Characteristics
Sashes	Exposed faces and edges are to be free of all knots.
All other timber	Exposed faces and edges are to be free of loose knots, splits, and resin, gum and bark pockets. Limitations are also imposed on slope of grain, surface checks, tight knots and pin holes. Finger-joints are not considered imperfections.
All unexposed faces	Other features are allowed given that they do not affect joint strength, unit fixing or operation.

Source: AS 2047-1999 clause 3.2.2

Natural timber has some colour variation between species, between elements of the same species, and within each piece. Unreasonable expectation of colour can lead to irresponsible waste. Apparent colour variation can be moderated by:

- grouping timber of similar colour together within units before assembly;
- using grain fillers selected to match the timber and the intended finish; or
- staining, either before the timber is finished or as part of the finishing process.

1.2.4 Properties of Major Species

Performance requirements such as stability, durability, hardness and workability, and consideration for aesthetic qualities will determine appropriate species selection for a given application. For example, joinery exposed to the exterior will require greater durability or protection than timber used internally.

The properties of major Australian-produced and imported species are included in Tables 4 and 5. Table 3 provides an introduction to the terms used in Tables 4 and 5. The properties presented in Tables 4 and 5 are key properties for commonly used species to aid the designer in appropriate timber species selection. More species information can be found at www.timber.net.au. The supplier of the window or door units, or timber, should be consulted for more information.

Table 3: Description of timber characteristics.

Term	Description
Name	Common species name
Origin	The region that is the general source of the timber
Colour	The colour of the majority of the heartwood of the timber (the sapwood may be paler)
Supply	A general indication of supply levels for the species
Forest certification	A general indication if the species is broadly available from certified forests
Durability	Durability class outside above ground to *AS 5604-2005 Timber – Natural durability ratings*
Density	kg/m^3 of wood seasoned to a moisture content of 12%
Hardness	Janka hardness to *AS/NZS 1080 Methods of testing timber*
Workability	The stability and general machining characteristics

Table 4: Properties of major Australian timbers.

Name	Origin	Colour	Supply	Forest Certification	Durability	Density (kg/m³)	Hardness (kN Janka)	Workability
Blackbutt	NSW & SE Qld	Yellow to brown	Readily available	Available	1	930	8.9 – Hard	Good
Hoop pine	NSW & Qld	Pale cream to yellow	Readily available	Available	4	550	3.4 – Soft	Very good
Jarrah	WA	Dark red	Available	Available	2	835	8.5 – Hard	Good
Karri	WA	Pink to reddish brown	Limited availability	Available	2	900	9 – Hard	Moderate
Radiata pine	All states	Shades of yellow to brown	Readily available	Available	4	~500	3.3 – Soft	Good
Silvertop ash	Tas, Vic, NSW	Pale to dark brown	Limited availability	Available	2	820	9.5 – Hard	Moderate
Spotted gum	Tas, Vic, NSW	Pale to dark brown	Readily available	Available	1	~950	10.1 – Very hard	Good
Tallow wood	NSW & Qld	Pale to dark yellow brown	Limited availability	Available	1	1010	4.5–8.0 – Medium	Good
Tasmanian oak	Tas	Straw to pale reddish brown	Readily available	Available	3	530–800	4.5–8.0 – Medium	Very good
Victorian ash	Vic	Straw to pale reddish brown	Readily available	Available	3	530	4.50 – Medium	Very good

Table 5: Properties of major imported timbers.

Name	Origin	Colour	Supply	Forest Certification	Durability	Density (kg/m³)	Hardness (kN Janka)	Workability
Amoora	SE Asia	Red brown	Available	Occasionally available	4	550	3.8 – Firm	Good
Douglas fir/ Oregon	USA/ Canada	Yellowish to orange	Readily available	Occasionally available	4	560–480	3–3.4 – Firm	Good
Hemlock	USA/ Canada	Straw to pale brown	Available	Available	4	500	2.7–3 – Soft	Good
Kapur	SE Asia	Red brown	Available	Unknown	2	750	5.4 – Moderate	Good
Kwila/ Merbau	SE Asia	Yellow brown to orange brown	Readily available	Occasionally available	1	830	8.6 – Hard	Moderate
Meranti	SE Asia & Pacific	Pale to dark red/straw to yellow	Readily available	Occasionally available	Generally 3–4	523–900	Varied	Good
New Guinea rosewood	Pacific	Golden brown or dark blood-red	Available	Occasionally available	2	650	4.7 – Moderate	Very good
Surian	SE Asia & Pacific	Light red to red brown	Readily available	Occasionally available	1	480	Very soft	Very good
Western red cedar	USA/ Canada	Pale to dark brown	Readily available	Available	2	380	1.5 – Very soft	Very good
White oak, American	USA/ Canada	Light to mid dark brown	Available	Available	4	750	6 – Medium	Very good
Yellow cedar	USA/ Canada	Pale yellow to cream	Available	Available	1	500	2.6 – Soft	Very good

1.2.5 Timber Sizes

Timber is cut or 'converted' from tree logs, and is then milled into rectangular sections that can be dressed into a finished size, or machined or 'moulded' into the desired shape. The practical maximum size of sawn and milled sections is governed by the size of logs converted. The maximum size obtained is typically 300 mm wide, 50 mm thick and 4.8 m long. Pieces up to 6 m long are viable but high-quality pieces of large-section timber are difficult to obtain and more susceptible to distortion. Smaller pieces can be glue-laminated into stable large-section timber, referred to as 'glulam'. Glulam sections are available in widths to 1.8 m, thicknesses to 0.6 m and long lengths. Maximum available lengths vary between manufacturers and with transportation arrangements.

Timber is referred to in standard or 'nominal' sizes, such as 100 mm x 50 mm. However, the actual section size may vary from the specified size depending on moisture content, machining and tolerance. The sawn dimension of timber is the size at which the board is cut to allow it to shrink during production to the nominal dimension. As shrinkage is not always uniform, the board is often marginally larger than the nominal dimension after drying. The machined dimension is the measured size of a piece of timber, once it has been milled to a dressed size. The machined size is smaller than the nominal size.

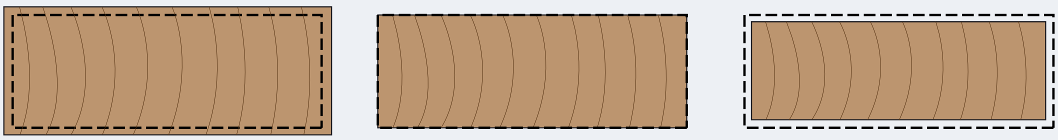


Figure 1: Timber sizing – sawn, nominal and machined.

1.2.6 Certification of Forest Management and Timber Supply

To ensure the timber used in building is a sustainable product it should be sourced from a sustainably managed forest. Forest certification and chain-of-custody certification are systems which aim to ensure the sustainability of timber products for use in buildings. The certification schemes benchmark processes used against internationally recognised best practices. The timber is tracked through the supply-chain from tree to retailer.

The two dominant international certification schemes are the Programme for the Endorsement of Forest Certification Schemes (PEFC) and the Forest Stewardship Council (FSC). Both schemes operate in Australia. PEFC has endorsed the Australian Forest Certification Scheme (AFCS) and the FSC operates in Australia under interim standards from internationally accredited FSC certifying bodies. Current information on the certification of forest and production companies and updates on the development of standards is available from the AFCS at www.forestrystandard.org.au, and from the FSC at www.fscaustralia.org.

1.3 Glass

Glass used in windows and doors must comply with *AS 1288-2006 Glass in buildings – Selection and installation.* The standard regulates the size and type of glass according to the required structural capacity of the glass, and ensures the safety of occupants by balancing risk posed and potential hazard.

Glass can be modified to reduce the danger of human impact, increase its aesthetic appeal, provide privacy, alter its thermal performance or change the amount of sunlight transmitted.

1.3.1 Safety Glass

Glass can break into dangerous shards. To reduce the risk of harm to building users AS 1288-2006 requires that safety glass be used in windows and doors susceptible to human impact. *AS/NZS 2208-1996 Safety glazing materials in buildings* establishes two grades of safety glass: Grade A offers a high level of protection against injury and includes laminated, toughened and toughened laminated glass; Grade B provides lesser protection and includes wired safety glass.

Laminated glass is two or more sheets of glass joined with adhesive inter-layers of transparent plastic. The glass adheres to the inter-layer if broken and generally remains in the glazed unit. Toughened glass is heat treated, which increases its strength beyond that of typical annealed glass and ensures that when shattered, it breaks into small, relatively safe pieces. Toughened glass is also called tempered glass.

The type and thickness of glass in windows and doors significantly influences thermal and acoustic performance, safety and security, and the amount of light admitted.

1.3.2 Modified Glass

Poor specification of glass and glazing can contribute to glare problems inside the building, the building overheating through solar gain, and heat loss on cold days. Solar transmission characteristics and thermal performance of the glass can be modified by applying a coating, colouring the glass, combining sheets of glass into sealed units, or a combination of all three. Manifestation uses markings adhered to or etched onto glazed areas for visual effect, or to ensure that the glass is visible to prevent accidental impact by people.

Table 6: Performance characteristics of different types of glass.

Glazing type	Visible light transmittance	U-Value [W/(m²K)]	Solar Heat Gain Coefficient
6 mm clear	88%	5.8	0.82
6.38 mm laminated	87%	5.7	0.78
6 mm low-e	81%	3.6	0.69
6.38 mm laminated low-e	82%	3.6	0.68
3/12/3; double-glazed; clear/air/clear	81%	2.7 (air), 2.6 (argon)	0.75
4/12/4; double-glazed; green tint/air/tint	73%	2.7 (air), 2.5 (argon)	0.55
4/12/4; double-glazed; clear/air/low-e clear	75%	1.9 (air), 1.6 (argon)	0.64

Source: Viridian Glass

1.4 Hardware

Timber windows and doors incorporate fixings, hinges, catches, locks, seals, etc, which are collectively known as ‘hardware’. The range of hardware available is diverse in quality, function and cost. Categories of hardware include:

- moving hardware (hinges, friction stays, roller and tracks, pivots);
- securing the moving components (locks, catches, closers, bolts);
- handling and restraint (handles, hooks, knockers, pull and push plates);
- excluding air and water (seals and barriers); and
- providing protection and security (stops, kick plates, insect screens, security mesh).

Hardware is generally specified by the load capacity required, quality and sophistication in manufacture and operation. Most load-bearing hardware is designed to reliably carry or operate within a specific load or capacity limit. Correctly securing the timber to the metallic hardware is crucial for satisfactory performance under load.

Architectural intent, the economics of construction, and required thermal performance determine the selection of hardware. Hardware manufacturers should be consulted when producing a hardware specification.

2

Design options

2.1 Introduction

This section introduces the most common window and door configurations. Diversity in window and door design is generated by manipulating the configuration of the types presented, the timber arrangement and finish in primary elements, and the type of glazing used.

2.2 Frame Options

Timber windows and doors can be made from solid timber of a single species or combinations of different timber species, laminated timber, or composite sections of timber and another material.

2.2.1 Solid Timber

Solid timber elements are available in a wide range of species and sizes. Species can be selected to maximise utility and economy. For example, the designer could specify sills of a durable species, the remainder of the frame in a more economical timber, and sashes or leaves from a light and highly stable species. The size of quality solid timber sections available is restricted by the logs available and cutting methods adopted.

2.2.2 Glue-laminated Timber

Glue-laminated timber consists of pieces of timber assembled with an adhesive to create larger sections. Sections range from pairs of solid timber glued together to create a more stable section, to large-section glue-laminated elements of finger-jointed material. Glue lamination uses high-quality sections of timber efficiently. Profiles can be assembled to match the required shape so there is typically little waste. Glue-laminated material can be stronger with more consistent structural properties than solid timber.

2.2.3 Composite Timber Sections

Composite elements feature a frame of timber faced with a metal profile of extruded aluminium or bent stainless steel. The primary advantage of a composite frame is elimination of maintenance of the covered timber surface while retaining the thermal and acoustic benefits associated with a timber window. In Australia, several manufacturers produce windows and doors with external aluminium facings. The size of timber and aluminium composites is restricted by the size of available aluminium extrusions.

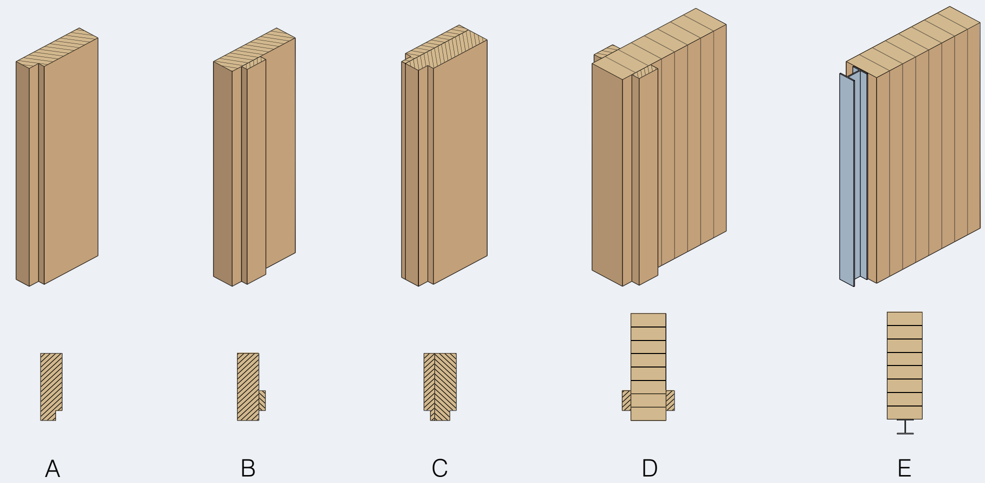
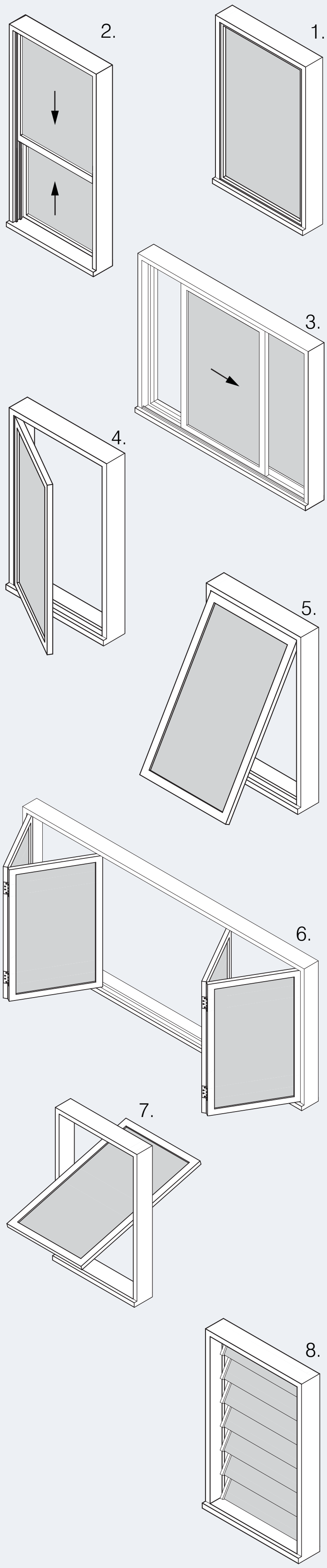


Figure 2: Timber frame arrangements:
(A) rebated solid timber (B) solid timber with a stop (C) rebated laminated timber
(D) glue-laminated timber with a stop (E) glue-laminated timber with an extruded glazing section.

2.3 Window Configurations



1. Fixed glass or light

A fixed pane of glass held in a timber frame. The glass can be set directly onto a rebate or 'stop' on the window frame, or set into a fixed sash (fixed light), and fixed in the frame.

2. Double-hung window

Two sashes set to slide past each other vertically within the frame. The weight of an individual sash is held by mechanical balances or counterweights on each side. The unit can also be arranged so that one sash moves over a fixed sash or glass.

3. Sliding window

Two or more sashes set to slide past each other horizontally within the frame. Several sashes can also slide past each other to stack to one side of the opening. The opening sashes should slide outside the fixed sashes for water shedding.

4. Casement window

A sash hung to open from one side, usually with hinges along the vertical edge of the frame, or friction stays on the top and bottom of the sash. The sash generally opens out, but can open in. Screens can only be fitted internally if opening out.

5. Awning window

A sash hung to open out from the bottom, usually with hinges along the top edge of the frame or friction stays along the sides of the sash. Some stays allow complete reversal of the window. Screening and security can only be fitted internally. Awnings hung to open out from the top are called hopper windows.

6. Bi-fold window

Two or more window sashes alternately hinged so they fold against each other to the sides of the opening, providing a full and unobscured opening. Bi-fold windows can be supported on an overhead track or, if there are only two sashes per side, hung without a track.

7. Pivot window

A sash that rotates on pivot hinges in either the horizontal or vertical plane. The pivot line can be central to the sash or off-set.

8. Louvre window

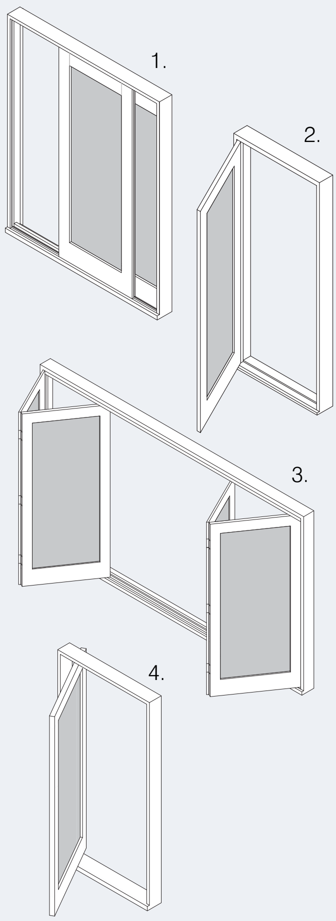
Sets of glass, timber or aluminium blades arranged horizontally across the frame. Fixed louvres can be rebated at each end into the frame. Moveable louvres fit into mechanical louvre galleries. With moveable louvres, the blades' angle of inclination is adjustable to allow more or less light or air into the enclosure.

Table 7 provides a qualitative comparison of standard versions of the window types presented above. For each window type there will be exceptions to these comparisons.

Table 7: Comparison of window configurations.

	Fixed	Double-hung	Sliding	Casement	Awning	Bi-fold	Pivot	Louvre
Economic	✔	✔ (Mechanical)	✔	✔	✔			✔
Simple to operate		✔	✔	✔	✔		✔	✔
Easy to clean at height							✔	✔
Provides ventilation		✔	✔	✔	✔	✔	✔	✔
Easy to weatherproof	✔	✔	✔	✔	✔	✔		
Easy to make airtight	✔			✔	✔			
Easy to make secure	✔	✔	✔	✔	✔	✔	✔	

2.4 Door Configurations



1. Sliding door

Two or more leaves set to slide past each other horizontally within the frame. Several leaves can also slide past each other to stack to one or both sides of the opening. They are suitable for large openings but the sliding leaves have to be stacked in the door frame, reducing the overall opening size.

2. Hinged door

A door leaf hung along a vertical edge of a frame with hinges and opening inwards or outwards. Pairs of doors hung on either side of the frame and meeting with a rebated central join are called French doors.

3. Bi-fold door

A series of doors, alternately hinged so they fold against each other on one or both sides of the opening, providing a full and unobscured opening. Bi-folds can be supported on an overhead track or, if there are only two doors per side, hung without a track.

4. Pivot door

Pivot doors rotate in the vertical plane on hinges at the top and bottom. They can pivot in either one direction or in both directions, giving a wide, generous opening.
Table 8 provides a qualitative comparison of standard versions of the door types presented above.
For each door type there will be exceptions to the comparisons.

Table 8: Comparison of door configurations.

	Sliding	Hinged	Bi-fold	Pivot
Economic	✔	✔		
Easy to operate	✔	✔		✔
Easy to weatherproof	✔	✔	✔	
Easy to make airtight		✔		

3

Meeting performance requirements

3.1 Introduction

Timber windows and doors are key components in the environmental performance of a building envelope by excluding water; providing ventilation; controlling air infiltration and sound; and contributing to the building's thermal and acoustic performance.

3.2 Designing for Moisture Control

Preventing water from entering the building is an essential part of window and door design. Designing for moisture control should consider:

- shedding standing water from the frames;
- controlling the entry or seepage of water into the building; and
- preventing water from entering the building envelope where the unit and envelope meet.

3.2.1 Shedding Standing Water

Water needs to be shed from any surface of window and door frames to prevent standing water. Any water build-up can cause deterioration in the finish, the timber and the joints of the unit. Water is shed by ensuring:

- the top of glazing beads are sloped to at least 1:6;
- the surface under the actual glazing or glazing unit is sloped to 1:10;
- any horizontal, exposed surfaces have a minimum slope of 1:8; at 1:8 slope water will drain off even with a moderate amount of opposing wind pressure;
- corners of the top of all horizontal or sloping faces feature rounded arises to improve water run-off and adhesion of finishes; and
- sills include a drip-line of a saw-cut or groove with a nominal 3 mm radius, 10 mm back from its outside edge.

The organisms that break timber down require a moisture content of above 20% in the wood to survive. Dry timber generally remains serviceable for centuries.

3.2.2 Water Entry into the Building

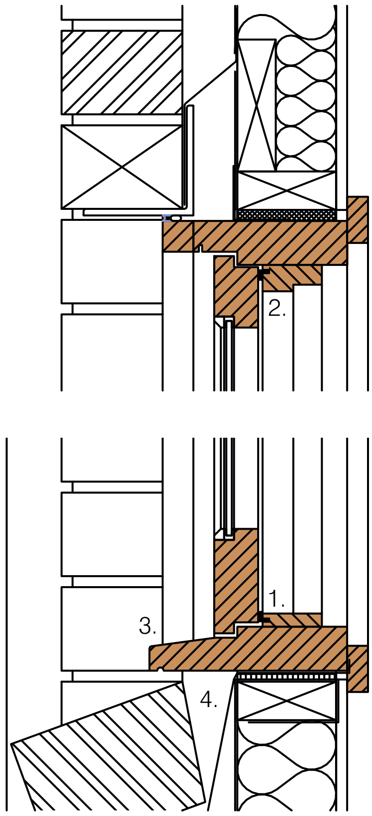


Figure 3: Window sash and frame section.

Controlling the flow of water on and through the window or door unit is essential to prevent water seeping into the building. Unwanted water seepage can be unsightly, a safety hazard, and can lead to the deterioration of the building fabric. AS 2047-1999 establishes the test method and test pressures to ensure that windows for domestic buildings resist water penetration through the assembly and detailing.

Water ingress through the unit is prevented by careful detailing of upstands, returns and seals. The configuration of these will vary between window and door types. For example: (1) the sill up-stand acts as a barrier to help prevent water ingress with the moving sash or leaf is shut in casement windows and doors. Compressive seals (2) should be fitted on adjacent faces which close together such as the top rail of awning windows.

Adhesion and wind pressure can push water across the underside of sills and across the outside face of the frame of the window or door to the joint between the unit and the building envelope. Saw cuts on 3 mm minimum radius should be used on the downward faces surfaces to facilitate dripping and prevent capillary action (3).

If water enters the joint between the unit and the surrounding envelope it has to be collected at a flashing and directed to the outside face of the external cladding (4). Flashing around the opening is a critical part of window installation.

3.2.3 Condensation

Condensation usually forms on (or in) a window or door when warm moist air comes in contact with a colder surface. Timber frames do not heat up or cool down quickly and are not as prone to condensation as metal frames (which are thermally conductive).

Condensation in a timber-framed unit generally occurs on the glass in colder climates. When the external temperature drops, the glass cools, and warm internal air meets the cold inside surface of the glass, causing condensation. If the glass is cold enough and the inside humidity high enough, sufficient water can condense on the glass and run down the glass and pool on the inside of the sill. The condensed water can discolour timber, damage finishes and encourage mould to grow.

In hot, humid climates, condensation can occur on the outside surface of the glass when the inside space is air-conditioned and significantly cooler than the outside air. Condensation can also form between the timber and the aluminium on composite sections.

Condensation can be limited by reducing the relative humidity of air adjacent to the window through ventilation, using low-e coatings on glass and insulated glass units (IGUs), and in colder climates by limiting convective air movement around the glass. However, the edge seal can deteriorate on IGUs with age, compromising the internal air space. Absorbent material in the edge spacers stops incidental small amounts of moisture becoming a problem but continuing moisture can migrate into the air gap and condense on the surface of the exterior pane. The moisture cannot be removed in sealed units and the unit should be repaired or replaced. Unsealed units are typically vented, which should allow moisture to escape.

3.3 Designing for Thermal Performance

The insulation value of windows and doors is generally much lower than that of the surrounding walls, floors and ceilings, making them highly influential in the thermal performance of a building. The thermal conductivity of timber is significantly lower than that of aluminium. In a direct comparison, timber is a better insulating material than aluminium. For an aluminium frame to achieve a thermal performance similar to a timber frame requires the use of complex shapes with seals and isolators. These elements provide a thermal break, and reduce heat transfer. The timber-framed equivalent can be relatively simple, which is typically reflected in the cost, particularly for bespoke designs.

Standard float glass has relatively high thermal conductivity and is therefore a poor insulator. Its insulation performance can be moderated with coatings or additives, or by arranging the glass in an insulated glazed unit (double- or triple-glazed sealed units). However, even with these improved measures the glazing will typically be the element with the least thermal resistance in a building envelope.

Table 9: Thermal values of various materials.

Material	U-Value [W/(mK)]	Relative Resistance (R) Value [(m^2K)/W]	
		6mm	40mm
Glass wool insulation	0.038	0.158	1.053
Softwood	0.135	0.044	0.296
Hardwood	0.175	0.034	0.229
Concrete	0.930	0.006	0.043
Glass	1.000	0.006	0.040
Steel	45.300	0.000	0.001
Aluminium	221.000	0.000	0.000

The National Construction Code Part J of Volume 1, and Section 3.12 in Volume 2, present requirements for a building's thermal performance. Limits are set on the amount of glazed areas included in the facades of a building, with the limits dependent on the building's location and the orientation, shading and thermal properties of the glazed unit. The glazed unit's U-value and solar heat gain coefficient (SHGC) is needed to show compliance to the National Construction Code. The U-value and SHGC of a glazed unit is highly dependent on the configuration of framing material and the particular type of glass used. The results of generic tests are included in Table 10. What is apparent from this table is that the choice of glazing system will be informed by climate. The generic 3/12/3 timber framed window has a 40% improvement for climates requiring heating and a 51% improvement for climates requiring cooling.

Note: In Table 10 Uw is the whole window U-value which incluldes the relative surface area of frame and glass, SHGCw is the whole window solar heat gain coefficient, and Tvw is the whole window visible (light) transmittance.

Key:

Glazing ID	Glazing description
3Clr	3 mm single clear
6.38CP	single solar control, pyrolytic low-e
5toned	5 mm toned
5supertoned	5 mm supertoned
3/6/3	3/6/3 clear IG, air fill
3/12/3	3/12/3 clear IG, air fill
5supertoned/6/5	5/6/5 supertoned IG with air fill

Source: WERS 2011 Generic Product Directory (www.wers.net)

Table 10: Performance of different window types.

		Cooling	Heating	Total Window System Values NFRC			
Glazing ID	**Frame**	**% impr.**	**% impr.**	**Uw**	**SHGCw**	**Tvw**	**Air Inf.**
GENERIC STANDARD INDUSTRY TYPICAL WINDOW – SINGLE-GLAZED							
3Clr	Generic: aluminium	2%	0%	7.4	0.77	0.80	5.00
3Clr	Generic: timber	21%	24%	5.5	0.69	0.72	5.00
5toned	Generic: timber	38%	16%	5.4	0.50	0.39	5.00
5supertoned	Generic: timber	40%	15%	5.4	0.47	0.59	5.00
6.38CP	Generic: timber	52%	33%	3.7	0.41	0.47	5.00
GENERIC STANDARD INDUSTRY TYPICAL WINDOW – DOUBLE-GLAZED							
3/6/3	Generic: aluminium	22%	27%	5.3	0.69	0.72	5.00
3/6/3	Generic: timber	38%	47%	3.3	0.61	0.65	5.00
3/12/3	Generic: timber	40%	51%	3.0	0.61	0.65	5.00
5supertoned /6/5	Generic: timber	55%	37%	3.3	0.41	0.34	5.00

Source: WERS 2009 Generic Product Directory (www.wers.net)

3.4 Controlling Air Infiltration

AS 2047-1999: Windows in buildings – Selection and installation establishes maximum air infiltration rates for particular window or building types. Maximum allowable air infiltration rates under the test procedures defined in the standard are shown in Table 11. However, limiting air infiltration is fundamental to ensure adequate thermal performance. Research has documented that as the thermal performance of the external fabric (walls and windows) is improved, the relative heat losses from infiltration increases. In the United States, up to 35% of heating and cooling losses have been attributed to infiltration. Several nations have set minimum window system infiltration rates much lower than those presently in use in Australia for residential construction. The use of long-lasting flexible seals between the fixed and operable portions of the window is contingent to the reduction of infiltration.

Table 11: Maximum air infiltration rates.

Building or window type	Pressure directions	Maximum air infiltration(l/s m^2)	
		Test pressure 75 Pa	**Test pressure 150 Pa**
Air-conditioned	Positive, negative	1.0	1.6
Non-air-conditioned	Positive	5.0	8.0
Louvre window	Positive	20.0	n/a
Adjustable louvres, residential and commercial building	Positive	20.0	32.0

Source: AS 2047-1999, Table 2.3

3.5 Designing for Acoustic Performance

Windows and doors are typically the most acoustically transmitting part of the building envelope. The most transmitting part of any window or door will be any unsealed gaps through which air can move. The type of unit should be selected which can close tightly onto one or two rows of seals which sit on a frame, such as a casement window.

The sound reduction through an element is linked to its mass. Increasing the mass in the glazed area through increasing glazed thickness will improve the sound reduction. The sound transmission will vary through an element at different frequencies. The sound reduction performance of IGUs can be improved by using inner and outer leaves of different thicknesses to avoid the two leaves vibrating at the same frequency. Laminated glass will provide a greater sound reduction than the equivalent solid thickness because the inter-layer between laminates acts to dampen the glass vibration.

Table 12: Sound reduction by glass type.

Glass	Decibel level reduction (dB)
3 mm	30
6 mm	32
IGU (6/16/6)	35
6.38 mm laminated glass	33
10.38 mm laminated glass	36

Source: Viridian Architectural Glass Specification Guide

3.6 Designing for Durability

Durability is a key consideration when specifying timber windows and doors. Timber windows and doors should be designed and detailed to meet the thermal, structural, acoustic and aesthetic performance requirements for the intended design life. There is no simple rating or guarantee of the durability of a timber window or door. The reputation of the manufacturer and the warranties they provide will be an indicator of the unit's reliability.

Several factors govern the durability of a window or door unit, including its exposure to the external environment, the individual durability of the assembled components (mainly the timber frame and glazing) and the maintenance regime.

3.6.1 Exposure

The service life of window and door units in the external envelope will be directly related to their level of exposure to rain, wind, sunshine and persistent moisture. Exposure needs to be considered at several scales: the macro scale of different climatic areas, the location scale of the site, the building scale, and the micro scale of the element or detail.

Climate scale

Timber exposed to a climate that is regularly damp or wet will generally decay faster than timber in a regularly dry climate. The rate of decay is exacerbated by heat and moisture. Hazard zones for the decay of timber above ground are shown in Figure 4. Hazard zones for embedded corrosion of fasteners are shown in Figure 5 and give broad guidance on the longevity of embedded fixings in exposed timber joinery and probably also for exposed hardware. More information can be found in FWPA Timber Service Life Design Guide.

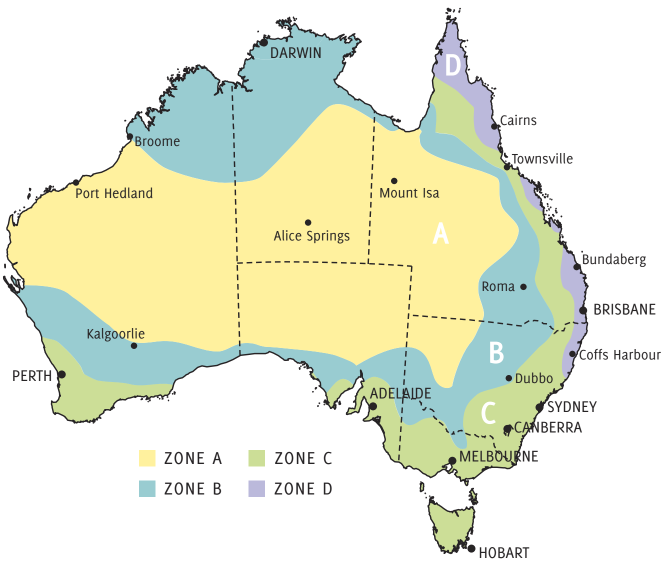


Figure 4: Above-ground decay hazard zones. Zone D has the highest decay hazard.

Climate can affect the performance of timber, embedded fastenings and any applied finishes.

Figure 5: Hazard zones for embedded corrosion. Zone C has the highest hazard.

Source: FWPA Timber Service Life Design Guide

Location and building scale

Local site conditions include topography, vegetation and the proximity of lakes or ocean. These modify the local climate, potentially reducing or increasing exposure to rain, wind, sunshine and persistent moisture, and can introduce additional hazards. The south side of hills in temperate, wet climates will generally be damper than the north side and more conducive to decay. Proximity to the sea, especially salt spray near the ocean, will influence the performance of hardware.

The position of a window or door unit in the building affects its durability. Units on the south side of a building are generally protected from direct sunlight. In hot climates, this can significantly increase the service life of finishing systems. In cool and wet climates, the regularly higher moisture content of the timber on the south side of the building can potentially expose it to an increased rate of decay.

Element and detail scale

An effective means of increasing the durability of timber windows and doors is to limit their direct exposure to the elements by providing an eave, overhang, sunshade or verandah over the facade or the unit. These reduce the level of sunlight, the force of wind and the amount of rain driven onto or running across the joinery unit, significantly increasing service life.

In windows, the window sill, bottom rail of any sash, and the joints between the sill and the rest of the frame endure the most exposure and therefore are at the highest risk of deterioration. In doors, it is the bottom rail of a panel door, the bottom 300 mm of any door and the joints between the sill and the rest of the frame.

These surfaces are generally angled more towards the sunlight, exacerbating the effect of heat on the timber or the paint finish and the rate of breakdown or decay, and are further away from any protection given by eaves or sunshades. Water runs down onto these surfaces from above; it can also be splashed up onto doors or full-height windows from the surrounding floor or ground. Dust and water accumulates on these surfaces.

3.6.2 Durability of the Timber Frame

The durability of the timber frame is affected by hazards in the surrounding environment, the resistance of the timber to decay and weathering, the arrangement of species, the quality of assembly, and any coating or treatment on the timber.

Hazard classes

The timber can resist decay and weathering naturally or with preservative chemical treatments.

AS 1604-2005 Timber – Preservative-treated – Sawn and round identifies the degree of hazard for timber in construction. For timber in window and door joinery, the relevant hazard classes are:

- Hazard Class H3 for units exposed outside above ground; and
- Hazard Class H1 for units exposed inside, fully protected from the weather and termites.

Hazard Class H3 includes a wide range of conditions from under the shelter of eaves to full exposure to the sun and wind. However, while the whole unit is rated as Hazard Class H3, in practice the different parts of the window or door are exposed to different hazard conditions.

Decay, weathering and insect attack

Decay is the decomposition of timber by fungi and can occur if the moisture content of the timber is maintained above 20% and the temperature is between about 5°C and 60°C. While the temperature on the outside of a building is hard to control, the timber can be kept dry by shedding water, keeping moisture out of the joints and allowing wet timber to dry out. Decay can occur on any surface of timber but tends to attack the end-grain of any unprotected piece most vigorously. Absorption through the end-grain of the piece can be much quicker than through the surface grain and the higher moisture content sustains the fungi.

Weathering is the greying and minor cracking of a timber surface caused by light, dust or recurrent wetting and drying. Weathering affects appearance, the performance of finishes and eventually the decay rate, as water retained in any indentations in the surface of the wood or under any fractured finishing coat can nurture the growth of fungi.

Insects, such as termites and lyctid borers, can attack the timber. Exclusion of termites is a whole-of-building issue and should be addressed as set out in the relevant Australian Standard. The lyctid borer attacks the sapwood of susceptible hardwood species. The adult insect lays its eggs in the pores of wood and the insect larva attacks the starch-rich sapwood, leaving behind fine, powdery dust, or frass, and small holes on the timber's surface. The starch level in the heartwood of the timber is generally not high enough to sustain the larva and is not attacked. AS 2047-1999 and timber marketing legislation in several states preclude the sale or use of lyctid-susceptible sapwood in timber. All susceptible sapwood has to be excluded or treated. Industry practice in Australia is to mill the timber without sapwood or to treat the timber of susceptible species to H1 under AS 1604, often with a boron-based or synthetic pyrethroid preservative.

Timber's natural resistance to hazards

The natural durability of a piece of timber is generally a characteristic of the species. Timber species are rated in one of four durability classes in *AS 5604-2005 Timber – Natural durability ratings. Durability classes are* based on years of comparative tests of timber samples. Durability ratings are given for two types of exposure: durability in-ground contact and durability exposed out-of-ground contact (Table 13). Durability ratings only refer to the performance of heartwood. Sapwood is either excluded or treated. The untreated sapwood from all species is rated as Durability Class 4.

Table 13: Timber durability life expectancy.

	Probable heartwood life expectancy (years)	
Natural durability class	**Hazard class 1 Fully protected from the weather and termites**	**Hazard class 3 Above ground exposed to the weather but protected from termites**
Class 1 (highly durable)	50+	40+
Class 2 (durable)	50+	15–40
Class 3 (moderately durable)	50+	7–15
Class 4 (non-durable)	50+	0–7

Source: AS 5604-2005

Preservative treatment to resist decay, weathering and insects

Timber's natural resistance to decay and insects can be enhanced by adding preservative chemicals. AS 1604-2005 specifies the requirements for preservative treatment, including the penetration and retention of chemicals in the timber. Treatment options are generally targeted at achieving resistance in particular hazard classes. For example, low-durability timber can be treated to H3, meaning it is suitable for use outside above ground.

The main types of preservative treatments for joinery timber in Australia are combinations of insecticides and fungicides, applied by dip diffusion or by commercial pressure treatment. The major treatment options are:

- waterborne preservatives applied to unseasoned timber, generally boron-based mixtures; and
- light organic solvent-borne preservatives (LOSP) applied to seasoned timber and finished product. Current commercial treatments include azole or tri-butyl tin combined with a pyrethroid.

Not all timber can be successfully treated to the level required by AS 1604 using currently available commercial processes. Generally, the sapwood of all species can be treated to H3 but the heartwood of most species resists consistent treatment because the preservative cannot penetrate into the timber sufficiently or consistently enough to provide the level of chemical retention required. Such pieces only receive surface coating. If cut, the exposed ends of treated timber should be dipped in preservative to maintain the envelope protection.

Research carried out by CSIRO sought to gauge the comparative durability of six test window frames constructed from timber species of differing durability with varying finishes. The timber was tested untreated, treated with boron when unseasoned, or treated with LOSP when seasoned, painted and unpainted.

After eight years of exposure, the windows were examined and rated on an 8 to 0 scale based on the amount of cross-section lost to decay. A rating of 8 means the frame was sound while 0 equalled a destroyed frame. A specimen rated 3 or lower was regarded as unserviceable.

Table 14 presents a summary of results from the research. Timbers with relatively low inherent durability and thus poor untreated performance can be seen to perform similarly to the higher durability species when treated with either boron or LOSP (AZOLE). The use of 'no-rot' rods in the frames, which provide a slow impregnation of preservative, significantly improved the service life of the units. Painting either as a sole finish or in combination with other treatments can also be seen to significantly improve the service life of the units. The results of this research are not reflected by current codified practices, but the research provides evidence of what may be achieved with such treatments.

The appearance of timber windows and doors is often a critical part of a design concept and the selected finish of the unit strongly influences its appearance.

Table 14 Summary comparison of performance.

Species	Durability	Treatment	Mean performance (std dev.)
Western red cedar *(T. pilcata)*	2	untreated, painted	7.4 (0.8)
Mountain ash *(E. regnans)*	3	LOSP (azole), painted	7.4 (0.3)
Mountain ash *(E. regnans)*	3	LOSP (azole), unpainted	4.5 (2.5)
Mountain ash *(E. regnans)*	3	untreated, painted	0.9 (1.0)
Mountain ash *(E. regnans)*	3	untreated, unpainted	0.6 (0.8)
Mountain ash *(E. regnans)*	3	boron, painted	7.4 (0.5)
Messmate *(E. obliqua)*	3	boron, painted	7.4 (0.3)
Alpine ash *(E. delegatensis)*	3	boron, painted	7.0 (1.6)
Silvertop ash *(E. sieberi)*	2	boron, painted	6.0 (1.4)
Mountain ash *(E. regnans)*	3	No-rot rods	8.0 (0.1)

Source: Cookson 2007

Finishing

There are four common approaches to finishing timber windows and doors: natural or unfinished; coated with a stain or clear finish; coated with an opaque paint; or clad with an extrusion in a composite system, usually aluminium or stainless steel. Finishes can be combined on the same unit to maximise protection while maintaining design intent. Windows and doors can be finished differently internally and externally. Window and door elements within a unit can be finished differently, for example frames may be painted while sashes left unfinished.

The selection of an appropriate finish for the application can be critical to the unit's service life. Coating external timber with a well-maintained paint or a high-build translucent finish sheds water off the unit's surface quickly, slowing the uptake of moisture and reducing the chance of decay. Detailed specifications should be developed in consultation with a manufacturer.

The expected life of finishes depends on the quality of the coatings, care taken in application and ongoing maintenance regime. Quality products should be used and applied and maintained strictly to the manufacturer's recommendation to maximise service life. Even if coatings are of the same type, their composition and performance can be quite different and so should not be mixed across brands or systems.

Natural or unfinished

Timber windows and doors can be left unfinished, exposing the natural texture and tone of the wood. Well-detailed unfinished windows and doors will need little maintenance, reducing the potential environmental impact associated with coating and subsequent refinishing. However, an unfinished element will not remain as the installed colour. Over time, the surface of the timber will start to weather, first darkening as moisture mobilises extractives in the wood, and then turning grey. The expectations of client and the building users should be managed with respect to the ongoing colour of the timber. Local precedents can be studied. Another approach is to paint the timber with a temporary coat of grey that fades as the wood itself greys. Key considerations for a natural or unfinished approach are:

- Take care in species selection and detailing of unfinished joinery. Uneven exposure and wetting can lead to variable weathering, staining, bleaching and localised surface mould as shown below.
- Select species with suitable durability to match with the element exposure. Do not use low-durability timbers without treatment or younger and more unstable species without a coating.
- Unfinished timber will absorb and lose moisture more readily than finished timber so clearance between opening sashes and the frames should be increased to allow for any moisture-induced movement.
- Glazing seal materials need the capacity to expand into increasing gaps between the glass and bead, or have sufficient flexibility to bond to both the glass and timber if glazing beads are to be left uncoated. Putty should be painted.
- Metal elements such as hardware should be stainless steel or other corrosion-resistant metals to resist climatic exposure and reaction with timber-extractives.
- Elements should be painted on the concealed surfaces, with the remainder coated with a temporary water-repellent coating in the factory. This temporary coating will break down quickly on the exposed surfaces, but will continue to protect the covered surfaces for some time.

Figure 6: Differential weathering and decay on a facade.

Transparent coatings and stains

Transparent coatings and stains protect the timber while allowing the grain and texture of the timber to show through. Coatings suitable for external applications usually include preservatives, fungicides and colourants with an oil that soaks into the timber and a tougher medium- or high-build surface coating. The oil improves appearance and adhesion, while the surface coating protects the timber from occasional wear and excludes moisture. The preservatives and fungicides in these finishes protect the finish and the timber directly in contact with it. However, while they may be marketed as preservatives, they are not substitutes for factory-impregnated timber treatment.

Transparent coatings shed water and reduce other impacts but the surface of the timber is usually exposed to ultraviolet light and can weather over time. The resulting timber breakdown allows the finish to lose adhesion and crack or peel. Semi-translucent stains that pigment the surface of the timber without necessarily obscuring its natural features can provide better ultraviolet resistance. Simple oil-based coatings may contain preservatives and fungicides but are generally not long-lasting in external applications, especially those regularly exposed to sunlight. The oil can be a ready food source for fungi and cause surface mould. Simple clear varnishes are not suitable for outside applications, as the timber quickly weathers and the finish crazes and can trap water under the coating.

Coatings for internal finishes do not have to face the rigours of external coatings and more variety is available. There are three main types for internal applications: clear polyurethane finish (or varnish); a combination of an oil and a surface coating such as polyurethane; or an oil or wax preparation.

- Polyurethanes are available in two major types: moisture-curing and water-based. Moisture-curing polyurethanes produce a clear, very hard surface in a matt, satin or high-gloss finish. However, they darken with age. Water-based polyurethanes can produce a clear, hard surface in a matt, satin or gloss finish. Water-based polyurethanes produce less fumes during application and curing, but are more expensive than moisture-curing polyurethanes.
- Modified oil coatings are clear varnishes, generally made from a mixture of resin and oil. These are easy to apply and penetrating, are more visually subtle than polyurethanes, but are not as hard-wearing.
- Oils are penetrating finishes that are generally less hard-wearing than modified oils or polyurethanes. They produce a subtle, natural appearance but require regular maintenance in high-contact areas.

The consequences of any breakdown of the finish can be severe. Once the surface of the finish splits, water can enter and be trapped next to the wood. This can lead to further breakdown of the finish, more ingress of water and hastened decay.

Paints

Paints protect timber from water, sunlight and abrasion and are able to conceal flaws in the surface of the timber. These finishes last much longer than translucent coatings because ultraviolet light cannot reach the surface of the timber to cause weathering.

The choice of colour is important. Light-coloured paints typically last longer and give greater protection to the timber than dark-coloured paints because dark colours absorb and retain heat from sunlight, straining the paint. Once the surface of the finish splits, water can enter and be trapped next to the timber which can lead to further breakdown of the finish, more ingress of water and hastened decay.

The paint needs to be flexible and remain flexible because timber expands and contracts with changes in moisture content. When paints become hard and brittle, usually associated with prolonged exposure to sunlight, they can break down and flake away from the timber. Quality paints, properly applied and maintained, can be long-lasting and accommodate moisture-induced movement without fissuring or flaking.

There are two main types of paints commonly available for windows and doors: oil- (or solvent-) based paints and water-based acrylics. Oil-based paints were traditionally used with all external joinery. They have better flow characteristics than water-based paints, and were believed to provide a better adhesion to the surface. However, older solvent-based paints did not have the long-term flexibility of modern systems, and tended to become brittle and chalky and crack away from the timber.

Older acrylics were believed to form a plastic wrap on the wood, and cause sticking in sashes and doors. They did not have the durability of contemporary solvent-based paints. However, with advances in acrylic technology, acrylics are now preferred for coating external windows and doors. Acrylics do not have the chemical emissions commonly associated with solvent-based finishes, are easier to apply and clean up, and have a shorter recoat time.

Joints and fixings

The quality of assembly can assist in keeping the timber in the joints of the frame dry and protected from decay. The joints between the sill and the rest of the frame should be completely sealed to exclude water. Joints in the frame should be protected by:

- treating the cut ends of any treated or low-durability material. A minimum three-minute dip immersion of the end-grain in an azole-based LOSP treatment can significantly increase the frame's service life.
- sealing the end-grain of the pieces with paint before assembly which slows water entering the timber;
- sealing the joint with a flexible, waterproof sealant to fill any gaps that water may enter; and
- shaping joints so that they do not trap water unnecessarily.

Corrosion of metal fasteners can split the timber and retain moisture. AS 2047-1999 requires that all steel fixings should be hot-tip galvanised steel in accordance with service condition No. 2 of *AS 1789-2003 Electroplated zinc (electrogalvanised) coatings on ferrous articles (batch process),* or stainless steel. Do not use uncoated steel fixings on any part of the frame.

Flashings

Flashings are needed at the head, sill and jambs of the opening to prevent water entering the 'dry' side of the water barrier around the joinery frame. Incorporating only storm beads or sealing the external cladding to the unit is inadequate because they inevitably fail, allowing water to enter the building. The final configuration of the flashings changes with the frame, the external cladding type, the position of the unit in the opening and the architectural intent.

Arrangement in the frame

Durability characteristics of species can be aligned with the deterioration risk of different components of the window or door unit as presented in Table 15. As a minimum, AS 2047-1999 requires that timber windows be constructed of:

- Durability Class 1 or 2 timber;
- timber treated in accordance with AS 1604-1997; or
- timber of any durability class provided that it is protected from ingress of moisture by appropriate joint details, and either the application of a protective coating or installation under a protective shelter, such as a verandah.

Table 15: Preferred species arrangement for commercial and Exposure Zone D residential projects.

Element	Relative exposure	Building exposure	Finish	Timber**
Sill	High	Normal	Painted or stained	Durability Class 1 or 2 timber
Sill	High	Normal	Painted	Durability Class 1 or 2 timber or commercially treated LOSP (azole) hardwood
Frame (excluding the sill)	Medium	Normal	Painted or stained	Durability Class 1 or 2 timber, or commercially treated LOSP (azole) hardwood, or VPI boron-treated hardwood
Frame (excluding the sill)	Medium	Normal	Painted	Durability Class 1 or 2 timber, or commercially treated LOSP (azole) hardwood, or VPI boron-treated hardwood, or H3 treated softwood
Sash or door*	Medium	Sheltered	Unfinished	Durability Class 1 or 2 timber
Sash or door*	Medium	Normal	Painted or stained	Durability Class 1 or 2 timber, or commercially treated LOSP (azole) hardwoods, or VPI boron-treated hardwood, or H3 treated softwood
Sash or door*	Medium	Normal	Painted	Durability Class 1, 2 or 3 timber, or H3 treated softwood

** Timber for sashes and doors has specific stability requirements that need to be met.*
*** If any treated timber is cut, the end-grain needs to be re-treated to maintain the treatment envelope.*

Design for durability internally

Finishes on windows and doors wear away with regular hand contact, or can be damaged where units are kicked or hit by trolleys or bags. Identifying points of wear and detailing to protect them will extend the life of surfaces and finishes. Replaceable inserts or protective coverings can be applied. Push and kick plates protect the timber from indentation.

3.6.3 Durability of the Glass and Glazing

Clear glass is a durable and chemical-resistant material with a very long service life if protected from impact or heat stress. Deep scratches in toughened glass can induce failure. The coating of low-e and heat-reflective glasses is subject to wear and potentially staining, especially during construction.

The service life of insulated glass units is influenced by the quality of design, manufacture and installation, and exposure to the elements. Wind loads and pressure fluctuations load the seals between and around the glazing panes which leads to fatigue in the seals and can reduce the thermal performance and permit air to enter. Consult manufacturers of specialist coatings and insulated units for advice on the correct installation and maintenance in order to maximise the service life of the units.

3.7 Designing for Bushfire

Bushfires expose buildings to extreme heat and wind-blown embers which affect timber windows and doors. Windows and doors can fail when the glass cracks, shatters or moves in the frame to form a gap that allows embers and potentially flame into the building. Buildings should be designed in compliance with *AS 3959-2009 Construction of buildings in bushfire-prone areas.*

AS 3959 specifies requirements for the construction of new buildings, or significant alteration to existing buildings, in State or locally defined bushfire-prone areas in order to improve their resistance to bushfire attack from burning embers, radiant heat, flame contact and combinations of these three forms of attack.

3.7.1 Bushfire Attack Levels and Material Selection

Compliance with AS 3959 requires establishing the threat level for the site and then detailing the building envelope to resist that threat. The standard establishes six possible Bushfire Attack Levels (BAL) for a site. The design BAL applied to a proposed building or renovation is based on an assessment of the threat posed to the site by nearby organic fuels and other factors.

Greater restrictions are placed on the materials used in the construction of the external envelope with increasing threat level. Timber species suitable for use with the different bushfire resisting classes can be found in Appendix E of AS 3959-2009, an extract of which is included in Table 16. Timber species can be regarded as bushfire-resistant due to the natural properties of the material, or by coating or impregnation with fire-retardant chemicals. Timbers rated as naturally bushfire-resistant after testing are included in Table 17. Timber can be impregnated with fire-retardant chemicals or coated with fire-retardant systems to comply with AS 3959, Appendix F.

Table 16: Bushfire requirements for doors and windows.

Bushfire Attack Level	External doors	External windows	Bushfire shutters
BAL LOW	No special requirements	No special requirements	No special requirements
BAL 12.5 & 19	Bushfire shutters or screen and any timber frame or door assembled with bushfire-resisting timber or timber species from E2 (AS 3959)	Bushfire shutters or screen and any timber frame or window assembled with bushfire-resisting timber or timber species from E2 (AS 3959)	Non-combustible material, bushfire-resisting timber or timber species from E1 (AS 3959)
BAL 29	Bushfire shutters and any timber frame or door assembled with bushfire-resisting timber	Bushfire shutters and any timber frame or window assembled with bushfire-resisting timber	Non-combustible material or bushfire-resisting timber
BAL 40 & FZ	Bushfire shutters and any timber frame	Bushfire shutters and any timber frame	Non-combustible material

Table 17: Density and fire resistance of major species.

Requirement	Compliant species
Bushfire-resistant	Blackbutt, spotted gum, red ironbark, river red gum, silvertop ash, turpentine, kwila (merbau)
Timber species* from E1 – density 750 kg/m^3 or greater	Silvertop ash, blackbutt, brownbarrel, Sydney blue gum, grey gum, manna gum, river red gum, spotted gum, grey ironbark, red ironbark, jarrah, kwila (merbau), messmate
Timber species* from E2 – density 650 kg/m^3 or greater	All species from E1 (above), also alpine ash, mountain ash, white cypress, shining gum, celery-top pine, slash pine

3.7.2 Detailing against Ember Attack

External vents, weepholes and gaps through which a 3 mm diameter probe can be passed penetrating the building envelope or into the building cavity should be screened with a mesh with apetures less than 2 mm. More detail can be found in *AS 3959-2009 Construction of buildings in bushfire-prone areas*

3.7.3 Bushfires, Glass and Openings

Toughened or safety glass is required in glazed areas within 400 mm of the ground or decks because these are deemed liable to flame exposure. Mesh screens are required for the openable section of windows from threat category BAL 12.5 and higher. Mesh requirements vary between openings glazed with normal annealed glass and those glazed with toughened or safety glass. AS 3959-2009 should be consulted for details.

3.8 Designing for Safety

3.8.1 Safe Movement and Access

Volume 1 Part D.2, Volume 2 Part 3.9 of the National Construction Code and AS 1926 impose requirements to ensure safe movement and access to pool areas. The implications for the specification of windows and doors include requirements for child-resistant doors sets, limiting the opening of windows to 100 mm or protecting the openable windows with bars or mesh, and limiting the extent to which upper-storey windows can open.

Doors and windows on the external wall of an upper storey form part of the system of barriers that prevent occupants from falling out. As such, they need to comply with general provisions for balustrades included in the National Construction Code. These require that a continuous balustrade or other barrier be provided across the window if its level above the surface beneath is more than 4 m and it is possible for a person to fall through it. The height of a balustrade or other barrier must be not be less than 1 m above the floor and it must be constructed so that any opening in it does not permit a 125 mm sphere to pass through it. To comply, a window must provide the same performance: any sash less than 1 m above the floor needs to be constrained to limit its opening so that a 125 mm sphere cannot pass through.

3.8.2 Safe Glazing

All glass used in windows and doors in Australia needs to comply with AS 1288-2006 **Glass in buildings – Selection and installation**. The standard regulates the size and type of glass according to the required structural capacity of the glass and the safety of occupants. AS 1288-2006 recognises two grades of safety glass manufactured to AS/NZS 2208-1996. Grade A offers a high level of protection against injury and includes laminated, toughened and toughed laminated glass. Grade B provides lesser protection and includes wired safety glass.

Building occupants can be injured or killed if they hit or run into the glass in windows and doors. In order to reduce possible risk and hazard, AS 1288-2006 regulates the types of glass used in areas susceptible to human impact such as:

- glazing in doors and sidelights;
- windows capable of being mistaken for an opening, and glazing within 500 mm of the floor;
- glazing generally or within 1 m of the floor in schools and childcare buildings;
- shop fronts and internal partitions; and
- windows in bathrooms.

Mechanical protection can be provided to the glazing, and the glass can be made more visible or obvious. AS 1288-2006 requires that glass that may be mistaken as an opening be marked to increase its visibility.

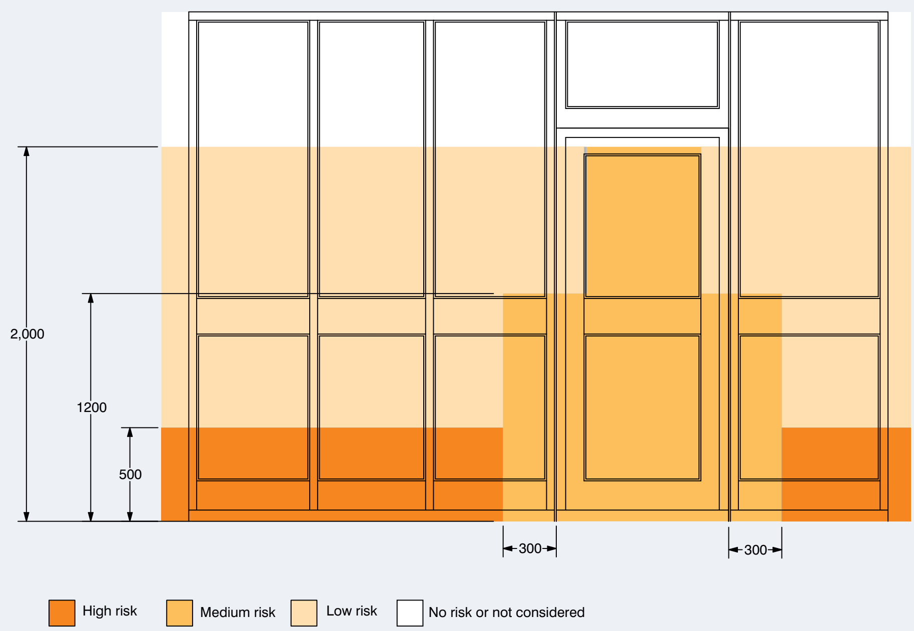


Figure 7: Level of risk of injury from human impact.

Source: AS 1288-2006

3.9 Structural Considerations

Generally, timber window and door units do not carry structural building loads but act as non-loadbearing insertions into the loadbearing frame of the building. If the joinery units are to carry structural building loads, member sizes and jointing must be determined in accordance with *AS 1720 Timber structures*, *AS 1684-2006 National Timber Framing Code – Residential timber-framed construction* and allied Standards.

Windows and doors may generate significant loads onto the surrounding structure, as wind loads or direct gravity loads. This is particularly the case with bi-fold and top-hung sliding units where the windows and doors are supported directly from the lintel. In these cases, the allowable deflection in the lintel needs to be limited to below the level that will affect the unit's operation.

Windows and doors have to resist wind loads applied to the assembly. AS 2047-1999 *Windows in buildings – Selection and installation* requires windows to perform satisfactorily to particular design wind pressures. These pressures are provided in *AS/NZS 1170.2-2002 Structural design actions – Wind actions for buildings other than housing.* For housing, the design and ultimate strength test pressures are shown in Table 18.

Table 18: Window ratings for housing.

Window wind pressure rating	Serviceability design wind pressure (Pa)	Ultimate strength wind pressure (Pa)
N1	500	700
N2	700	1,000
N3	1,000	1,500
N4	1,500	2,300
N5	2,200	3,300
N6	3,300	4,500

Source: AS 2047-1999, Tables 2.1 & 2.5

Under the applicable design wind pressures, Table 19 shows the maximum allowable deflection of a structural element in the unit:

Table 19: Allowable deflection under design wind pressure.

Building Class	Deflection limit
Class 1 (residential)	Span/150
Class 2, 3 or 4 (multi-residential apartments, hotels etc)	Span/180
Class 5, 6, 7, 8 or 9 (commercial and public buildings)	Span/250

Source: AS 2047-1999

3.10 Reducing 'Whole-Life' Energy Costs

The 'whole-life' energy costs associated with buildings consist of embodied energy in construction, energy in operation, maintenance and end-of-life processes, such as demolition and disposal. 'Whole-life' energy costs should be as low as possible in order to limit environmental impact. Three significant strategies that can be adopted to reduce the whole-life energy costs include:

- Design for longevity – using highly durable materials.
- Design for flexibility – recognising the human need for change and making buildings flexible enough to adapt to changing needs.
- Design for disassembly and replacement – designing elements so that materials may be re-configured and used again, and recognising that some parts of the building will have longer effective service lives than others.

The three approaches listed above are commonly adopted for internal joinery. Internal doors and similar joinery are regularly refreshed in place, removed, renovated or recycled. The reuse of old windows and doors can be limited because of increasing performance requirements. Some new designs incorporate a means of replacing the most vulnerable sections, particular the sill, without significant effort or change to the unit.

4

Assembly and installation

Timber brings flexibility to the design and fabrication of windows and doors. Timber can also be easily shaped or moulded to suit a particular project or assembled into much larger units, either with glue or mechanical fixings.

4.1 Introduction

The section size of timber frame required is influenced by required clearance, glass thickness, timber species, structural performance, and the fabrication of robust connections.

4.2 Containing the Glass

Glass in a timber frame has to be adequately supported and provided with sufficient clearance to allow for movement in the frame, expansion or contraction of the timber due to changes in moisture content, or movement of the glass due to changes in temperature.

4.2.1 Glazing Clearance

Table 20 lists the minimum clearance, cover and rebate depths required by AS 1288 for glass in frames sealed with glazing putty or non-setting glazing materials. Table 21 lists the clearance and cover distances required by *AS/NZS 4666-2000 Insulating glass units* for an insulated glazing unit (IGU). The required minimum rebate depths do not necessarily allow sufficient depth to install front putty or fix a glazing bead.

Table 20: Clearance, cover and rebate depth for single-glazed units.

Glass thickness	Front and back clearance (min.)	Edge clearance (min.)	Edge cover (min.)	Rebate depth (min.)
Putty Glazing				
3 (panel <0.1 m^2)	2	2	4	6
3 (panel >0.1 m^2)	2	3	6	9
4	2	2	6	8
5	2	4	6	10
6	2	4	6	10
Non-setting compounds				
3	2	3	6	9
4	2	2	6	9
5	2	4	6	10
6	2	4	6	10
8	2	5	8	13
10	2	5	8	13

Source: AS 1288, Table 8.1

Table 21: Clearance cover and rebate depth for IGUs.

	Face and back clearances (min.)	Edge clearance (min.)	Edge cover (min.)
Sills	2	6	12
Head and jamb (unit length <2 m)	2	3	12
Head and jamb (unit length >2 m)	2	5	12

Source: AS/NZS 4666-2000

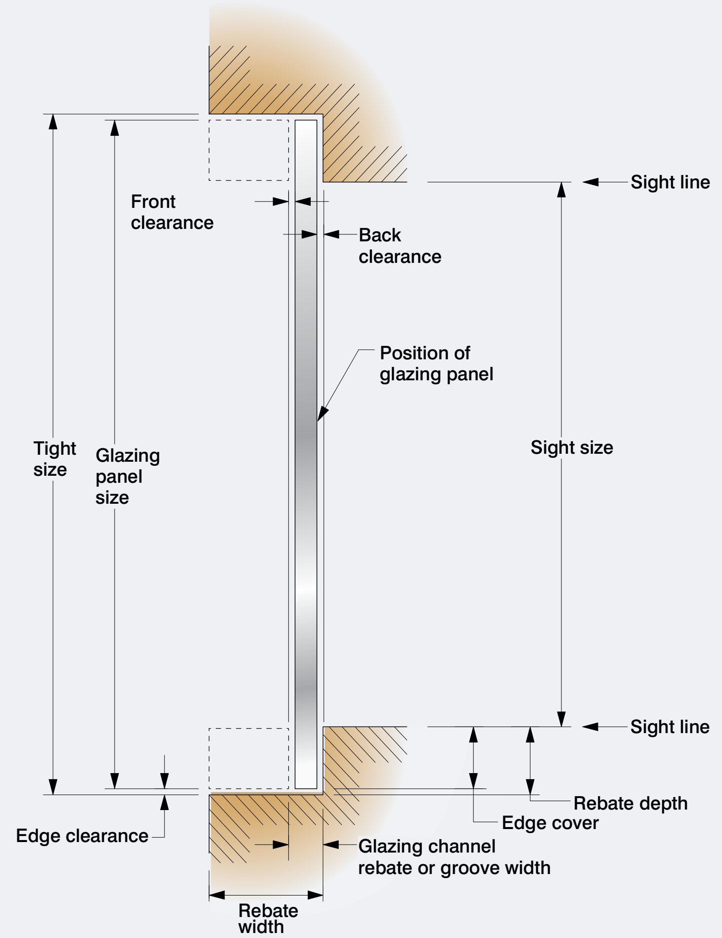


Figure 8: Rebate depth and clearances.

4.2.2 Glass and Sash Thickness

The thickness of the selected glass or IGU influences the thickness of the timber required for window and door sashes. Common sash sizes will accommodate standard glass and common IGU sizes. Table 22 gives general limits to the thickness of glass or glazing units used with available solid section timber thicknesses giving consideration for the up-stand of the rebate and front beading. Check this with the manufacturer because the capacity of the selected timber and the size of the sash and selected beads may vary and will influence the final maximum glass thickness. Note that typical nominal sizes available of Australian timber are smaller than sizes available in North American timbers. It may be necessary to adopt glue-laminated timber if the required glass thickness exceeds that of available stable solid section material available.

Table 22: Timber and glass thickness for IGUs.

	Timber thickness		Glass
	Nominal (mm)	**Dressed (mm)**	**Thickness limit* (mm)**
Solid section Australian timber	50	40–42	16
Solid section North American timber	50	42	16–18
	65	54	28
	75	65	38

Confirm this limit with your manufacturer

4.3 Connecting the Frame

The size of the frame and sash elements required is influenced by glass thickness (as described above), structural adequacy, section stability, and jointing. Making sufficiently robust joints is often the governing factor in determining section size. Most manufacturers use a set of standard profiles and element dimensions to build units of particular types and sizes, developed through experience with particular species and conditions. Some manufacturers will work with architects and specifiers to produce individual frames for specialist projects.

4.3.1 Carpentry Joints

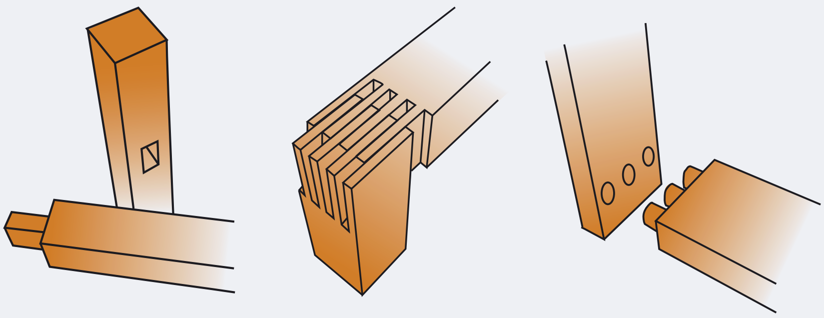


Figure 9: Types of joints – tenon, open-slot mortice, dowel joints.

The main joint types used in the construction of timber frames, sashes and doors are variations of the traditional mortice and tenon joint. A tenon is a projecting piece of timber shaped to fit into an enclosed slot or mortice in the other piece of timber. The mortice can be a 'through' mortice, which goes from one side of the piece to the other and, once assembled, the end of the tenon is visible from the outside face, or a blind mortice which has a enclosed slot that does not go all the way through the piece. Wedges can be inserted around the tenon or into the tenon to tighten the joint so that the tenon cannot be withdrawn once assembled. The joint may also be glued.

A variation on the traditional mortice joint is an open-slot mortice which includes at least one slot that goes through the sides and the end of the piece and receives the tenon. In this arrangement the joint has to be glued and possibly pinned. Multiple slots and tenons can be included in a joint to form a comb-type connection.

Dowel joints can also be used to assemble the frame elements. Aligned holes are made in the pieces to be joined which receive a timber or other dowel. The dowel is glued into place as the pieces are assembled.

Each of these joints has particular advantages and disadvantages. The shoulders on the pieces of the traditional mortice and tenon increase racking resistance, stabilising the joint. The comb-type open-slot mortice provides a greater surface area for glue and can be easier to make. Dowels are economical, using less timber and fewer milling operations. The manufacturer will be able to advise on which of these to use based on factors such as the chosen timber's ability to bond with adhesives.

4.3.2 Adhesives

Adhesives are used in timber windows and doors to glue-laminate members of the frame together or to bond the joints of the frame, sashes and door. The service life of an adhesive is influenced by the type of adhesive, the type of connected elements, and the exposure.

Timber glue-laminated for general structural applications is manufactured to the requirements of *AS 1328-1998 Glue-laminated structural timber*. Commercially produced glue-laminated timber made to this standard generally features Type A waterproof phenolic bonds with a distinct dark-brown glue-line.

Timber in the joinery for non-loadbearing windows or door frames does not need to meet the same standard and can be glued with adhesives that comply with, or are at least equivalent in performance to, adhesives complying with *AS 2754.2 Adhesives for timber and timber products – Polymer emulsion adhesives*. The adhesive needs to achieve at least a Type B bond to *AS/NZS 2098.2-2006 Methods of test for veneer and plywood – Bond quality of plywood (chisel test)*. Joints made with adhesives that do not give this performance have to be held together by other means if the glue fails.

Correct installation is critical to the service life of the unit, as incorrect installation can lead to premature failure of the glass, especially in IGUs.

Two glues commonly used in window and door joinery are polyurethanes and polyvinyl acetate (PVA) emulsions.

- Polyurethanes are thermosetting glues that include two components that react with the moisture in the wood to produce a clear polyurethane resin. They have good strength and some gap-filling capabilities, though their performance is improving with further research.
- PVAs are thermoplastic glues made by polymerising vinyl acetate alone or with other polymers. Most cure at room temperature and set rapidly. They are easy to use, result in a clear glue-line, and have good gap-filling properties, though steady pressure on the joint is required. Cross-linked glues have better moisture resistance than other types.

4.4 Installing Glazing

Glass inserted into a timber frame has to be weatherproof, restrained to resist the design load imposed, and supported, while still allowing for movement, expansion or contraction. AS 1288-2006 sets out minimum requirements for the installation of single glass into a frame, while AS/NZS 4666-2000 establishes the requirements for IGUs.

Units can be glazed in the factory or on-site. Site glazing after installation reduces the weight of the units being handled on-site, but can also decrease performance, especially with IGUs. Glazing under factory conditions can significantly reduce the possibility of early IGU failure. The process of glazing involves making the correct clearances and cover in the frame to suit the glass, preparing the rebates, installing positioning blocks and sealing the unit.

4.4.1 Preparation

The rebates or stops that are to receive the glass or IGUs need to be clean, flat and smooth to provide good adhesion for the sealant material. They should be free from moisture or contaminants. If the window is to be painted, they should be primed or sealed.

4.4.2 Positioning

Setting blocks, location blocks and distance pieces are used to maintain the clearances required between the glass and the frame. Setting blocks are resilient non-absorbent blocks used to support the dead load of the glass on the rebate and prevent the bottom edge of the glass from coming into contact with the frame. Location blocks are similar blocks used to prevent glass-to-frame contact in other parts of the frame due to movement caused by thermal change or distortion in opening and closing the unit.

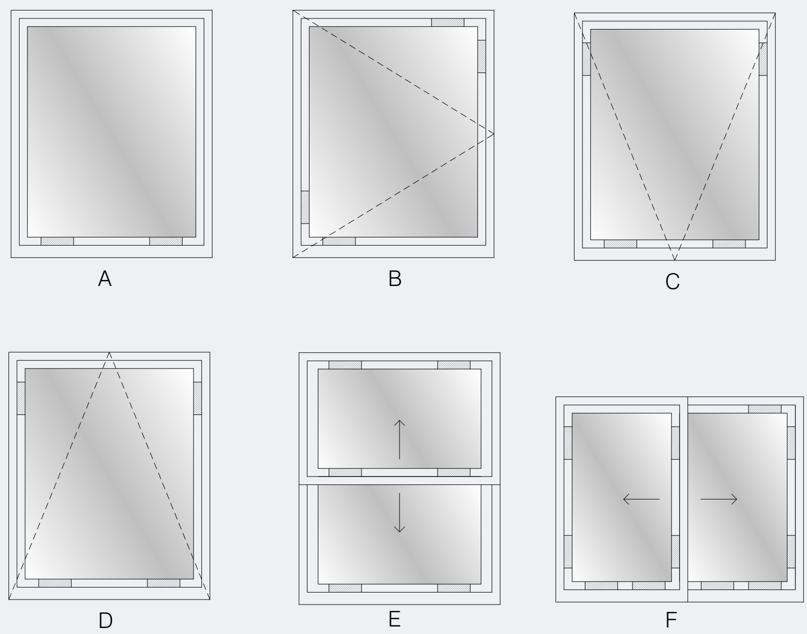


Figure 10: Position of location blocks:
(A) fixed (B) casement (C) awning (D) hopper (E) double-hung (F) sliding.

Glazing tapes are suitable for both single glazing and IGUs. They can accommodate considerable wind load, and generally eliminate the need for distance pieces.

Each setting block needs to be a minimum length of 25 mm for each square metre of glass in the unit, with a minimum length of 50 mm. Location blocks are positioned around the head and jambs between the glass and the frame. These blocks also need to be resilient, generally equal to extruded rubber with 55–65 shore-A hardness (AS 1288-2006). Each location block is to be at least 25 mm long.

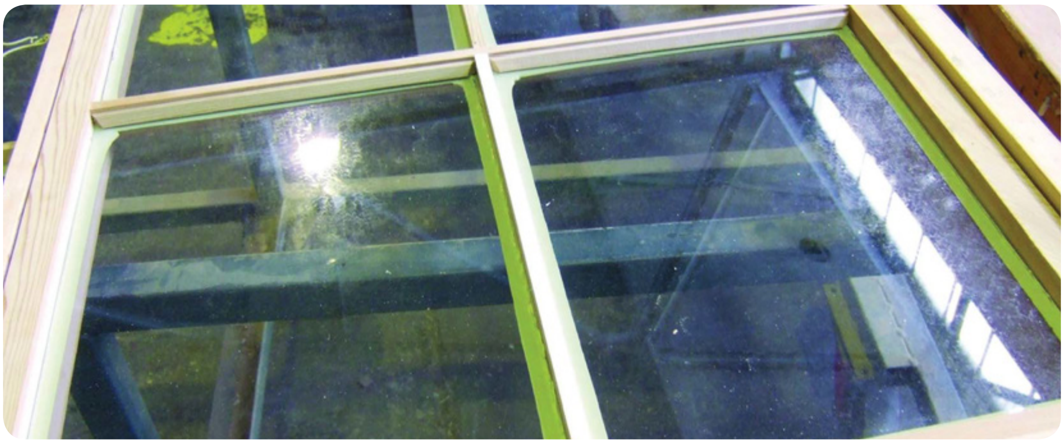
Distance pieces are small blocks of resilient non-absorbent material used to prevent the displacement of the glazing compound or sealant on the face and back of the glazing unit. Distance pieces should be 25 mm long and of a size to match the rebate depth and required face and back clearances. They are placed opposite each other, generally 50 mm from each corner and not more than 300 mm apart.

4.4.3 Silicone and Beads

The glass can be set in a bed of neutral cure silicone and retained by timber beads. The silicone should be installed to provide a full adhesive bond to frame, while maintaining the necessary face and back clearances. In Australia, timber beads are almost always on the outside face of window and door joinery. They can be clear or paint finished. Beads allow immediate handling and painting and are easier to remove if re-glazing is required. The backs of beads should be primed or sealed before they are fixed in place. Installing beads on curved work can be expensive and difficult.

IGUs should be installed so that the gap between the unit and the sash or door frame is free to drain, with the unit sealed between the glass and the face of the rebate or the glazing bead. Sealing between the edges of the IGU (around the seals) and the frames can tend to pull the seals out of the IGU and cause it to fail.

Timber beads restraining IGUs should be at least as high as the timber rebate, and at least as wide as they are high. The top and side beads should preferably not overhang the face of the sash. The bottom bead can overhang the bottom of the sash to provide some protection to the bottom weep holes.



4.4.4 Glazing Sealants and Tapes

Glazing tapes are compressible, generally butyl adhesive tapes that are applied around the faces of the glass before it is installed in the rebate. Once the backing film is removed, the glass can be fitted into the frame. The tape adheres to the face of the rebate, and to the glazing beads when they are installed. It can be trimmed back to the edge of the frame. Some glazing tapes are designed to be capped with sealant.

4.4.5 Glazing Putty

Linseed oil putty was used traditionally for glazing almost all external joinery. Modified oil and synthetic resin putty is available as an alternative. These putties can be used with or without glazing beads. If used without glazing beads, the glass needs to be restrained with glazing pins, and include at least 12 mm of tapering front putty. Putty is weather-tight but can commonly take some weeks to become firm and is prone to site damage. Unhardened linseed oil is very attractive to birds and animals.

Putty requires several days to set before it can be transported and may sag in hot weather. It should be painted not less than two weeks and not more than four weeks after glazing. Putty is used as standard for curved work. However, it should not be used with laminated glass as it can attack the inter-layer and lead to delamination. It is not suitable for glazing IGUs, and is not recommended for use with heat-absorbing glass. Putty should be painted in all external applications so is unsuitable for units with external timber stain or clear finishes.

4.5 Applying Finishes

Coating systems are designed to be solely factory applied or site-applied (site-applied coatings can also be factory applied but not vice-versa). Coating timber windows and doors requires control of the preparation of the substrate, the order and application rate of the coatings, the curing time between coatings, the temperature of the surrounding environment during curing, and protection of the finished item until the painting system has hardened and cured fully.

Timber windows and doors can be satisfactorily finished on-site. However, site conditions can leave a system application vulnerable to mistakes or problems. Primers and top coats, which should be matched, may be mixed and come from different suppliers, compromising adhesion and rendering warranties void. Extended delay in applying a top coat can lead to a deterioration of the primer. Temperatures and dust contamination can be hard to control, and the finished unit can be damaged while the coating is still soft and vulnerable. Care should be taken in ensuring the finishes are applied in accordance with the manufacturer's recommendations.

Coating the frames under controlled conditions in the factory removes many of these risk factors and is more likely to achieve a high-quality and maintenance-reduced application of the selected paint system. Some longer-lasting coating systems can only be reliably applied in a factory.

4.6 Installation

Installation needs to ensure that the units can perform as designed and the integrity and performance of the building fabric is maintained at the junction between units and the building's envelope.

4.6.1 Window Installation Diagrams

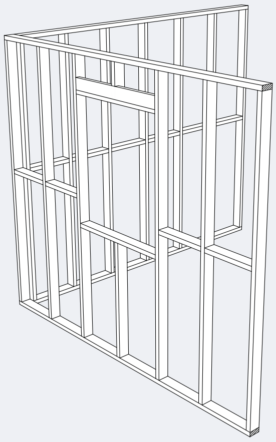


Figure 11(a): Frame with lintel.

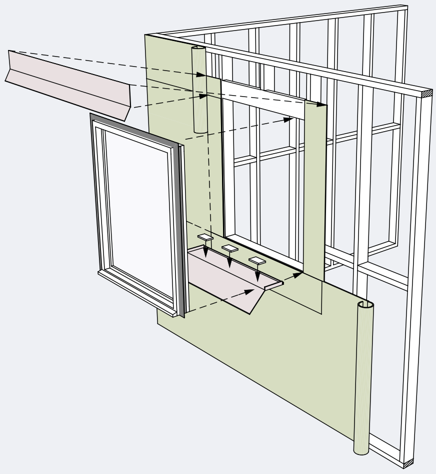


Figure 11(b): Window and flashing with sarking.

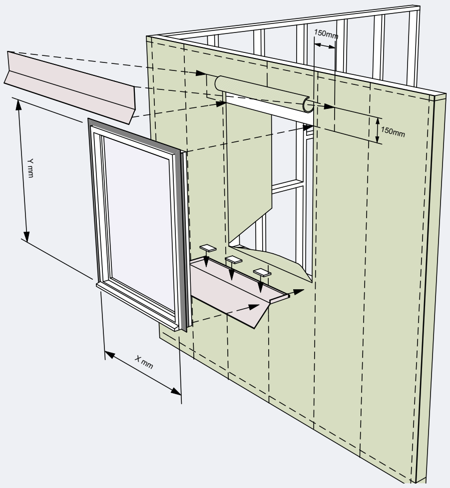


Figure 11(c): Window and flashing with wrap.

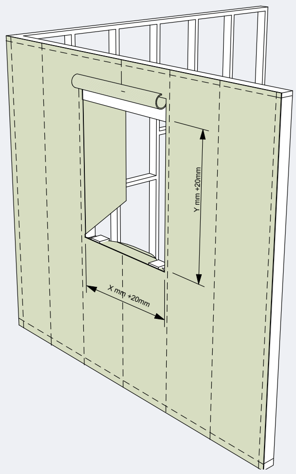


Figure 11(c): Opening sizes and wrapping.

4.6.2 Door Installation Diagrams

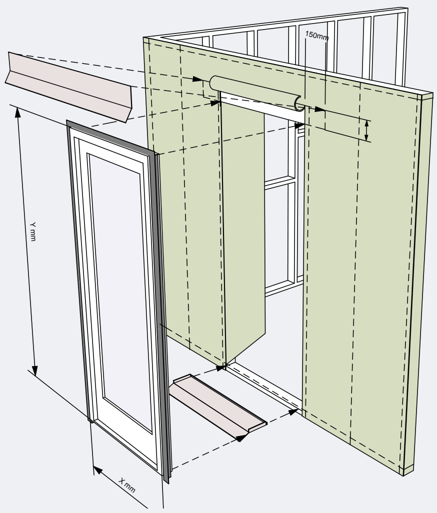


Figure 11(e): Door and flashing with wrap.

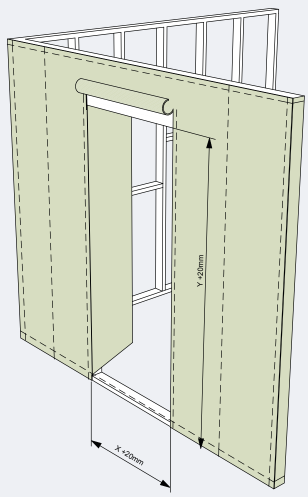


Figure 11(f): Opening sizes and wrapping.

5

Maintenance

5.1 Introduction

Windows and doors perform a vital role in maintaining the integrity of the building envelope and require regular maintenance to keep them performing optimally for their service life. Maintenance includes cleaning and minor repair, occasional recoating, and timely upgrading of components.

5.2 Cleaning

Cleaning should be factored into the management plan for the building. The windows, doors and glass should be washed two or three times a year and any built-up dirt and grime removed. Washing may need to be more frequent in coastal or high-pollution areas. Tracks for sliding windows and doors and any weep holes should be cleaned and any build-up removed because dirt on the roller tracks can cause premature wear and damage. Any pooling of moisture or significant discolouration should be investigated to ensure that sills have been fitted at the correct angles for drainage, and flashing has been fitted correctly.

5.3 Regular Minor Maintenance

Hardware and moving parts should be lubricated regularly. Lubrication should be more frequent in coastal or high-pollution areas. Malfunctioning hardware should be replaced. Seals should be in place and performing efficiently. Coating or paint finish and condition of the timber frame should be inspected regularly. Insulated glass units should be inspected regularly for condensation. IGUs should be replaced if the seals have failed.

5.4 Finishes and Coatings

The expected life of paint or other finishes depends on the quality of the original and subsequent coatings, and the care taken in application. Good-quality finishes increase the service life of the unit. Re-coating should take place before the existing finish has deteriorated to the extent that it exposes bare timber. Poorly maintained paint film can accelerate decay by trapping moisture adjacent to the timber. Expected service life of the major coatings systems is given in Table 23. Manufacturers should be consulted in developing the maintenance regime for the coatings in a building.

Ensure any new finish is compatible with previous coatings, especially factory-applied ones. Consult the suppliers of the original finish or a reputable paint supplier for advice. Follow the manufacturer's instructions closely.

Windows and doors fully exposed to the sunlight or weather, especially coastal winds, will need more frequent maintenance than those more protected from the weather.

Table 23: Expected service life of exterior wood finishes: types, treatments and maintenance.

Finish	Initial Treatment	Appearance of wood	Maintenance procedure	Maintenance period of surface finish	Maintenance cost
Paint	Prime and two top coats	Grain and natural colour obscured	Clean and apply top coat or remove and repeat initial treatment if required	7-10 years*	Medium
Clear (film forming)	Four coats (minimum)	Grain and natural colour unchanged if adequately maintained	Clean and stain bleached areas and apply two more coats	2 years or when breakdown begins	High
Water repellent**	One or two coats of clear material, or preferably dip applied	Grain and natural colour; visibly becoming darker and rougher textured	Clean and apply sufficient material	1-3 years or when preferred	Low to medium

** Using top-quality acrylic latex paints.*
*** With or without added preservatives. Addition of preservative helps control mildew and mould growth.*

5.5 Glass

Manufacturers of particular glass products with special surface coatings should be consulted for advice on the required maintenance of their specialist products.

Silicone sealing and security glazing tapes may have high levels of adhesion which may make removal difficult without irreparably damaging the frame. In such a case, replacing the sash may be necessary in the event of broken glass.

5.6 Timber Elements

Gaps in joints or around glazing beads can allow water to enter, encouraging corrosion and decay. Such gaps need to be carefully cleaned out and repaired. Decayed or damaged timber should be repaired by cutting back the affected timber and patching with new compatible timber. The repair of the timber element could require re-fitting parts of the frame if the timber has deteriorated and joints have decayed.

References

Australian Standards Online (www.standards.org.au). Accessed September 2011.

Carr, D.R. 1964, 'Diffusion impregnation for house timbers', International Pest Control 6 (2): 13-19, (3): 11-15.

Cookson, L.J. 2007, 'Six year interim inspection of model windows exposed in the Accelerated Field Simulator', Ensis Client Report No 1759, FWPRDC Project No PN07.2034.

Crawford, H.A. 2006, 'A review of forest certification in Australia', Forest & Wood Products Research & Development Corporation.

Drysdale, J.A. 1994, 'Boron treatments for the preservation of wood – a review of efficacy data for fungi and termites', International Research Group on Wood Preservation Document No IRG/WP/94-30037.

Scown, D.K., Cookson, L.J., McCarthy, KJ and Chew, N 2004, 'Accelerated testing of window joinery made from eucalypts', CSIRO, FFP Client Report No 1434, FWPRDC Project No PN98.702 (www.fwprdc.org.au/content/pdfs/PN98.702.pdf).

Straube, J.F. 1998, 'Moisture control and enclosure wall systems' (PhD thesis), Civil Engineering Department, University of Waterloo.

Viridian Architectural glass specifiers guide (www.viridianglass.com). Accessed September 2011.

Wang C.H., Leicester R.H., Foliente G.C., Nguyen M.N. 2007, 'Timber Service Life Design Guide', FWPA.