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Mid-rise Timber Buildings
Healthcare
Class 9a and 9c

Technical Design Guide issued by Forest and Wood Products Australia

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IMPORTANT NOTICE

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1 Introduction

This document provides detailed guidance in relation to the design of mid-rise fire protected timber healthcare buildings but will also be a useful resource if other forms of construction are adopted. For example, the protection of service penetration and maintenance of penetration seals through the life of a health-care building has always been a major challenge. Practical designs have been developed that can be adapted to all forms of construction to simplify installations and subsequent maintenance of fire protection systems. As for all forms of construction it is critical to develop detailed documentation and ensure evidence of suitability is available during the design stage to avoid unnecessary complications during construction and commissioning

1.1 Scope

The National Construction Code (NCC) Volume One, Building Code of Australia 2019 Amendment No. 1 2020 allows the use of fire-protected timber construction using the Deemed-to-Satisfy (DTS) pathway for all buildings up to 25 metres in effective height ('mid-rise construction', see Figure 1.1).

The DTS pathway provisions cover both traditional 'lightweight timber framing' and 'massive timber' products, such as Cross-laminated Timber (CLT) and Laminated Veneer Lumber (LVL), in conjunction with the use of appropriate non-combustible fire-protective coverings – termed 'fire-protected timber' in the NCC – and appropriate compliant automatic sprinkler systems, among other things.

Low-rise timber healthcare buildings
are buildings of:

- Type B or C construction (1 or 2 storey)

Mid-rise timber healthcare buildings
have an effective height
of not more than 25 metres.}
Typically, they are 3-8 storeys high
(the maximum number of storeys depends on the floor-to-floor height)

High-rise timber healthcare buildings
have an effective height
greater than 25 m.

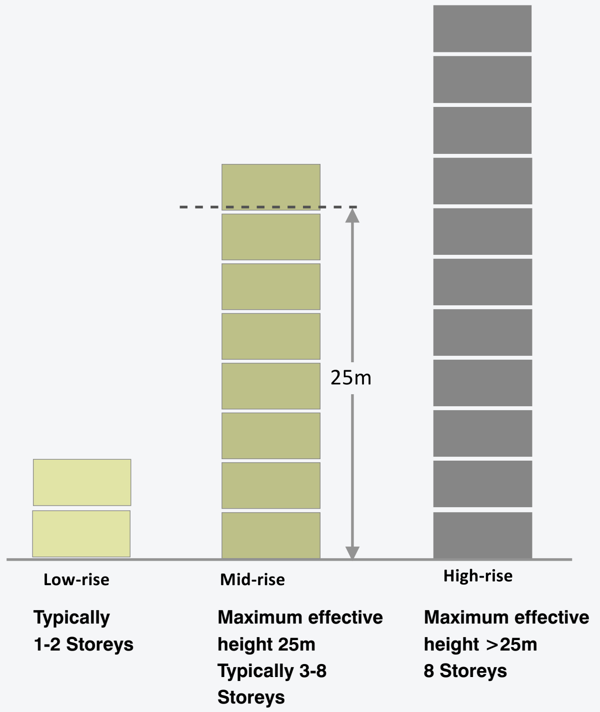


Figure 1.1: Low, mid and high-rise Class 9 healthcare buildings.

This Guide applies to mid-rise NCC Class 9a and Class 9c healthcare buildings or parts of buildings that are to be constructed using fire-protected timber in accordance with the DTS pathway.

The NCC defines a healthcare building as a building whose occupants or patients are undergoing medical treatment and generally need physical assistance to evacuate the building during an emergency and include:

- a public or private hospital
- a nursing home or similar facility for sick or disabled persons needing full-time care
- a clinic, day surgery or procedure unit where the effects of the predominant treatment administered involve patients becoming non-ambulatory and requiring supervised medical care on the premises for some time after the treatment.

Healthcare buildings can be classified under the NCC as Class 9a, Class 9c or Class 3 (refer Note 1 and Note 3).

Class 9a – A building that is a healthcare building including any parts of the building set aside as laboratories and may include a healthcare building used as a residential care building (e.g. a hospital).

Class 9c – A building that is a residential care building.

A residential care building is defined as a place of residence where 10% or more of persons who reside there need physical assistance in conducting their daily activities and to evacuate the building during an emergency, including any aged care building or residential aged care building, but does not include a hospital.

Note 1: Some residential care buildings providing long-term or transient accommodation for the aged, children, or people with disabilities may be classified as a Class 3 building; particularly if full-time care is not provided. Reference should be made to WoodSolutions Technical Design Guide #37R for further information if the building has been classified as Class 3.

Note 2: Buildings or parts of buildings used as consulting suites by medical practitioners within an office setting, may be considered as Class 5 buildings under some circumstances. Reference should be made to WoodSolutions Technical Design Guide #37C for further information if the building has been classified as Class 5.

Note 3: The determination of the appropriate Class for a healthcare building can be complex and open to interpretation. It is critical that the classification is defined by the appropriate authority at the start of the project as it may have a significant impact on the design. Healthcare buildings can be subject to change and allowance for future flexibility can be important including the choice of a more onerous classification for various parts of the building.

1.2 Design of Healthcare Buildings

Healthcare buildings vary substantially with respect to size and complexity. For example:

- Hospitals can vary from small single-storey rural hospitals with small numbers of beds and limited or no emergency facilities through to multi-storey city hospitals with large numbers of beds providing a broad range of health services and typically include restaurants, shops, carparks as well as facilities such as laboratories to support healthcare services. Some ward areas may require extensive security provisions, further complicating the design.
- Residential care facilities can vary from small single-storey facilities to multi-storey facilities housing large numbers of residents requiring various levels of support and healthcare.

It is critical that the building designs are developed to satisfy the specific needs for each healthcare facility and that all members of the design team have a detailed understanding of the operational needs of the facility and the various drivers and constraints that apply to the specific project.

Various National and State guidance documents have been produced relating to the design of healthcare buildings to clarify key drivers and constraints and in some cases specify additional administrative processes which should be adopted as appropriate.

It is also good practice to involve key stakeholders and the design team in a Design Brief process early in the project to ensure all drivers and constraints have been identified, and highlight essential criteria before the design is prepared. This is important as there may be additional criteria that may not be fully addressed by compliance with the minimum NCC requirements. Figure 1.2 shows a typical process. The proposed design will need to be assessed for compliance with the NCC and other project drivers and constraints. The primary focus of this Guide is NCC compliance via the Deemed-to-Satisfy pathway with the fire safety provisions.

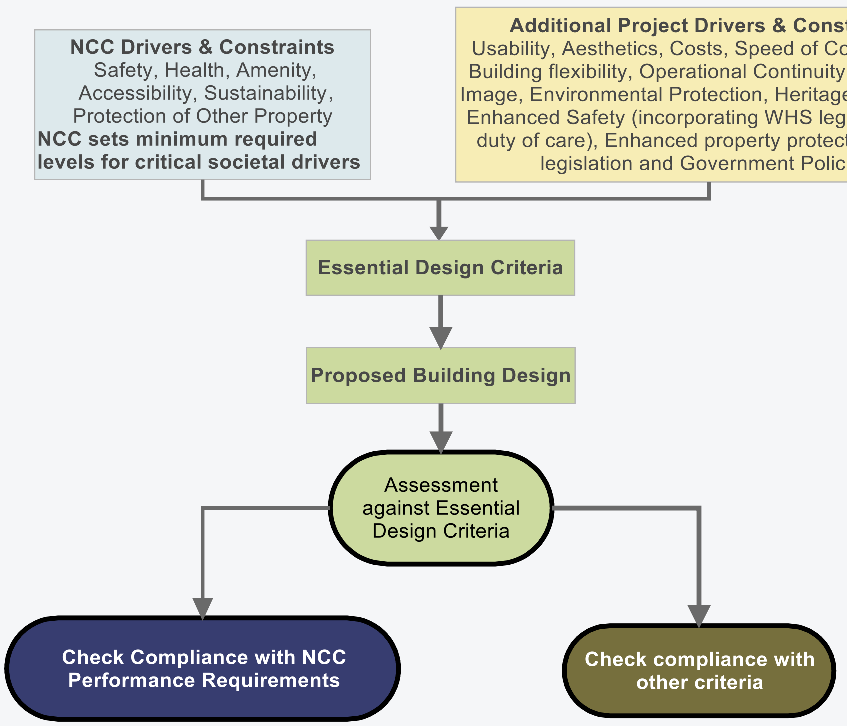


Figure 1.2: Identification of essential design criteria.

Details of compliance checks for other project design criteria such as those described below are not discussed in detail.

1.2.1 Robust Structural Design

The structural design of mid-rise timber buildings must comply with the relevant NCC requirements, including design to sustain local damage, with the structural system as a whole remaining stable and not being damaged to an extent disproportionate to the original local damage – refer NCC Clause BP1.1(a)(iii).

Further guidance is provided in WoodSolutions Technical Design Guide #39 Robustness in Structures.

1.2.2 Fire Precautions During Construction

Mid-rise timber buildings, when complete, provide a high level of safety because of the combination of automatic fire sprinklers and fire-protected timber, among other things.

While the use of timber significantly reduces a number of risks during construction, the fire risk can be increased as a result of the increased volumes of unprotected timber. WoodSolutions Technical Design Guide #20 Fire Precautions during Construction of Large Buildings helps building professionals, and organisations with responsibilities for fire safety on a construction site, reduce the risk of fire.

There are additional matters that must be addressed to satisfy work, and health and safety requirements in addition to compliance with minimum NCC DTS provisions for fire precautions during construction – refer NCC Clause E1.9 and Australian State and Territory guidelines.

1.2.3 Other Design Criteria

Designers need to take account of a broad range of matters to ensure that a building is fit-for-purpose and complies with all requirements of the NCC and other legislation. These include:

- structural design (for safety and serviceability)
- weatherproofing
- safe access and egress
- light and ventilation (including condensation control)
- energy efficiency
- durability (including termite management)
- design in bushfire-prone and flood-prone areas.

Some sources of information on these matters are referenced in the Appendices of this Guide.

1.3 Checking Compliance with the National Construction Code (NCC)

To comply with the NCC, it must be demonstrated that the NCC's Governing Requirements and Performance Requirements have been satisfied.

The Governing Requirements are documented in Section A of the NCC and provide rules and instructions for using and complying with the NCC including:

- interpreting the NCC
- complying with the NCC
- application of the NCC in States and Territories
- applying documents referenced in the NCC
- documenting the suitability of the design, construction and/or use of materials to comply with the NCC
- classifying buildings by their characteristics and intended use.
- The performance requirements can be satisfied by means of a Performance Solution or a Deemed-to-Satisfy Solution or a combination (see Figure 1.3).

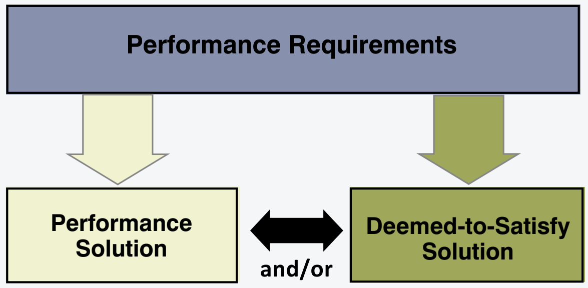


Figure 1.3: Pathways for demonstrating compliance with NCC performance requirements.

Figure 1.3 is a derivative of Figure 1 of the National Construction Code 2019 Amendment 1 provided by ***https://www.abcb.gov.au/*** *Australian Building Codes Board © 2020.*

The focus of this Guide is the Deemed-to-Satisfy Pathway but some of the content may have relevance to Performance Solutions. For example whilst many Class 9a and 9c buildings may be designed generally in compliance with a Deemed-to-Satisfy Solution there may be some variations to these provisions to provide the necessary functionality. Reference should be made to other WoodSolutions publications and Design Guides, and Australian Building Codes Board publications for further advice in relation to developing Performance Solutions.

1.4 Checking Interpretations of Regulations and Standards

This Guide focuses on NCC requirements. From time-to-time, State and Territory-based NCC amendments or other State legislation and department policies may vary requirements. Users of this Guide should make themselves aware of these differences and develop a full understanding of the resulting implications. It is prudent to check any interpretations of the regulations and required evidence of suitability with the relevant regulatory authorities during the early stages of the design process.

1.5 Guide Structure

An overview of Timber Construction Options is provided as a general introduction to typical forms of timber construction.

A 6-step design process for sound and fire-resisting construction has been followed to broadly follow the development and assessment of a design against the NCC DTS provisions.

Step 1 High-level NCC design Issues (schematic design)

Step 2 Determine NCC design requirements for sound, thermal resistance, weatherproofing and structural tests

Step 3 Improve and upgrade sound performance

Step 4 Determine NCC fire-protected timber design requirements (design development)

Step 5 Integrate architectural, structural and building service designs (detailed design)

Step 6 Further design assistance (Appendices)

2

Timber Construction Options for Mid-rise Buildings

2.1 Overview of Structural Timber Construction Methods

A number of timber system options are available for the construction of mid-rise timber buildings, such as those shown in Figure 2.1. Note: Under the NCC DTS provisions, only fire-protected timber building systems are permitted where an element is required to be of non-combustible construction or of masonry or concrete construction.

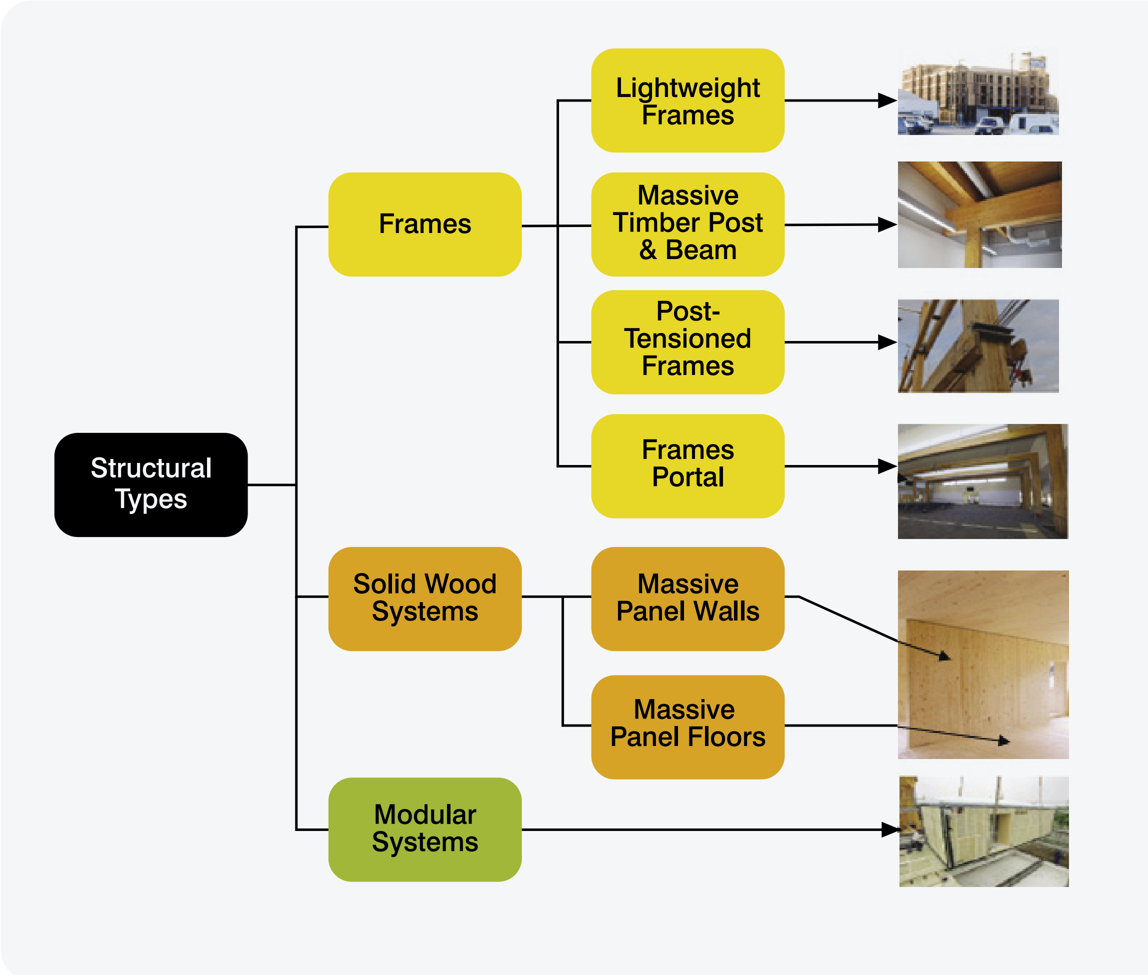


Figure 2.1: Summary of structural timber construction options

No exposed structural timber is currently permitted under Deemed-to-Satisfy Provisions where an element must be of non-combustible construction.

Loadbearing fire-protected timber-framed construction is most suited to applications where individual rooms have closely spaced walls that, in effect, form a 'honeycombed' structure; with many individual load paths. Lightweight timber-framed systems (up to around six storeys) combined with fire protective coverings are an efficient form of construction. Alternatively, a solid massive timber system, or a mixture of massive and lightweight timber construction, might be considered. Fire-protected timber-framed construction is also useful for non-loadbearing elements where smoke or fire-resistant separations are required.

For larger open-plan spaces, a post and beam approach for the overall structure may be more appropriate. Typically, the main columns and beams might be constructed using glued-laminated timber (Glulam) or laminated veneer lumber (LVL) with floors being either lightweight prefabricated cassettes or solid massive timber panel floor plates. Refer Figure 2.2 for a comparison of timber frame and post and beam construction.

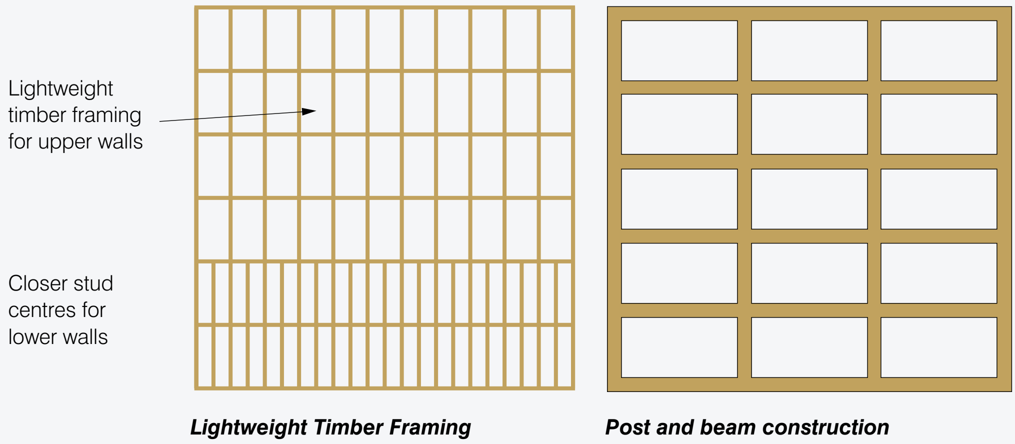


Figure 2.2: Schematic comparison of timber frame and post and beam construction.

There are significant efficiency, speed and cost benefits in using structural timber systems compared to alternative material such as reinforced concrete. These include:

- Reduced on-site construction infrastructure (preliminary costs) such as fixed cranes, site accommodation, storage areas, scaffolding and edge protection, hoists, etc.
- Direct savings from faster methods of construction compared to traditional steel and concrete structures due to:
  - increased scope for off-site prefabrication and panelisation
  - lighter and more easily manoeuvred and installed materials.
- Reduced foundation requirements due to a lighter above-ground structure.
- Significantly reduced on-site costs and Work Health and Safety (WHS) issues, particularly with a shift to more prefabricated solutions.
- Increased ability to commence follow-on trades earlier in the construction process, reducing the overall construction time.
- Increased accessibility of the construction site and significantly lower impacts of noise and site activities on local neighbourhoods (less truck movements), which is a major benefit for suburban multi-residential developments.

Detailed information on the specific construction cost benefits of timber systems in different classes of buildings can be found in various WoodSolutions Technical Design Guides, including *#28 Rethinking Aged Care Construction – Consider Timber – A material cost comparison of typical aged care accommodation.*

2.2 Fire-protected Timber Options for Mid-rise Buildings

Whichever timber construction option is selected, the prescriptive Deemed-to-Satisfy (DTS) solutions for mid-rise timber buildings require timber members to be fire-protected where an element is required to be of non-combustible construction, or of concrete or masonry construction.

The ‘general timber’ requirements that apply for fire-protected timber are:

- the building element must be protected to achieve the required FRL
- a non-combustible fire-protective covering must be applied to the timber that achieves a Resistance to the Incipient Spread of Fire (RISF) of not less than 45 minutes when tested in accordance with AS1530.4
- cavity barriers must be provided in accordance with relevant NCC requirements.

The NCC permits a ‘relaxation’ to the general requirements in the case of fire-protected massive timber panels if the following additional criteria are satisfied:

- the timber panel is at least 75 mm thick
- any cavities between the surface of the timber and the fire-protective covering and between timber elements within the fire protective covering are filled with non-combustible materials.

If both these conditions are satisfied, it is still necessary for the fire-protected timber member to achieve the required FRL and have a non-combustible fire-protective covering. However, the thickness of the fire-protective coverings, based on the covering's RISF performance and required FRL, can be modified depending on the application (e.g. internal SOU wall, external wall).

The basis for allowing specific provisions for massive timber panels is that timber with a large cross-section can achieve high fire-resistance due to the formation of a char layer that protects the timber core and allows it to continue to support an imposed load or maintain a fire-separating function for significant periods. If there is an early failure of the fire-protective covering, the timber structure is likely to maintain its loadbearing capacity for longer than lighter forms of construction. By not permitting any concealed spaces between the massive timber members, or between the timber and fire-protective coverings, the risk of fire spread is reduced.

The different timber construction systems generally use one or more of a range of different sawn or engineered timber products, including:

- sawn timber – softwood (MGP) and hardwood (F- and A-grade)
- engineered timber – particleboard, plywood, Oriented Strand Board (OSB), Laminated Veneer Lumber (LVL), Parallel Strand Lumber (PSL), I-beams, fabricated floor and roof trusses, Glued Laminated Timber (Glulam) and Cross-laminated Timber (CLT).

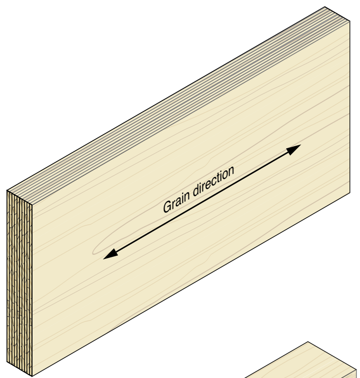
2.3 Timber Frame Construction

Lightweight timber-frame construction systems use commonly available structural timber framing products assembled into lightweight systems such as wall frames, floor and roof trusses, and prefabricated cassette floor modules.

Sawn Timber Products

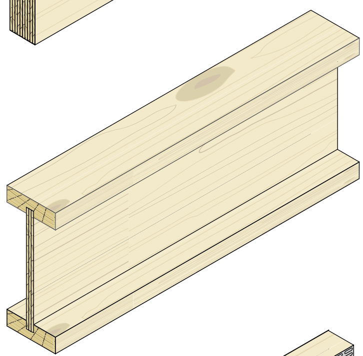
Sawn timber products include seasoned structural softwood (MGP10, 12 & 15) or seasoned structural hardwood (typically F17 or F27). Typical thicknesses are 35 and 45 mm and depths include: 70, 90, 120, 140, 190, 240* and 290* mm. (* available on order)

Laminated Veneer Lumber (LVL)



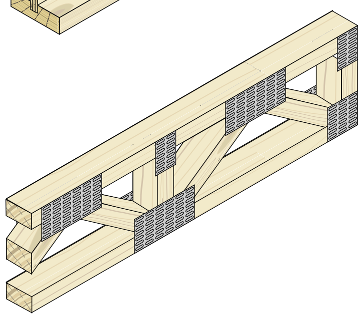
Lightweight framing elements are available in LVL, a widely used softwood engineered wood product, available in all the standard framing sizes. LVL is manufactured by bonding together rotary peeled or thin-sliced wood veneers under heat and pressure. As LVL is typically used in a beam or stud application, the grains of the veneers are all oriented in the same direction. LVL is typically manufactured in slabs 1200 mm wide, known as billets, which are then cut into the commonly available framing member depths required. LVL is typically manufactured in lengths up to 12 metres in 0.3 metres increments.

I-Beams



I-Beams are lightweight, high-strength, long-span structural timber beams. They typically comprise top and bottom flanges of LVL or solid timber – which make the distinct shape. The flanges are separated by a vertical web, usually manufactured from structural plywood, Oriented Strand Board (OSB) or light gauge steel. Typical depths are: 200, 240, 300, 360 and 400 mm in lengths up to 15 metres.

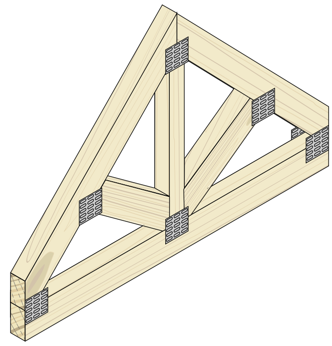
Parallel Chord Trusses



Parallel Chord Trusses are similar to I-beams in that they have top and bottom chords (flanges) of LVL or solid timber but instead of solid webs, web struts are used.

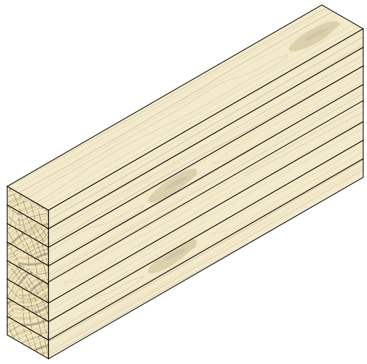
The struts may be either timber or light gauge steel and are secured to the chords typically with nailplates. The struts may be diagonal (more common for steel struts) or a mix of vertical and diagonal (more common with timber struts).

Roof Trusses



Timber roof trusses provide an engineered roof frame system designed to carry the roof or roof and ceiling, usually without the support of internal walls. The characteristics of a roof depend on the purpose of the building, the available roofing materials and the wider concepts of architectural design and practice. Light truss roofs are formed from sawn or LVL timber elements connected with nailplates or other mechanical fixings designed and supplied by frame and truss manufacturers.

Glued-laminated Timber (Glulam)



Glulam consists of a number of strength-graded, kiln-dried laminations face bonded and finger-jointed together with adhesives. Elements can be manufactured to practically any length, size or shape: beams are often manufactured with a built-in camber to accommodate dead load deflection or curved for aesthetic appeal.

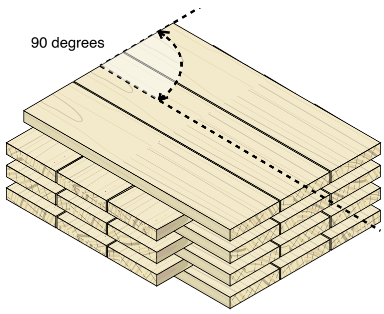
A range of GL Grades are produced in Australia or imported depending on the timber species used in manufacture: GL10 (Cypress), GL13 (Radiata Pine, Oregon), GL17 (Slash Pine, Merbau), GL18 (Tas Oak, Vic Ash), GL21 (Spotted Gum) – the GL descriptor refers to the element's Modulus of Elasticity (E), i.e. GL10 describes a Glulam member that has an E-value of 10GPa.

A wide range of depths are available in increments from 90 mm to more than 1,000 mm; and thicknesses from 40 mm to 135 mm (65 mm and 85 mm are commonly used). Lengths up to 18 metres are available in 0.3 metre increments from traditional suppliers and up to 27 metres in length from specialist manufacturers.

2.4 Solid Massive Wood Panel Construction Systems

Solid wood panel construction systems utilise massive timber engineered wood panels such as Laminated Veneer Lumber, Cross-laminated Timber (CLT), or Glue/nail-laminated Mass Timber panels, in minimum panel thicknesses of 75 mm when used in accordance with the NCC DTS provisions. Solid wood panels can be used to form complete floors, walls and roofs and construction methods have more in common with precast concrete panels than timber framing; except that timber panels are much lighter, more easily worked and easier to erect.

Cross-laminated Timber (CLT)



Cross-laminated Timber (CLT) utilises individual planks of timber 12-45 mm thick and 40-300 mm wide face-glued together (and edge-glued in some instances), each layer at 90° to its neighbouring lamella – effectively 'jumbo plywood'. CLT panels are typically 57-320 mm thick and made up of 3, 5, 7 or 8 layers depending on application. Panels are available in 2.2 to 2.95 metres wide and up to 11.9 metres long (dictated mainly by transport restrictions).

More detailed information on CLT can be found at the WoodSolutions website or in *WoodSolutions Technical Design Guide #16 Massive Timber Construction Systems: Cross-laminated Timber (CLT),* which introduces the use of CLT in construction and provides an overview of CLT building systems as well as fire, acoustic, seismic and thermal performance.

2.5 Modular Systems

A major benefit in using timber structural systems in mid-rise construction is the ability to prefabricate off-site and manufacture frames or cassettes, panelised elements or full volumetric modules to minimise the on-site construction requirements and costs.

Prefabricated Cassette Floor Systems

Prefabricated cassette floor systems use a range of timber structural products, typically for flooring (particleboard, plywood or OSB panels) and for floor joists and bearers (sawn timber, LVL, OSB beams, floor trusses or I-beams). Cassettes tend to be about 3 metres wide and up to about 12 metres long (due to travel restrictions). Cassette floor systems are highly effective in mid-rise construction as they are extremely fast to install and far safer for on-site workers, dramatically reducing 'fall-from-height' risks for workers.

With mid-rise construction, where effective acoustic separation is required, a Timber/Concrete Composite Cassette Floor might be considered; the concrete screed adding mass for acoustic and vibration control as well as acting compositely with the timber components for improved structural performance. For more detailed information on this refer to *WoodSolutions Technical Design Guide #30, Timber Concrete Composite Floor Design.*

Panelised Elements

Fully panelised elements involve the total off-site manufacture of all components, including structural members, insulation, sarking, plumbing and electrical fittings, window and/or door installation and internal lining installation (and external cladding if appropriate).

Modular Wood Construction Systems

Modular wood construction systems (volumetric modules) use either light-frame systems (mainly) or solid wood panel systems. The main principle is that the entire volumetric box consisting of walls, floor and ceiling, as well as inner lining and all services are assembled in a factory and transported to the construction site for erection. To assemble the modules on top of each other, a male-female connector arrangement is often used. The size of the modules is generally limited by transportation restrictions with maximum dimensions of about 4.2 metres wide, up to 13 metres long and 3.1 metres high. The overall building height is generally the same as for light-frame systems, around 6–7 storeys. Modular systems are used in a range of applications, including aged care facilities.

2.6 Hybrid Construction

Mid-rise timber buildings may also use a 'mix' of materials – hybrid construction – to achieve cost-effective, practical and robust solutions.

There are two main categories of Hybrid construction. The first applies to buildings that have a mix of timber and other structural elements.

For example, a common configuration is to use concrete construction for below-ground structures, such as car parks and basements, to reduce the risks to timber elements associated with groundwater and for ground floor construction to provide a physical separation from the ground as part of a termite management strategy (where required). Another common configuration is the use of concrete cores housing lifts and fire exits providing lateral and some vertical support for the structure supplemented by timber floors, beams and walls

The second form hybrid construction may use timber and other structural materials within the same element of construction, for example:

- concrete toppings to timber floors with shear connections to use composite action
- floors constructed with a mix of steel beams and timber beams to manage a mix of spans as shown in Figure 2.3 (LVL timber beams are increasingly used to replace steel beams for this application).

Figure 2.3: Mix of steel and timber beams in a floor.

3

Step 1 – High-Level NCC Design Issues (Schematic Design)

The National Construction Code (NCC) provides a regulatory framework for determining the minimum design and construction requirements for buildings in Australia. This step covers high-level design issues relating to fire-resisting and sound-insulating construction for the DTS pathway.

3.1 Application of this Guide and Additional Sources of Information

WoodSolutions Technical Design Guide 37H applies to mid-rise NCC Class 9a and Class 9c healthcare buildings.

For low-rise buildings, refer to:

- *WoodSolutions Technical Design Guide #03 Timber Framed Construction for Commercial Buildings Classes 5, 6, 9a & 9b, and*
- *WoodSolutions Technical Design Guide #42 Building Code of Australia Deemed to Satisfy Solutions for Timber Aged Care Buildings (Class 9c)*

Other mid-rise timber resources include:

- *WoodSolutions Technical Design Guide #37R Mid-rise Timber Buildings – Multi-residential Class 2 and 3*
- *WoodSolutions Technical Design Guide #37C Mid-rise Timber Buildings -Commercial and Education Class 5, 6, 7, 8 and 9b (including Class 4 parts).*

For high-rise timber buildings (greater than an effective height of 25 m), or for other buildings that vary from an NCC DTS provisions, the performance pathway should be followed. Further general information on the application of this pathway is provided in the NCC and related publications.

Useful additional resources if a Performance Solution Pathway is being followed are:

- *WoodSolutions Technical Design Guide #38*, which provides the technical basis behind the changes to the NCC to provide a DTS pathway for mid-rise timber buildings.
- Fire Safety of Hospitals – a guide for designers (Bennetts, I., et al., *Fire Safety of Hospitals – a guide for designers. 2018: Melbourne)*

3.2 Determine the Type of Construction Required

Note: For mid-rise Class 9a and 9c buildings or parts of buildings, Type A construction will be required in most situations.

The Class of Building in conjunction with the building height, expressed in terms of the rise in storeys, and the maximum size of fire compartments, are used to determine the Type of Construction required. Maximum fire compartment sizes (floor area, volume) as defined in the NCC Clause C2.2 are not usually the primary driver of the Type of Construction in Class 9a and 9c buildings.

The NCC defines three types of construction:

Type C construction is generally applicable to buildings with a rise in storeys of 1 or 2 depending on the class of building. It is the least fire-resisting form of construction and places few fire-related restrictions on the use of structural timber members.

Type B construction is generally applicable to buildings with a rise in storeys of 2 or 3 depending on the class of building. Type B construction requires greater use of fire-resisting construction and applies greater controls on the combustibility of construction materials than Type C construction. Fire-protected timber options provided in the NCC DTS provisions, or using the performance pathway, can be applied to address these constraints.

Type A construction generally applies to buildings with a rise in storeys of 3 or more and so applies to most mid-rise structures. Type A construction is the most fire-resisting and the prescriptive solutions within the NCC can impose severe limitations on the use of timber through the prescription of masonry and concrete construction, and non-combustibility for elements required to achieve a prescribed Fire Resistance Level (FRL). The fire-protected timber options provided in the NCC DTS provisions may be applied or the performance pathway may be taken to address these limitations..

An overview of the process for determining the Type of Construction is described below.

3.2.1 Determine the Building Classification

The NCC contains mandatory performance requirements that apply to 10 primary classes of building that are determined by the building's purpose. This classification is generally undertaken by the appropriate authority (e.g. building surveyor or building certifier). The classes directly applicable to this Guide from NCC Clause A6.9 and the relevant definitions providing further explanation from Schedule 3 of the NCC are summarised in the accompanying box.

A6.9 Class 9 buildings

A Class 9 building is a building of a public nature that includes one or more of the following sub-classifications:

1. Class 9a – a *healthcare building* including any parts of the building set aside as laboratories and includes a *healthcare building* used as a *residential care building*.
2. Class 9c — a residential care building.

Healthcare building means a building whose occupants or patients undergoing medical treatment generally need physical assistance to evacuate the building during an emergency and includes—

a) a public or private hospital; or

b) a nursing home or similar facility for sick or disabled persons needing full-time care; or

c) a clinic, day surgery or procedure unit where the effects of the predominant treatment administered involve patients becoming non-ambulatory and requiring supervised medical care on the premises for some time after the treatment.

Residential care building means a Class 3, 9a or 9c building which is a place of residence where 10% or more of persons who reside there need physical assistance in conducting their daily activities and to evacuate the building during an emergency (including any aged care building or residential aged care building) but does not include a hospital.

Residential aged care building means a Class 3 or 9a building whose residents, due to their incapacity associated with the ageing process, are provided with physical assistance in conducting their daily activities and to evacuate the building during an emergency.

Aged care building means a Class 9c building for residential accommodation of aged persons who, due to varying degrees of incapacity associated with the ageing process, are provided with personal care services and 24 hour staff assistance to evacuate the building during an emergency.

Note: Refer NCC A6 for details of other Classes of Building

Where areas of hospitals are likely to be assigned different uses during the life of a building, the most onerous classification may be selected to provide flexibility for future applications. These matters should be discussed with the client / operators during the design phase.

The demarcations between Class 3, Class 9a and Class 9c buildings can overlap, reflecting the continuum of occupant characteristics; especially where a facility allows for ageing 'in place' where these characteristics can vary over time.

In addition, large hospitals may have parts with different classifications, for example restaurants, shops or carparks. These may be classified separately or treated as an ancillary use, depending on the proportion of floor area occupied, among other things. Where it is unclear which classification should apply, the appropriate authorities have the discretion to decide.

Note: The DTS provisions for fire-resisting and sound-insulating construction vary significantly between the Building Classes and therefore the applicable Building Class(es) should be determined at the start of the Schematic Design Stage and be confirmed by the appropriate authority.

3.2.2 Determine the Rise in Storeys

The rise in storeys is the sum of the greatest number of storeys at any part of the external walls of the building and any storeys within the roof space:

- above the finished ground next to that part; or
- if part of the external wall is on the boundary of the allotment, above the natural ground level at the relevant part of the boundary.

Note: NCC Clause C1.5(b) allows Class 9c buildings to have a rise in storeys of 2 if it is protected throughout with a sprinkler system (other than a FPAA101D or FPAA101H system) complying with Specification E1.5 and complies with the maximum compartment size specified in Table C2.2 for Type C construction. Refer to WoodSolutions Technical Design Guide #42 (Class 9c) if this option is adopted.

3.2.3 Determine Type of Construction from Rise in Storeys and Building Class

Table 3.1 Shows the Type of Construction required by Clause C1.1 of NCC Volume One.

Table 3.1: Types of construction required by NCC Volume One.

Rise in storeys	**Multi-residential (includes some Class 3 residential care buildings)**		**Office**	**Retail**	**Car Park/ Storage**	**Factory/ Laboratory**	**Hospitals/ Residential Care Facilities/ Assembly**
	Class 2	Class 3	Class 5	Class 6	Class 7	Class 8	Class 9
4 or more	**A**	**A**	**A**	**A**	**A**	**A**	**A**
3	**A***	**A***	**B**	**B**	**B**	**B**	**A**
2	**B(C)***	**B(C)***	**C**	**C**	**C**	**C**	**B(C)****
1	**C**	**C**	**C**	**C**	**C**	**C**	**C**

Table 3.1 is a derivative of Table C1.1 of the National Construction Code 2019 Amendment 1 provided by **https://www.abcb.gov.au/** *Australian Building Codes Board © 2020.*

** Refer low-rise concessions (e.g. Specification C1.1 Clause 3.10 and Clause 4.3) for Type B construction or Clause C1.5 for applications where Type C applies.*

***For Class 9a and 9c healthcare buildings, Type B construction is required for buildings having a rise in storeys of 2 unless Type C construction is permitted for Class 9c buildings having a rise in storeys in accordance with Clause C1.5.*

Type A construction is required for all Class 9a and Class 9c buildings having a rise in storeys of 3 or more and this Guide applies to mid-rise buildings of Type A construction with an effective height not greater than 25 m.

3.3 Determine NCC Compliance Pathway

3.3.1 NCC Compliance Pathway

To comply with the NCC the relevant Performance Requirements must be satisfied; as demonstrated by means of the Assessment Methods specified in the NCC. There are two pathways (or a combination of the two) that can be followed.

- For a Deemed-to-Satisfy Solution, it is necessary to provide Evidence of Suitability to show that the Deemed-to-Satisfy Provisions have been met.
- For a Performance Solution, specific building solutions are developed for a building that may vary from the Deemed-to-Satisfy Provisions.

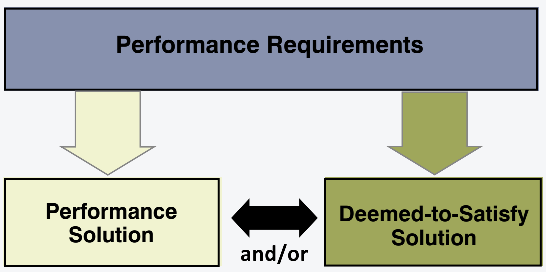


Figure 3.1: Pathways for demonstrating compliance with NCC performance requirements.*

Figure 3.1 is a derivative of Figure 1 of the National Construction Code 2019 Amendment 1 provided by* **https://www.abcb.gov.au/ *Australian Building Codes Board © 2020.*

The construction systems and details in this Guide are based on the Deemed-to-Satisfy (DTS) Solution pathway for mid-rise timber buildings that was first introduced into the 2016 edition of the NCC for Class 2, 3 and 5 buildings and extended to all classes of buildings in the 2019 edition. This does not prevent designers using Performance Solutions, but it should be ensured that any variations from the DTS Solution do not adversely affect the fire safety strategy for the building.

More information on the design principles and supporting data for fire-protected buildings is provided in *WoodSolutions Technical Design Guide #38 Fire Safety Engineering Design of Mid-Rise Buildings.*

3.3.2 NCC Compliance Options for Timber Buildings

In the context of this Guide, timber buildings are defined as buildings where timber is the predominant material in the structure. There are still opportunities to use timber for some structural and non-structural applications in buildings using other materials for the primary structure.

Table 3.2 summarises options for complying with the NCC Performance Requirements for Class 2 to 9 buildings with further details provided below. DTS Solutions are available for the building configurations shaded in green (light, mid and dark green) with this Guide being directly applicable to Class 9a and 9c buildings of 3 or more storeys and an effective height not greater than 25 m, which are shaded in mid green and highlighted with a red box.

At the time of writing, Performance Solutions are required to be developed for the areas shaded in blue.

Table 3.2: Design options for timber buildings.

Rise in storeys or effective height	**Multi-residential (includes some Class 3 residential care buildings)**		**Office**	**Retail**	**Car Park/ Storage**	**Factory/ Laboratory**	**Hospitals/ Residential Care Facilities/ Assembly**
	Class 2	Class 3	Class 5	Class 6	Class 7	Class 8	Class 9
Effective height greater than 25m	High	High	High	High	High	High	High
8 ***(Effective height of not more than 25 m)***	Mid	Mid	Mid	Mid	Mid	Mid	Mid
7	Mid	Mid	Mid	Mid	Mid	Mid	Mid
6	Mid	Mid	Mid	Mid	Mid	Mid	Mid
5	Mid	Mid	Mid	Mid	Mid	Mid	Mid
4	Mid[1]	Mid[1]	Mid	Mid	Mid	Mid	Mid
3	Low[1]	Low[1]	Mid	Mid	Mid	Mid	Mid
2	Low[1]	Low[1]	Low	Low	Low	Low	Low
1	Low	Low	Low	Low	Low	Low	Low

Note 1: Refer to Technical Design Guide #02 to check if low-rise timber concessions apply.

Low	*Low-rise DTS options – Guide #42 for Class 9c, #02 for multi-residential and #03 for commercial buildings.*
Mid	*Mid-rise fire-protected timber DTS – Guide #37R for Class 2 and 3 buildings*
Mid	*Mid-rise fire-protected timber DTS – Guide #37C for Class 5, 6, 7, 8 and 9b commercial and educational buildings and Guide #37H for Class 9 healthcare buildings (this Guide).*
High	*High-rise Performance Solution*

Low-rise timber buildings

There are relatively few fire-related restrictions on the use of structural timber members in Buildings of Type C construction, irrespective of the Class of Building, under the DTS Solution pathway. While fire-protected timber options could be adopted for these buildings, there may be more practical options and reference should be made to the relevant guides identified in the key to Table 3.2.

The NCC DTS pathway also includes concessions that facilitate the use of timber-frame construction for Class 2 and 3 buildings up to a rise in storeys of 3 and, in limited cases, up to 4 storeys. Guidance in relation to construction of these low-rise options is provided in the relevant guides identified in the key to Table 3.2.

Note: The NCC defines effective height as "the vertical distance between the floor of the lowest storey included in the calculation of rise in storeys and the floor of the topmost storey (excluding the topmost storey if it contains only heating, ventilating, lift or other equipment, water tanks or similar service units)". If there is any doubt as to whether a building's effective height does not exceed 25 metres, it is recommended that the effective height is checked with the relevant authorities.

Low-rise buildings would normally be designed following the Deemed-to-Satisfy Solution pathway with Performance Solutions being used to address minor variations and/or unusual design circumstances as required.

Mid-rise timber buildings

Mid-rise buildings have an effective height of not more than 25 metres. The use of timber structural members under the NCC prescriptive pathway is restricted for mid-rise buildings unless the option to use fire-protected timber in conjunction with automatic fire sprinklers is adopted. This Guide applies to fire-protected timber Class 9a and Class 9c healthcare buildings with a rise of storeys of 3 or more up to a maximum effective height of 25 m fitted with an automatic fire sprinkler system throughout.

Some healthcare buildings (e.g. large hospitals) may be of mixed classes and parts of a building may fall under different classifications. Refer to the key to Table 3.2 for relevant design guides.

While the focus of this Guide is mid-rise healthcare buildings, which can be designed following the DTS pathway, Performance Solutions can be adopted to address minor variations and/or innovative design circumstances. Guidance on the technical derivation of the mid-rise fire-protected timber solution is provided in *WoodSolutions Technical Design Guide #38 Fire Safety Engineering Design of Mid-rise Timber Buildings*, which may assist with the development of a Performance Solution.

High-rise buildings

All high-rise timber buildings (effective height greater than 25 m) need to follow the Performance Solution pathway.

3.4 Overview of Fire-protected Timber DTS Solutions for Mid-rise Buildings

3.4.1 Overview of NCC Prescriptive Requirements specific to fire-protected timber

The NCC 2019 includes Deemed-to-Satisfy Provisions that allow the construction of mid-rise timber buildings. The main features specific to the mid-rise fire-protected timber building DTS Solutions are:

- the building has an effective height of not more than 25 metres
- the building has a sprinkler system, other than a FPAA101D or FPAA101H system, complying with Specification E1.5 of the NCC throughout
- fire-protected timber complying with Specification C1.13a of the NCC can be used for loadbearing timber elements, non-loadbearing timber walls required to achieve an FRL and for elements of construction required to be non-combustible
- cavity barriers are provided in accordance with Specification C1.13 of the NCC
- any insulation installed in the cavity of the timber building element required to have an FRL is non-combustible.

These fire safety precautions aim to provide a robust building solution on the following basis:

Automatic fire sprinkler suppression system: Objective is to suppress a fire before the structure is threatened and greatly reduce the risk to people and property.

Fire-protected timber (NCC prescribes FRLs AND non-combustible fire protective coverings):
The objective of these measures is to prevent or delay ignition of the timber structural members so that the response to an enclosure fire will be similar to non-combustible elements, masonry or concrete during the fire growth period and prior to fire brigade intervention.

Cavity barriers: The objective is to prevent uncontrolled spread of fire through cavities in the low probability events of either failure of the protective covering or fire starting within the cavity.

Non-combustible insulation: The objective is to minimise the risk of fire spread through cavities by removing a potential source of fuel, i.e. combustible insulating materials.

Note: These above specific fire-protected timber requirements are used in conjunction with other DTS provisions of the NCC that apply to healthcare buildings.

3.4.2 Evidence of Suitability

The NCC requires every part of a building to be constructed in an appropriate manner to achieve the performance requirements, using materials and construction that are fit for the purpose for which they are intended, including safe access for maintenance.

The NCC Volume One specifies requirements for Evidence of Suitability in Clause A5.2 but there are additional specific requirements that apply to certain aspects of fire safety under NCC prescriptive requirements:

- NCC Clause A5.4 Fire-Resistance of Building Elements
- NCC Clause A5.5 Fire Hazard Properties
- NCC Clause A5.6 Resistance to the Incipient Spread of Fire.

In most instances, for the materials and systems considered in this Guide, the Evidence of Suitability for the fire resistance or Resistance to the Incipient Spread of Fire (RISF) of an element of construction will be in a report from an Accredited Testing Laboratory.

If a Performance Solution is proposed, compliance should be demonstrated using the procedures prescribed in Clauses A5.4 and A5.6 of the NCC as appropriate for fire-protected timber elements.

3.5 Determine Schematic Building Layout

3.5.1 Mixed Class Buildings

The NCC DTS Solution, using fire-protected timber in conjunction with an automatic fire sprinkler system, can be applied to mixed class buildings; provided the different classes are adequately fire separated (refer Step 4) and the entire building is protected by an automatic fire sprinkler system complying with NCC Volume One Specification E1.5, other than a FPAA101D or FPAA101H system.

This provides added flexibility for the design of new buildings and facilitates the refurbishment or expansion of existing buildings which is relatively common for major hospitals.

3.5.2 Check Fire and Smoke Compartment Sizes

General floor area and volume limitations

The NCC Clause C2.2 does not nominate a maximum fire compartment size for Class 2, 3 and 4 buildings or parts of buildings but the NCC does require the bounding construction of Sole Occupancy Units (SOUs) to be of fire-resisting construction.

For Class 5 to 9 buildings maximum compartment sizes are prescribed in Clause C2.2 of the NCC and are summarised in Table 3.3 for the mid-rise buildings considered in this Guide.

Table 3.3: NCC Maximum Fire Compartment Sizes for mid-rise Commercial and H ealthcare Buildings.*

<table>
<tr><th rowspan="2">Building Class</th><th colspan="2">Type A Construction</th><th colspan="2">Type B Construction</th></tr>
<tr><th>Floor Area</th><th>Volume</th><th>Floor Area</th><th>Volume</th></tr>
<tr><td>5</td><td rowspan="3">8,000 m²</td><td rowspan="3">48,000 m³</td><td rowspan="3">5,500 m²</td><td rowspan="3">33,000 m³</td></tr>
<tr><td>9b</td></tr>
<tr><td>9c See sub-section below for ‘Additional fire and smoke compartmentation’ requirements</td></tr>
<tr><td>6</td><td rowspan="4">5,000 m²</td><td rowspan="4">30,000 m³</td><td rowspan="4">3,500 m²</td><td rowspan="4">21,000 m³</td></tr>
<tr><td>7</td></tr>
<tr><td>8</td></tr>
<tr><td>9a See sub-section below for ‘Additional fire and smoke compartmentation’ requirements</td></tr>
</table>

Table 3.3 is a derivative of Table C2.2 of the National Construction Code 2019 Amendment 1 provided by **https://www.abcb.gov.au/ Australian Building Codes Board © 2020.*

Note: There are concessions permitted by the NCC for large isolated buildings that allow relaxations to the above limits under certain circumstances (refer NCC Clause C2.3).

Individual floors are normally substantially less than the maximum floor areas specified in Table 3 above and under these circumstances each floor will generally comprise at least one separate fire compartment unless relaxations are permitted (e.g. non-required, non-fire isolated connections as permitted in Clause D1.2 of the NCC).

Additional fire and smoke compartmentation for Class 9a patient care areas

NCC Clause C2.5(a) requires additional fire and smoke compartmentation of patient care areas in Class 9a buildings. These are summarised in Table 3.4.

Table 3.4: Additional fire and smoke compartmentation for Class 9a patient care areas.

Part	Smoke Compartment (smoke-proof walls, NCC Spec C2.5)	Fire Compartmentation Max areas	
		Sub Compartment FRL 60/60/60	Fire Compartment FRL 120/120/120
Treatment area	1,000 m^2	-	2,000 m^2
Ward areas	500 m^2	1,000 m^2	
Hazardous ancillary areas within patient care areas	-	Fire separation from remainder of patient care area	

Hazardous ancillary areas that contain equipment or materials that are a high potential fire hazard are required to be separated from the rest of the patient care area by walls having an FRL of not less than 60/60/60 and include:

- a kitchen and related food preparation areas with floor area of more than 30 m^2
- a room containing a hyperbaric facility (pressure chamber)
- a room used for the storage of medical records having a floor area of more than 10 m^2
- a laundry, where items of equipment are of the type that are potential fire sources.

Additional fire and smoke compartmentation for Class 9c Buildings

A fire compartment must be separated from the remainder of the building by fire walls and floors with an FRL of not less than 60/60/60. (Refer to Table 3.3 for maximum fire compartment sizes). Lift and stair shaft walls are required to achieve an FRL of at least 120/120/120 or –/120/120 if non-loadbearing.

NCC Clause C2.5(b) requires Class 9c buildings to be subdivided into smoke compartments having a maximum floor area of 500 m^2.

Hazardous ancillary areas that contain equipment or materials that are a high potential fire hazard are also required to be separated from the rest of the patient care area by smoke-proof walls and include:

- a kitchen and related food preparation areas with floor area of more than 30 m^2
- a room containing a hyperbaric facility (pressure chamber)
- a room used for the storage of medical records having a floor area of more than 10 m^2
- a laundry, where items of equipment are of the type that are potential fire sources.

Note: Note the NSW variations to the NCC modify Clause C2.5 to require additional smoke/fire separation around SOUs in Class 9c buildings.

3.5.3 Determine Schematic Fire Safety Design Strategy

The preliminary specification of a fire safety strategy for a building is important as it may significantly affect the building layout. This is applicable irrespective of the compliance pathway chosen (Performance Solution or DTS Solution) since, even within the DTS pathway, options have to be selected that affect the building layout, detailed design and on the use of the building through its life cycle.

The schematic fire safety design strategy should, at the preliminary stage, provide as a minimum:

- A summary of the fire safety objectives.
- Building uses that the design needs to address.
- Occupant characteristics that the design addresses.
- Approach to demonstrating compliance with the NCC (Performance Solution, DTS Solution or a combination).
- Where a DTS Solution is specified, it is still necessary to provide details of the DTS options selected as detailed below.

- Schematic drawings and brief descriptions as appropriate indicating:
  - design requirements for automatic fire sprinkler systems
  - design requirements for detection and alarm systems
  - general layout showing fire/smoke resistant compartmentation and structural elements
  - active smoke control measures if provided
  - means of egress during a fire emergency including travel distances to exits, discharge of exits, door operations, etc
  - evacuation strategy and associated emergency warning and intercom system (EWIS)
  - means to alert the fire brigade and equipment to facilitate fire brigade intervention
  - any other fire protection measures.
- An implementation plan relating to the scheduling and inspection of all fire safety measures and systems, stating who is responsible for ensuring compliance and measures that will be in place to facilitate compliance (e.g. inspection schedule).
- Protection measures required during construction.
- Fire safety management measures after completion to ensure ongoing effectiveness of the fire safety strategy through the life of the building.

This preliminary strategy should be regularly reviewed and updated with further details added as the design develops.

3.5.4 Determine Building Services and Preliminary Layout

The preliminary selection of building services and service locations should be considered when determining the general building layout and provision allowed for safe maintenance, modification, and addition of services without compromising fire safety and sound separation.

Typical matters for consideration include:

- location of plant rooms (noting that some plant rooms may contain transformers, emergency generators and associated fuel tanks that may present additional hazards that need to be addressed)
- selection of heating, ventilation and air conditioning (HVAC) systems (centralised v localised systems)
- locate service shafts to minimise nuisance noise and facilitate fire compartmentation
- minimise service penetrations through fire barriers
- group service penetrations together and select treatments that minimise the risk of fire spread to cavities
- avoid the need for hot works (e.g. welding, grinding) on services at the position of penetrations through fire-resistant elements
- provide for maintenance and additional services (e.g. allow for the provision of sufficient inspection hatches to allow adequate viewing of potential penetrations through smoke or fire walls)
- select services and materials that minimise the need for hot works (e.g. welding, grinding, soldering).
- distribution systems for medical gasses and bulk storage locations.

3.6 Consideration of Other Drivers and Constraints

3.6.1 Safe Design

Safe design principles should be applied throughout the design process and consider the entire building life cycle. This section gives some general guidance in relation to mid-rise timber buildings.

Building life cycle

It is important to consider the impacts of design decisions on all phases of the building's life cycle.

For example, the NCC Deemed-to-Satisfy Provisions may require a fire safety feature to be incorporated into a building. During the design process it is necessary to determine:

- how the provision can be installed/constructed safely to achieve its required performance (e.g. avoiding hot works during installation)
- how the feature will be commissioned and its performance verified, (e.g. provision of safe access for inspection)
- that the feature will not present a hazard during occupation of a building, (e.g. where there is a significant risk that occupants may self-harm detail fire protection measures top avoid hanging points.)
- how the feature can be maintained and repaired safely
- measures to be taken to ensure the feature does not present a hazard during renovation/modification or demolition and to ensure that the performance of the feature is not compromised during the renovation/modification process.

Many of these matters lie outside the scope of the NCC but they are addressed through State and Territory Building Acts and regulations and Work Health and Safety (WHS) legislation.

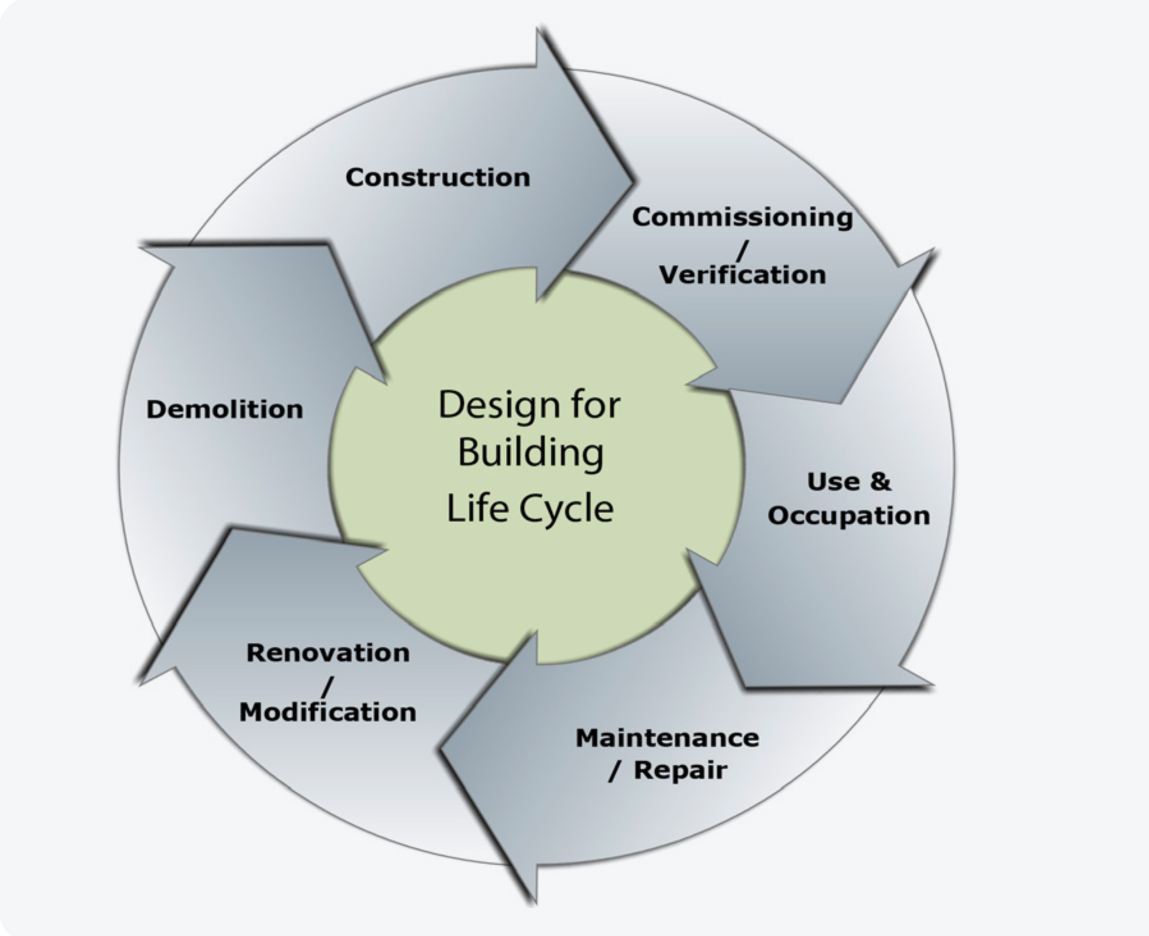


Figure 3.7: Typical Building Life Cycle.

Responsibilities for safe design

This Guide focuses on NCC 2019 requirements relating to Deemed-to-Satisfy Solutions for mid-rise timber buildings.

The NCC does not regulate matters such as the roles and responsibilities of building practitioners and maintenance of fire safety measures that fall under the jurisdiction of the States and Territories. State and Territory building legislation is not consistent in relation to these matters, with significant variations with respect to:

- registration of practitioners
- mandatory requirements for inspections during construction
- requirements for maintenance of fire safety measures.

WHS legislation requires safe design principles to be applied. A Code of Practice – Safe Design of Structures published by Safe Work Australia provides guidance to persons who design structures that will be used, or could reasonably be expected to be used, as a workplace. It is prudent to apply these requirements to all buildings as they are generally a workplace for people doing building work, maintenance, inspections and the like.

The Code defines safe design as: "The integration of control measures early in the design process to eliminate or, if this is not reasonably practicable, minimise risks to health and safety throughout the life of the structure being designed."

It indicates that safe design begins at the start of the design process when making decisions about:

- the design and its intended purpose
- materials to be used
- possible methods of construction, maintenance, operation, demolition or dismantling and disposal, (e.g. avoidance of working-at-height issues through the provision of safe access to elevated equipment)
- what legislation, codes of practice and standards need to be considered and complied with.

The Code also provides clear guidance on who has health and safety duties in relation to the design of structures and lists the following practitioners:

- architects, building designers, engineers, building surveyors, interior designers, landscape architects, town planners and all other design practitioners contributing to, or having overall responsibility for, any part of the design
- building service designers, engineering firms or others designing services that are part of the structure such as ventilation, electrical systems and permanent fire extinguisher installations
- contractors carrying out design work as part of their contribution to a project (for example, an engineering contractor providing design, procurement and construction management services)
- temporary works engineers, including those designing formwork, falsework, scaffolding and sheet piling
- persons who specify how structural alteration, demolition or dismantling work is to be carried out.

In addition, WHS legislation places the primary responsibility for safety during the construction phase on the builder.

The design team, in conjunction with owners/operators and the builder, have a responsibility to document designs, specify and implement procedures that will minimise risks to health and safety throughout the life of the structure being designed.

Applying safe design principles

A key element of safe design is consultation with stakeholders to identify risks, practical mitigation measures and to assign responsibilities to individuals/organisations for ensuring the mitigation measures are satisfactorily implemented.

This approach should be undertaken whichever NCC compliance pathway is adopted and applies to all forms of construction.

Some matters specific to fire safety are summarised below:

- The NCC and associated referenced documents represent nationally recognised standards for fire safety for new building works.
- The NCC's limited treatment of fire precautions during construction focuses on manual fire-fighting, egress provisions and fire brigade facilities. Additional precautions are required to address WHS requirements such as fire prevention and security. Refer to Section 1.4.4 and WoodSolutions Technical Design Guide #20 Fire Precautions During Construction of Large Buildings, for further information.
- Minimising service penetrations through fire-resisting construction.
- Grouping of service penetrations through fire-resisting walls with safe access for installation, inspection and maintenance.
- Detailed design of fire safety measures to optimise reliability and facilitate safe installation, maintenance and inspection where practicable. Special attention should be given to protection of service penetrations and cavity barriers.

Importance of Ongoing Documentation

Throughout the design and construction phase it is important to undertake the following tasks culminating at the end of the commissioning stage with the development of a Fire Safety Manual.

- Documentation of procedures and allocation of responsibilities for determining Evidence of Suitability for fire safety measures.
- Documentation of procedures and allocation of responsibilities for the verification and commissioning of all fire safety installations.
- Provision of specifications and drawings of all fire safety measures within the building, Evidence of Suitability, commissioning results and requirements for maintenance and inspection to the owner as part of the fire safety manual. (Note: Some State and Territory legislation contains minimum requirements for inspection of fire safety measures).
- The fire safety manual should also provide information on how to avoid compromising fire safety through the life of a building (e.g. preventing disconnection of smoke detectors or damage to fire-resisting construction or preventing unauthorised / unitentional isolation of automatic fire sprinkler systems).

Fire precautions during construction

Fires may occur on building construction sites due to the nature of the works. Typical causes include:

- hot works (cutting and welding)
- heating equipment
- smoking materials
- other accidental fires
- arson.

Mid-rise timber buildings complying with the NCC 2019 Deemed-to-Satisfy Provisions offer a safe and economical building solution. The addition of the fire-protective coverings plays an important role in providing this fire safety and, due to the construction sequencing, there may be a period where the timber is not fully protected and/or automatic fire sprinkler protection is not fully operational. During this period timber buildings are at their highest risk from construction fires.

The builder and design team need to consider fire precautions during construction. The scope of the NCC is limited to specifying minimum requirements for fire hydrants, hose reels and extinguishers and egress provisions (NCC Clause E1.9).

Addressing WHS requires a broad holistic approach that considers the building layout and site layout throughout the construction process to minimise the fire risk at a time when the building could be at its most vulnerable. Typical matters that should be considered include:

- progressive installation of services
- progressive installation of fire-protective grade covering of timber members and compartmentation of the building
- prefabrication and delivery to site with full or partial encapsulation of timber
- access for fire fighters and egress provisions for staff and visitors on the building site
- selection of materials and work methods that minimise the need for hot works
- security provisions (to address arson)
- safe access for maintenance of equipment and minimising the down time of fire safety equipment during maintenance
- detailing service penetration and construction interfaces to minimise the risk of cavity fires during installation.actual construction phase.throughout the life of the structure being designed.

WoodSolutions Technical Design Guide #20 Fire Precautions During Construction of Large Buildings provides additional information that can be applied to the design and planning stages as well as the actual construction phase.

3.6.2 Additional User Requirements

Additional user requirements may include the following items. Many State and Territory Health Authorities provide guidance on these matters and may have standard specifications/room layouts.

- usability
- aesthetics
- costs
- speed of construction
- building flexibility
- operational continuity
- corporate image
- environmental protection
- heritage protection
- enhanced safety (incorporating WHS legislation and duty of care)
- enhanced property protection
- other legislation and government policies.

It is critical these matters are addressed at the schematic stage by the design team to reduce the risk of costly reworks of a design.

4

Step 2 – Determine NCC design requirements for sound, thermal resistance, weatherproofing and structural tests

Timber building systems can be designed to achieve the regulatory requirements of the National Construction Code Volume One (NCC). From a performance perspective, the NCC sound provisions tend to govern the choice of timber building systems more than the fire provisions, due to the lightweight nature of the timber systems.

In relation to Class 9a (hospitals) and Class 9c (aged care), the NCC only applies sound trasmission provision to Class 9c buildings.. Keep in mind that the NCC Provisions are minimum requirements and may not meet the expectations of the building occupants. There is also a parallel need to address sound induced by poor spatial design of a building, flanking noise issues and, where appropriate, upgraded sound performance requirements to meet end user needs.

4.1 Utilising the Deemed-to-Satisfy Provisions for Sound

Part F5 of the NCC is concerned with safeguarding 'occupants from illness or loss of amenity as a result of undue sound being transmitted' and primarily addresses Class 2, 3 and 9c buildings. Therefore, there are no mandatory sound transmission NCC Performance Requirements for Class 9a buildings.

However, in large open plan spaces in hospitals, consideration should be given to the way occupants will work and interact in the spaces and the effects of generated sound within the built environment. In hospital facilities, this would include workstations, private meeting rooms, waiting rooms through to kitchen areas and should consider levels to enable the ability to hold 'comfortable' conversations without affecting adjacent occupied spaces.

A holistic acoustic design would consider:

- sound insulation between spaces (e.g. wards and lift lobbies)
- internal room spaces
- noise from building services/plant
- vibration
- external noise.

The NCC Performance Requirements for Class 9c buildings focus on limiting the transmission of both airborne and impact-generated sound via floor and wall building elements bounding sole-occupancy units (SOUs) where separating:

- adjoining SOUs
- SOUs from a common space (e.g. kitchen)
- SOUs from another building classification within the building.

The sound performance of these floor and wall building elements must consider the impact of any pipe penetrations or other service elements (e.g. air-conditioning) as well as door openings on bounding construction. (Note: The provisions include the sound isolation of pumps but issues pertaining to this are not dealt with in this Guide). When interpreting these requirements, it is important to understand the difference between airborne and impact sound (Figure 4.1).

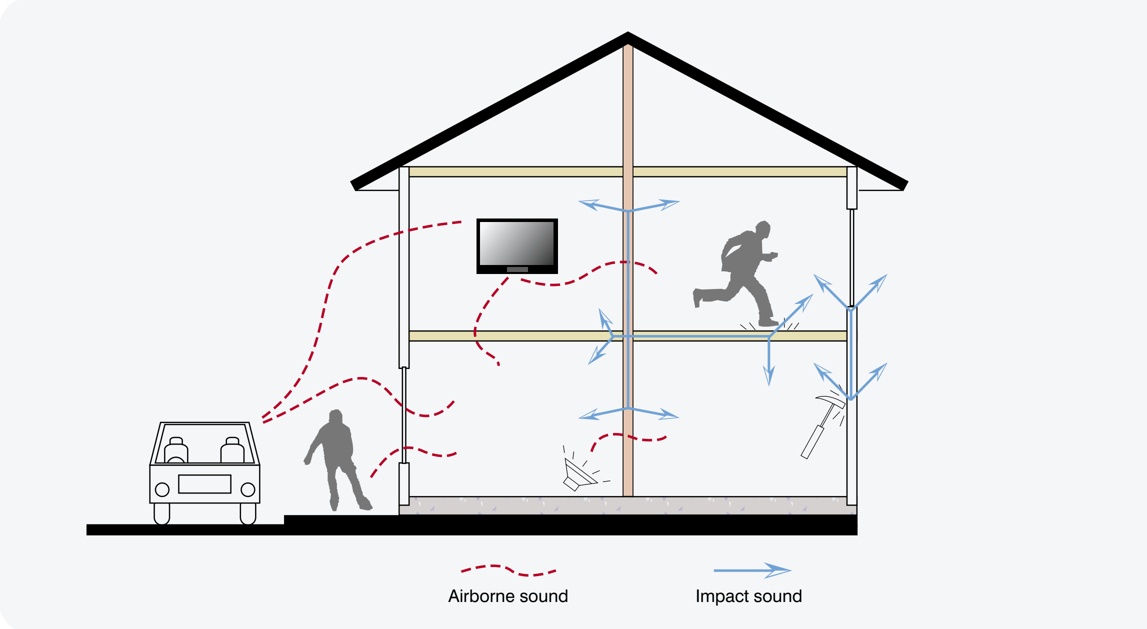


Figure 4.1: Examples of impact and airborne sound.

It is also important to understand how each type of sound is measured in order to select appropriately sound-insulated wall, floor and ceiling elements. The nomenclature used in the Deemed-to-Satisfy Provisions using results from laboratory requirements, is explained in Figures 4.2 and 4.3.
Note: Alternative methods of sound measurement also exist.

Airborne sound is typically measured in the Deemed-to-Satisfy Provisions using the Weighted Sound Reduction Index and is expressed as R_w (e.g. R_w 50).

- 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} (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 noise (bass, sub-woofer).

C_{tr} is usually a negative number with a typical range of -1 to -15. It is added to the R_w value and the net result is a lower number than the R_w value on its own. It is therefore significantly harder to achieve $R_w + C_{tr}$ 50 than R_w 50 on its own.

Applying the above involves finding out the minimum stated R_w or $R_w + C_{tr}$ for a given building element (as determined using the Deemed-to-Satisfy Provisions) as dealt with in Section 2.2.

Figure 4.2: Airborne sound.

Impact sound is typically measured in the Deemed-to-Satisfy Provisions using the Weighted Normalised Impact Sound Pressure Level expressed as $L_{n,w}$ (e.g. $L_{n,w}$ 62).

- It is usually applied to floor elements.
- The lower the number the better the performance.

Note: Although not required by NCC 2019, a C_I modification factor can be added to the $L_{n,w}$ value to bias the overall measurement into taking greater account of low frequency impact sound such as footsteps. It is usually a positive number, and so when added to the $L_{n,w}$ measurement, the net result is a higher number than the $L_{n,w}$ measurement on its own. It is therefore significantly harder to achieve $L_{n,w} + C_I$ 62 than $L_{n,w}$ 62 on its own.

Applying the above involves finding out the maximum stated $L_{n,w}$ for a given building element (as determined using the Deemed-to-Satisfy Provisions) as dealt with in Section 2.2.

Figure 4.3: Impact sound.

There are no NCC requirements for sound ratings of external walls, but in some parts of Australia state planning regulations or local government requirements may apply. For information on the sound performance of common timber-framed external walls, refer to *WoodSolutions Technical Design Guide #11 Timber-framed Systems for External Noise;* and for Cross Laminated Timber internal walls, floors and for service isolation refer to *WoodSolutions Technical Design Guide #44 CLT Acoustic Performance.*

4.2 Determining Sound Insulation Requirements for Individual Building Elements

Of importance to construction is the minimum airborne and impact sound insulation requirements for individual building elements, e.g. wall and floor elements. Table 4.1 provides a simple means for finding out such information and is necessary for selecting appropriate timber-framed construction, systems.

Table 4.1: Deemed to Satisfy Requirements for sound insulation of wall and floor elements in Class 9c buildings.

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 & $_{LnT,w}$ (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

Where a wall required to have sound insulation has a floor above, the wall must continue to the underside of the floor above, or the ceiling must provide the equivalent sound insulation required for the wall. (Professional advice should be sought to upgrade the ceiling to the required wall sound insulation.)

4.3 Services

If a duct, soil, waste or water supply pipe serves or passes through more than one SOU, the duct or pipe must be separated from any SOU by construction with an Rw + Ctr (airborne) not less than:

- 40 if it is adjacent to a bedroom or living room (other than a kitchen); or
- 25 if it is adjacent to a kitchen or bathroom.

It is also required where a duct or pipe is located within a wall or ceiling cavity.

If a storm water pipe passes through an SOU, it must comply with both of these provisions.

4.4 The Next Step

Having used the previous information to obtain an understanding of the NCC's minimum sound-insulation requirements, the next step is to either:

- go to Step 3 to find out about possible options for consideration for improving and/or upgrading sound performance; or
- go to Step 5 to select timber building systems that will comply with minimum NCC sound requirements.

4.5 Other Design Considerations

There are other design considerations that need to be taken into account in meeting NCC requirements. The following are not covered in detail in this Guide but are listed as requiring consideration.

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4.5.1 Thermal Resistance (R-value)

NCC 2019 Volume One, Section J, provides the energy-efficiency requirements that a building, including its services, must achieve in order to address the annual greenhouse gas emissions of buildings.

The energy efficiency provisions can be met via the NCC 2019 Verification (modelling) Methods, including the Additional Requirements (e.g. floor edge insulation, building sealing) contained in Specification JVa or complying with the Deemed-to-Satisfy Provisions. These provisions will vary based on a range of factors including: the building's location (climate zone), direction of heat flow, level of external wall/window ratio and shading, size and performance of external glazing/windows and form of construction of the external building fabric.

The thermal resistance of timber building elements depends on the level of installed insulation (i.e. thickness), number and thickness of sheet lining layers (plasterboard, flooring), element construction (e.g. incorporating furring channels) and overall thickness of the building element.

Guidance on timber wall and floor/ceilings can be found in the *WoodSolutions' R-values for Timber-framed Building Elements* publication.

4.5.2 Damp and Weatherproofing

The requirements for the damp and weatherproofing of buildings are provided in NCC Volume One Part F1. The intent is to protect the building from external (rain) and internal water (e.g. laundry overflow) and the accumulation of internal moisture in a building causing unhealthy conditions for occupants and potential damage to building elements.

Key areas of consideration include:

- External walls. There are currently no Deemed-to-Satisfy Provisions in the NCC for weatherproofing and therefore suppliers of weatherproofing products/membranes are relied on to demonstrate compliance with the NCC Performance Requirement (FP1.4). It is important that installed weatherproofing membranes/ systems are vapour permeable (i.e. allowing timber building components to breathe) but do not permit water to penetrate (i.e. water barrier) through to the structural timber building elements.
- Internal wet areas (e.g. bathroom) must be waterproofed in accordance with the NCC requirements (F1.7) and have adequate overflow systems (e.g. floor waste) in place to deal with the possibility of wastewater overflow.
- Roof coverings. For the purposes of this Guide, and as required by the NCC, roof coverings must be of non-combustible materials (e.g. concrete, metal, terracotta) and be fixed in accordance with, and comply with, the relevant Standard as specified in the NCC Clause F1.5.

Note: *The drawings in this Guide have either omitted damp, weatherproofing and waterproofing details or provided indicative details only. Specific details may vary with climatic conditions and in many instances the only compliance pathway is a Performance Solution that may yield solutions that vary from project to project. Take care to ensure that the Performance Solutions for damp, weatherproofing and waterproofing do not conflict with NCC fire safety requirements.*

4.5.3 Structural Tests

NCC Specification C1.8 describes structural tests for fire-resisting, lightweight wall construction that bounds lift, stair and service shafts, fire-isolated passageways and ramps as well as external and internal walls. The test methods and criteria for compliance are stated in relation to materials, damage, deflection (under static pressure and impact) and surface indentation.

Lightweight wall systems do not require testing if designed and constructed in accordance with the relevant design and loading standards specified in the NCC Part B1 Structural Provisions.

5

Step 3 – Improve and Upgrade Sound Performance

The NCC 2019 Volume One Amendment 1 does not nominate sound transmission requirements for Class 9a (hospitals) buildings but it does provide minimum Deemed-to-Satisfy requirements for Class 9c buildings.

Sound performance between floor levels and between adjacent rooms has a positive benefit for building occupants and can often be improved by simple attention to the form and spatial arrangement of the building design. Attention to flanking noise is another important way to improve sound performance. End users may wish to enhance the sound performance of their buildings and, as a result, this Step in the Guide focuses on ways to improve and upgrade sound performance.

5.1 Attention to Building Design to Reduce Sound Transmission

Aspects of the form and spatial design of a building that can be adapted to improve sound performance are dealt with under the following headings.

5.1.1 Floor Layout

Check that the floor layout is beneficial rather than detrimental to sound transmission. Service rooms, including photocopying/collation rooms and kitchens, create extra sound compared the typical work environment. Adequate sound insulation between spaces will assist in enhancing the acoustic environment for occupants.

5.1.2 Windows

Windows normally have lower sound insulation than the walls around them and can be used to improve the building occupant's comfort level from external noise. To improve the acoustic performance of window, 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
- reduce the area of windows in the façade.

5.1.3 Doors

As with windows, doors tend to be a weak link in sound-rated wall systems. Where sound control is desired, solid core doors should be used and be treated with soft acoustic gaskets at interfaces with door jambs. Threshold closers at the bottom of the door or air seals will also help reduce sound transmission. In most cases, achieving the required sound rating will involve the use of gaskets and seals. Sliding doors should be avoided where optimum sound-control is desired.

5.1.4 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 sound-insulated walls between SOUs but rather on internal walls or dedicated sound resisting service shafts. In all instances, service pipes should be located away from noise-sensitive parts of the dwelling, such as bedrooms.

5.1.5 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 common timber-framed external walls, refer to *WoodSolutions Technical Design Guide #11 Timber-framed Systems for External Noise.*

5.2 Addressing Flanking Noise

The ability to insulate against sound moving from one location in building to the next depends not only on insulating individual wall and floor elements, but also on stopping noise from jumping or transferring from one building element to the next or, worse still, moving through the building in an uncontrolled way. As a result, the effectiveness of sound-insulated construction is concurrently dependent on addressing flanking noise. Flanking noise refers to sound passing around rather than through wall/ floor elements, causing sound to unexpectedly manifest itself in unwanted places.

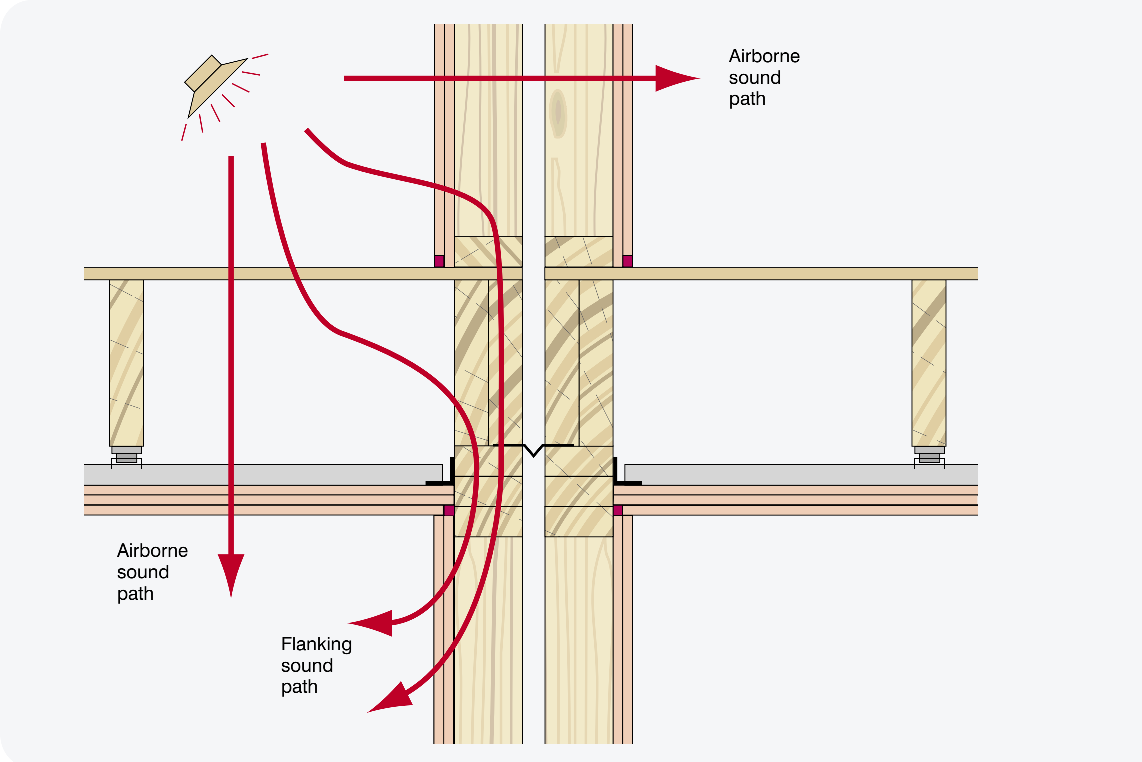

Figure 5.1: Flanking and airborne noise pathways – elevation view.

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 in order to ensure that laboratory-tested wall and floor elements perform to their full potential in the field.

This Guide's approach is to consider reducing flanking noise paths wherever possible. The content is the result of careful thought, taking into account issues such as the limits on what could be achieved in reducing flanking because of their 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 (Figure 5.1).

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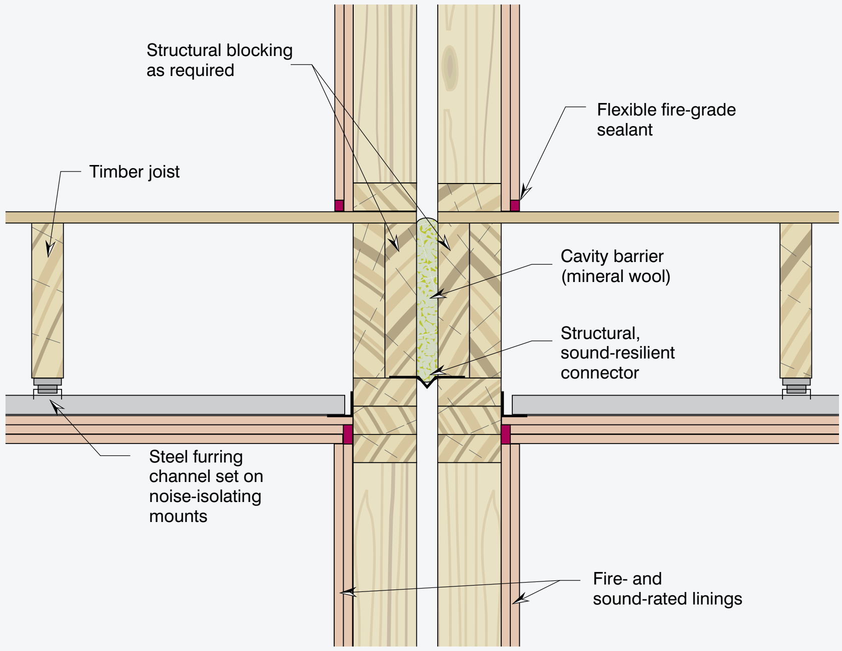


Figure 5.2: Discontinuous floor joist and floor sheeting – elevation view.

There are two main approaches used for addressing flanking noise in timber-framed buildings:

- Limit the ability of the noise to migrate from one element to another, e.g. dampening and isolation at junctions between elements (Figure 5.2).
- Limit the noise getting into wall/floor element, e.g. carpet, floating floors (Figure 5.3).

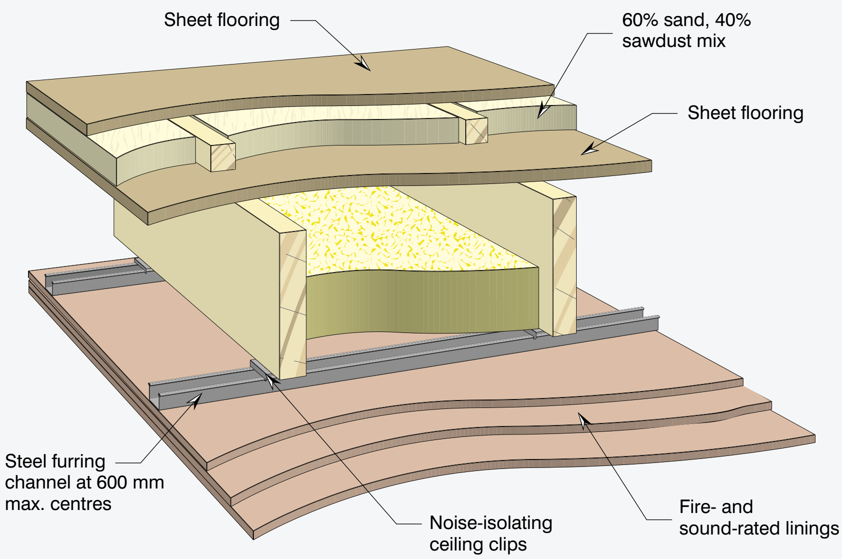


Figure 5.3: Acoustic isolating pad to reduce flanking noise.

In addition to these, timber-framed construction details orientated to improving flanking sound are provided in Section 5.3 and include:

- discontinuous elements at walls, floors and ceilings
- cavities within sound rated elements blocked or travel path increased to reduce noise
- introduced isolating elements, e.g resilient mats or brackets
- platform flooring discontinuous over double stud walls.

5.3 Strategies for Upgrading Sound Performance in Construction

Building occupants often desire higher sound performance than the NCC's minimum requirements. This is especially the case for impact sound and the related issue of vibration from footsteps, water movement through pipes, water hammer and sources such as 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). 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 and should generally only be used at floor or ceiling level.

Using absorptive materials to fill wall and floor cavities (non-combustible 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 Technical Design Guide #11 Timber-framed Systems for External Noise.*

5.3.1 Walls

Extra mass on the walls – the addition of mass is a simple yet effective way to improve sound performance in timber construction. In its simplest form, it involves adding extra layers of material such as plasterboard to the outer layer of the sound-rated wall system.

Use a 90 mm rather than 70 mm wall studs – The deeper the wall, the better its sound performance. This is particularly the case where 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 deep studs instead of 70 mm deep studs in a double stud wall system.

Upgrade batts in the wall/floor – There are many types and grades of non-combustible insulation batts in the marketplace. Sound insulation specific batts are best and high-density materials tend to outperform low-density materials. Always refer to the supplier's documented recommendations; some systems require insulation or linings to affect different frequencies and therefore may have differing advice.

5.3.2 Floors

Extra mass on the ceilings – adding mass is a simple yet important way to improve sound performance in timber-framed construction. At its simplest manifestation, this involves adding extra layers of material such as plasterboard to the sound-rated ceiling system.

Extra mass on floors – the addition of mass on floors is an effective way to address impact noise (e.g. footsteps). The additional mass can be in the form of additional layers of sheet flooring.

5.4 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:

- 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 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 construction system in Step 5.
- Go to Step 5 to select timber construction that will comply with minimum NCC fire requirements.

6

Step 6 – Determine NCC fire-protected timber design requirements (design development)

Designing fire-resisting construction involves a process of understanding how the NCC's Performance Requirements translate into the more objective and measurable Deemed-to-Satisfy Solutions for mid-rise timber buildings, prior to finalising the building layout and selecting timber construction systems that meet these requirements.

6.1 Utilising the Deemed-to-Satisfy Solutions for Fire Design

Section C of the NCC Volume One is concerned with safeguarding people if a building fire occurs. Specific attention is given to facilitating the evacuation of occupants and activities of emergency services personnel by restricting fire spread within a building and providing structural adequacy for the required length of time, avoiding the spread of fire between buildings, and protecting other property from damage as a result of fire.

The NCC details Deemed-to-Satisfy (DTS) Solutions that satisfy the Performance Requirements under:

Part C1 – Fire-resistance and stability

Part C2 – Compartmentation and separation

Part C3 – Protection of openings

These Parts deal with a wide range of issues but it is primarily the fire-resistance of building elements and provisions that relate specifically to mid-rise timber buildings that are dealt with in this Guide. To this end, only the more relevant clauses from Parts C1, C2 and C3 are discussed in more detail below together with the following provisions that apply specifically to mid-rise timber buildings.

- Protection of the building with an automatic fire sprinkler system complying with Specification E1.5 of the NCC (other than a FPAA101D or FPAA101H system)
- Fire-protected timber complying with Specification C1.13a of the NCC used for loadbearing internal walls, loadbearing fire walls and for elements of construction required to be non-combustible
- Any insulation installed in the cavity of the timber building element required to have an FRL is non-combustible
- Cavity-barriers provided in accordance with Specification C1.13 of the NCC.

The NCC Deemed-to-Satisfy Provisions that facilitate the construction of mid-rise timber buildings are shown in Figure 6.1.

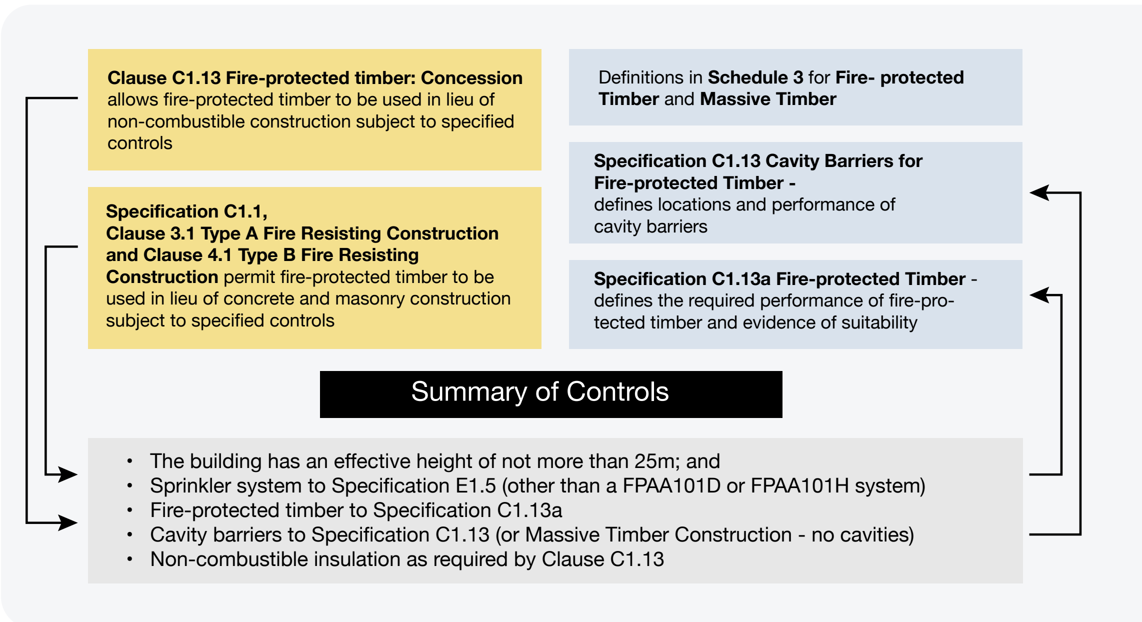


Figure 6.1: Mid-rise timber buildings overview of NCC DTS provisions.

6.2 Automatic Fire Sprinklers

A key fire safety feature for mid-rise timber buildings is the requirement to provide automatic fire sprinkler systems in accordance with NCC Specification E1.5 throughout the building (other than a FPAA101D or FPAA101H system), including any parts of the building that are not of timber construction. This requirement, in conjunction with other fire safety measures, is expected to significantly reduce the risk from fires in mid-rise timber buildings below that in other forms of construction complying with the minimum NCC DTS requirements that do not incorporate sprinkler systems.

6.2.1 Sprinkler Design Standards permitted by NCC Specification E1.5

Note: FPAA101D and FPAA101H systems are not currently permitted to be used in conjunction with fire-protected timber systems in accordance with the NCC DTS provisions.

Specification E1.5 allows sprinkler systems to be designed in accordance with:

- AS 2118.1: Automatic Fire Sprinkler Systems – General Requirements
- AS 2118.4: Automatic Fire Sprinkler Systems – Sprinkler protection for accommodation buildings not exceeding 4 storeys in height
- AS 2118.6: Combined sprinkler and hydrant systems in multi-storey buildings.

AS 2118.4 is limited to accommodation (residential) buildings not exceeding 4 storeys high. Therefore, most mid-rise timber building sprinkler systems will be designed to comply with AS 2118.1 or AS 2118.6.

6.2.2 Designing Fire Sprinkler Systems to Improve their Effectiveness

There are opportunities during the design process to incorporate features that can enhance the effectiveness of an automatic fire sprinkler system and simplify ongoing maintenance. A few examples are described below.

Fast response residential heads

Both AS 2118.1 and 2118.6 allow the use of appropriately listed fast response heads. These heads have a more rapid response than standard heads and are therefore more likely to either suppress a fire or limit its size, thus reducing the risk to occupants within the building. Therefore, where appropriate, fast response heads should be specified.

Monitored valves

The reliability of automatic fire sprinkler systems can be enhanced by providing monitored components, such as main stop valves and subsidiary stop valves. Monitored stop valves on each floor, for example, enables sprinkler protection to be maintained throughout the remainder of the building while work is undertaken on part of the sprinkler system. If the valve is left closed when the work is completed, the building owner/operator can be alerted to ensure the error is quickly corrected. This minimises the time periods and extent of areas where sprinkler protection is unavailable. The progressive installation of monitored valves during construction can be used as part of the strategy to address fires during construction by facilitating the progressive commissioning of the sprinkler system.

False ceilings

If sprinkler pipes are run above a ceiling system that is required to have Resistance to the Incipient Spread of Fire (RISF), the ceiling will need to be penetrated to accommodate sprinkler heads; potentially compromising the fire performance of the ceiling if the sprinkler system fails to operate successfully. This can be avoided by providing a false ceiling and running the pipes below the RISF ceiling and the penetrations for the sprinkler heads need only penetrate the non-fire-resisting false ceiling.

This detail also provides flexibility for lighting systems, air conditioning and other services.

Selection of materials and pipe connections

The use of materials and pipework connections that minimise the need for hot works on site and reduce the time the sprinkler system is not in operation during maintenance should be considered. The use of non ferrous sprinkler heads, piping and connections may be needed in MRI and similar environments where there are strong magnetic fields.

Note: Major modern hospitals can include a broad range of functional areas. It is therefore important to identify the appropriate hazard classifications that may apply to the sprinkler system at an early stage in the design process since it will impact on water supply requirements and potential requirements for on-site water storage and pumps.

Note: NCC Clause C1.9(e) permits some materials, including plasterboard and fibre-reinforced cement sheeting, to be used wherever a non-combustible material is required by the NCC. This dispensation does not apply for applications where non-combustible materials are specified under other legislation, e.g. specification of materials for enclosure of medical gas storage facilities.

Protection of voids/concealed spaces

Concealed spaces within fire-protected timber elements greater than 200 mm deep generally require protection in accordance with AS 2118.1 and AS 2118.6. Where these voids include elements such as beams, the void depth is measured from the soffit of the beam.

6.2.3 Hazard Classes of Occupancies for Sprinkler System Design

Sprinkler systems are classified based on hazard classes of occupancy, which depend on the expected rate of heat release rate together with the fuel loading and burning characteristics of materials in a fire compartment.

The following major classifications apply (including sub-classes).

- Light Hazard Occupancies
- Ordinary Hazard Occupancies
- High Hazard Occupancies.

The Hazard Class can have an impact on the required water supply and as consequence the building layout and costs. The Sprinkler Hazard Class(es) for a building or part of a building should be identified early in the project to determine if the existing water supply is adequate or pumps and water tanks are required to supplement the existing supply.

6.3 Fire-Protected Timber Requirements

The NCC defines fire-protected timber as fire-resisting timber building elements that comply with Specification C1.13a of the NCC.

6.3.1 Fire-Protected Timber – General Requirements

Specification C1.13a applies the following General Requirements to fire-protected timber:

- the building element must be protected to achieve the required FRL
- a non-combustible fire-protective covering must be applied to the timber; which must achieve a Resistance to the Incipient Spread of Fire (RISF) of not less than 45 minutes when tested in accordance with AS1530.4.

To adequately specify or check Evidence of Suitability of a fire-protected timber element, three items of information are required:

- Fire-resistance Level (FRL) – determined from AS 1530.4 test or an equivalent or more severe test
- Resistance to the Incipient Spread of Fire (RISF) – determined from AS 1530.4 test or an equivalent or more severe test
- results from a non-combustibility test in accordance with AS 1530.1 – for materials not deemed non-combustible by the NCC.

FRL is the grading period in minutes for the following three criteria expressed in the order listed below separated by forward slashes (/).

- structural adequacy – ability of a loadbearing element to support an applied load
- integrity – ability of an element of construction to resist the passage of flames and hot gases from one space to another
- insulation – ability of the surface of an element of construction, on the non-fire side of the element, to maintain a temperature below the specified limits.

For example, if an FRL of 120/60/30 is specified, the element would need to satisfy the structural adequacy criteria for 120 minutes, the integrity criteria for 60 minutes and the insulation criteria for 30 minutes. A dash means that there is no requirement for that criterion, i.e. an FRL of 90/–/– means that only the criterion of structural adequacy applies for 90 minutes.

The RISF in relation to a fire-protective covering means the covering's ability to insulate voids and the interfaces with timber elements so as to limit the temperature rise to a level that will not permit ignition of the timber and the rapid and general spread of fire throughout any concealed spaces. The performance is expressed as the period in minutes that the covering will maintain a temperature below the specified limits.

A material is classified as non-combustible if flaming is not observed and specified temperature rise limits are not exceeded when a sample of material is exposed to the heating conditions specified in AS 1530.1; or it is 'deemed' non-combustible in accordance with NCC Clause C1.9(e).

To facilitate a consistent approach to specifying the performance of fire-protected timber the following format is recommended: **Fire-Protected Timber – FRL120/120/120:RISF45:NC.**

This means that the element must satisfy the structural adequacy, integrity and insulation requirements for 120 minutes; the RISF criteria for 45 minutes and the fire-protective covering must have been shown to be non-combustible when tested in accordance with AS 1530.1 or comply with the requirements of the NCC Clause C1.9(e).

While individual test/assessment reports from NATA Accredited Testing Laboratories can be used as Evidence of Suitability, it may be more practical for Accredited Testing Laboratories to provide consolidated reports stating the performance in the above format. Further information relating to the test procedures to determine the FRL and RISF are provided in Appendix A.

Cavities are permitted within fire-protected timber elements that, without adequate measures in place, can allow fire spread through concealed spaces. The risk of fire spread from enclosure fires to the cavities is substantially reduced by the requirement for an RISF45 applied to the fire-protective covering, among other things. There is a small residual risk of fire spread to the cavity from an enclosure fire or a fire started within a cavity due to hot works, for example. The risk of fire spread via concealed spaces is further reduced by the provisions for cavity barriers and requirements for wall/ceiling cavity insulation, if present, to be non-combustible.

- Specification C1.13a deems two-layers of 13 mm fire-protective grade plasterboard fixed in accordance with manufacturer's system requirements to achieve equivalent performance to an RISF45:NC fire-protective covering.
- The timber-framed wall system in Figure 6.2 with two-layers of 13 mm fire-protective grade plasterboard either side of a cavity between studs could be classified as fire-protected timber FRL90/90/90:RISF45:NC if Evidence of Suitability (as required by the NCC) is provided for the loadbearing wall system to verify that it achieves an FRL of 90/90/90 under similar or more severe load conditions.
- This evidence would normally be an AS 1530.4 fire test report from an Accredited Testing Laboratory. The RISF45 for two-layers of 13 mm thick fire-protective grade plasterboard does not require further verification since it is Deemed-to-Satisfy the 45-minute requirement and plasterboard is also deemed non-combustible by Clause C1.9(e) of the NCC.
- The primary objective for the inclusion of the non-combustibility requirement for the fire-protective covering is so that the reaction of the fire-protected timber to external and enclosure fires is comparable to elements of construction that are non-combustible: such as reinforced concrete or steel protected with non-combustible materials.

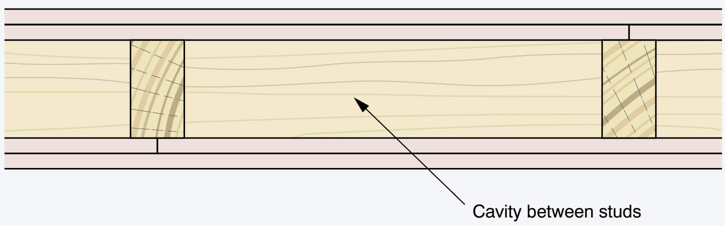


Figure 6.2: Horizontal section through typical FRL120/120/120: RISF45:NC timber stud wall showing allowable cavity.

The primary objective for the specification of RISF45 is to reduce the risk of the timber structural elements being ignited prior to burn-out of the contents or fire brigade intervention, in the unlikely event of the automatic fire sprinkler system failing. To achieve this, it is necessary that the RISF performance is not compromised by the presence of building service penetrations and openings for doors and windows. Refer to the relevant sections in this Step for further details on how the RISF performance can be maintained through appropriate penetration fire stopping systems, cavity barriers and lining of openings.

6.3.2 Relaxations for Massive Timber Panels

The NCC permits the General Requirements for fire-protected timber to be ‘relaxed’ if both the following additional criteria are satisfied:

- the minimum thickness of timber panels is not less than 75 mm
- there are no cavities between the surface of the timber and the fire-protective covering system or between timber members.

This 75 mm dimension relates to the minimum dimension of the dressed/finished timber member. In most instances, massive timber elements will have minimum dimensions much greater than 75 mm to meet the structural adequacy and integrity criteria of AS 1530.4. Typical examples of massive timber installations satisfying the conditions are shown in Figure 6.3. The rationale for allowing the ‘concession’ for massive timber is that it is reasonable to reduce the performance of the fire-protective covering, subject to maintaining the required FRL, because the consequences of ignition of timber structural members are significantly reduced:

- Timber with a large cross-section can achieve high fire-resistance levels due to its relatively high inherent fire resistance allowing it to continue to support an imposed load or maintain a fire separating function for significant periods. If there is an early failure of the fire-protective covering, the timber structure is likely to maintain its loadbearing capacity for a greater period than lightweight construction.
- By not permitting any concealed spaces between the timber and fire-protective coverings or between timber members, the risk of fire spread through concealed cavities is mitigated.
- If the massive timber conditions are met, the following requirements can be adopted for fire-protected timber in lieu of the General Requirements:
  - The building elements must be protected to achieve the required FRL and have a non-combustible fire-protective covering applied to the timber which achieves the Modified Resistance to the Incipient Spread of Fire (MRISF) of not less than the values stated in Table 6.1 when tested in accordance with AS 1530.4.
  - The Modified Resistance to the Incipient Spread of Fire (MRISF) is determined in accordance with Clause 3 of NCC Specification C1.13a. Further information relating to the test procedures to determine the Fire Resistance and the MRISF are provided in Appendix A.

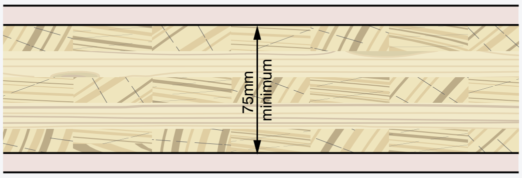
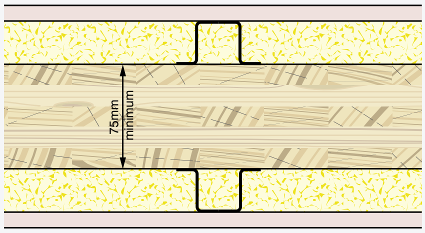
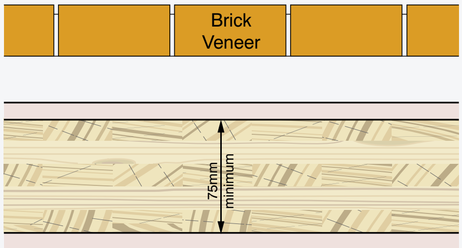
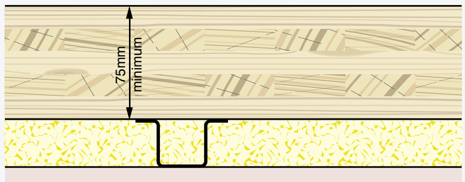
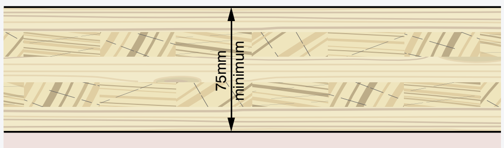
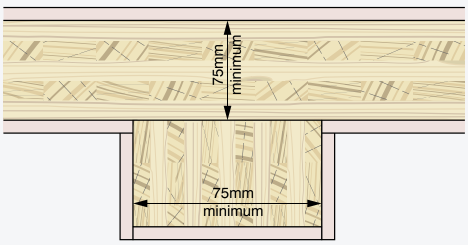
Description	Schematic section
Massive Timber Wall Panels	
Fire-protective covering direct fix to massive timber panel.	
Multi-layer fire-protective covering system direct fix to massive timber panel.	
External brick veneer wall – Note massive timber is faced on both sides with fire-protective coverings.	
Massive Timber Floor Panels	
Multi-layer fire-protective covering system direct fixed to the underside of the massive timber panel.	
Fire-protective covering direct fix to massive timber panel.	
Profiled ceiling fire-protective covering system follows the floor profile maintaining contact with massive timber element.	

Figure 6.3: Typical massive timber panel details for which the Modified Resistance to the Incipient Spread of Fire (MRISF) criteria may be applied.

To facilitate a consistent approach to specifying the performance of fire-protected massive timber the following format is recommended:

Fire-Protected Timber – FRL90/90/90: MRISF30: NC

This means that the element must satisfy:

- the structural adequacy, integrity and insulation requirements for 90 minutes
- the Modified Resistance to the Incipient Spread of Fire criteria for 30 minutes
- the fire-protective covering must have been shown to be non-combustible when tested in accordance with AS 1530.1 or comply with the requirements of the NCC Clause C1.9(e).

Table 6.1: Minimum fire-protective covering requirements – Massive timber.

Application	Modified Resistance to the Incipient Spread of Fire (MRISF)	Minimum Deemed-to-Satisfy Fire-protective Grade Plasterboard
Inside a fire-isolated stairway or lift shaft	20 min	1 layer x 13 mm thick
External walls within 1 metres of an allotment boundary or 2 metres of a building on the same allotment	45 min	2 layers x 13 mm thick
All other applications	30 min	1 layer x 16 mm thick

Table 6.1 is a derivative of Specification C1.13a Table 1 of the National Construction Code 2019 Amendment 1 provided by ***https://www.abcb.gov.au/*** *Australian Building Codes Board © 2020.*

Table 6.1 also includes Deemed-to-Satisfy fire-protective grade plasterboard minimum requirements if fixed in accordance with the manufacturer's system requirements in order to achieve the required FRL of the element for massive timber.

For example, if a non-loadbearing wall system is required to achieve an FRL of −/60/60, an appropriate specification for a massive timber element would be:

Fire-Protected Timber – FRL–/60/60: MRISF30: NC

If there is appropriate Evidence of Suitability to show a massive timber element can achieve an FRL of −/60/60 when protected by 16 mm fire-protective grade plasterboard, then no further evidence is required since the 16 mm thick plasterboard is Deemed-to-Satisfy the MRISF30 requirement and the plasterboard is also deemed to be non-combustible.

6.3.3 Fire-protected Timber Smoke-proof Walls (application of Specification C2.5)

Smoke-proof walls are used for sub-compartmentation in both Class 9a (e.g. hospitals) and Class 9c (e.g. aged care buildings). When implementing the fire-protected timber options, if the smoke walls are of timber-framed or massive timber construction, it is necessary for the level of encapsulation to be consistent with the minimum required for fire-resisting elements of construction. To achieve this, the required performance of fire-protective coverings and protection of openings and service penetrations needs to be increased.

To simplify the implementation, the requirements for Class 9a and 9c buildings have been consolidated and increased requirements for fire-protective coverings and protection of openings and service penetrations have been included in the following specification.

Fire-protected smoke-proof walls:

- Must be of fire-protected timber construction and extend to:
  - the floor above; or
  - a non-combustible roof covering; or
  - a ceiling having a resistance to the incipient spread of fire to the space above itself of not less than 60 minutes for a Class 9a building or 45 minutes for a Class 9c building subject to cavity barriers being provided directly above the smoke wall position within the ceiling cavity. The cavity barriers shall comply with NCC specification C1.13.
- Not incorporate any glazed areas unless the glass is safety glass as defined in AS 1288.
- Only have doorways that are fitted with smoke doors complying with Specification C3.4 of the NCC.

Note: While the NCC uses the term smoke proof and states that smoke doors must be constructed so that smoke will not pass from one side of the doorway to the other, smoke-proof walls constructed in accordance with NCC Specification C2.5 and smoke doors in accordance with the DTS provisions within Specification C3.4 may allow appreciable volumes of smoke to spread to adjacent smoke compartments particularly around the perimeter of smoke doors.

To manage the risk of smoke spread around the perimeters of doors, consideration should be given to the selection of appropriate and compatible door and seal combinations which can be evaluated by testing to AS1530.7 and requiring installation and construction in accordance with AS 6905.

- Have all openings around penetrations and the junctions of the smoke-proof wall and the remainder of the building stopped to prevent the free passage of smoke and maintain the Resistance to the Incipient Spread of Fire performance of fire-protected elements of construction and the required fire-resistance performance of elements of construction.
- Incorporate smoke dampers where air-handling ducts penetrate the wall (or cavity barrier above a wall) unless the duct forms part of a smoke hazard management system required to continue air movement through the duct during a fire.

Typical examples are shown in Figure 6.4.

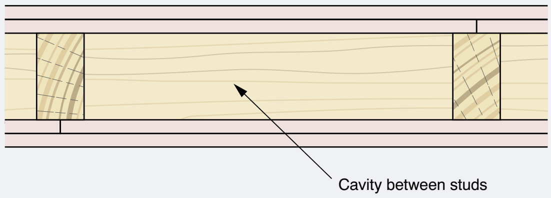
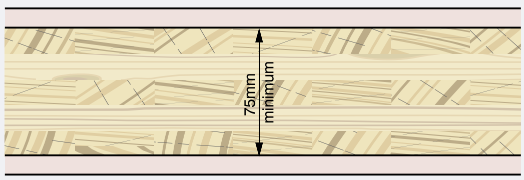
Description	Schematic section
Timber framed smoke-proof wall lined with two layers of 13 mm fire-protective grade plasterboard on each face (Evidence of Suitability to demonstrate the ability of fixings to retain plasterboard in place for ≥45 minutes in a standard fire-resistance test)	
Massive timber smoke-proof wall lined with one layer of 16 mm fire-protective grade plasterboard each side (Evidence of Suitability to demonstrate the ability of fixing to retain plasterboard in place for ≥30 minutes in a standard fire-resistance test)	

Figure 6.4: Typical examples of fire-protected timber smoke-proof walls.

The following requirements apply to the protection of doorways in smoke-proof walls.

A door required by C2.5 or Specification 2.5 of the NCC to be smoke-proof or have an FRL, other than one that serves a fire compartment provided with a zone pressurisation system in accordance with AS 1668.1, must provide a smoke reservoir by not extending within 400 mm of the underside of:

- a roof covering; or
- the floor above; or
- an imperforate false ceiling that will prevent the free passage of smoke.

Doors in smoke-proof walls have to comply with Specification C3.4, which states that smoke doors must be constructed so that smoke will not pass from one side of the doorway to the other and, if they are glazed, there is minimal danger of a person being injured by accidentally walking into them. The clause provides the following Deemed-to-Satisfy construction requirements for smoke doors with one or two leaves:

- The leaves are side-hung to swing:
  - in the direction of egress; or
  - in both directions.
- The leaves are solid-core and at least 35 mm thick, or are capable of resisting smoke at 200°C for 30 minutes.
- The leaves are fitted with smoke seals.
  - The leaves are normally in the closed position; or
  - (A) The leaves are closed automatically with the automatic closing operation initiated by smoke detectors, installed in accordance with the relevant provisions of AS 1670.1, located on each side of the doorway not more than 1.5 m horizontal distance from the doorway; and
    (B) in the event of power failure to the door, the leaves fail-safe in the closed position.
- The leaves return to the fully closed position after each manual opening.
- Any glazing incorporated in the door complies with AS 1288.
- If a glazed panel is capable of being mistaken for an unobstructed exit, the presence of the glass must be identified by an opaque mid-height band, mid-rail, crash-bar or other opaque construction.

6.4 Selection of NCC DTS Compliance Pathways for Mid-rise Class 9c Buildings

Class 9c buildings of 3 or more storeys are required to be of Type A construction. Using this classification, the Fire Resistance Levels, smoke-resistance and fire-protected timber requirements applicable to various elements of construction can be derived.

Before proceeding further, it is important to decide the most appropriate pathway to follow to demonstrate compliance with the NCC DTS requirements. For mid-rise Class 9c buildings, there are two main pathways that can be followed to demonstrate compliance if timber construction is to be adopted:

- Pathway 1 Fire-protected timber option
- Pathway 2 Hybrid timber option

6.4.1 NCC Compliance Pathway 1: Fire-protected timber option (this Guide)

Note: The fire-protected timber requirements must be applied to all timber structural elements, external walls that include structural timber elements and non-loadbearing timber walls that are required by the NCC to provide fire and/or smoke separation functions.

Under Pathway 1, fire-protected timber can be used for external walls and the construction of lift and fire stair shafts, among other things, but other timber elements of construction such as internal fire-resisting walls, floors and smoke-proof walls must also satisfy the fire-protected timber requirements. This provides consistent levels of encapsulation for timber elements intended to be fire or smoke resistant throughout the building.

As a consequence, the levels of encapsulation for timber smoke-proof walls, floors and fire-resisting internal walls may be greater than those under Pathway 2.

6.4.2 NCC Compliance Pathway 2: Hybrid option without fire protected timber

Under Pathway 2, timber construction is permitted to be used for internal walls (excluding lift and fire stair shafts), floors and smoke walls. The required levels of protection for the timber elements are prescribed within the NCC DTS provisions.

Note: There is a NSW variation in the NCC that requires additional protection to some of the timber elements that are permitted to be used under Pathway 2

However, the use of timber construction for external walls, and lift and fire stair shafts, is not permitted under Pathway 2. Non-combustible construction must be used for external wall construction and masonry or concrete construction is required for stair and lift shafts. Hence a hybrid approach needs to be adopted.

Where these constraints are acceptable, the hybrid timber option may be preferred. For more information on this pathway reference should be made to *WoodSolutions Technical Design Guide #42*.

This Guide addresses Pathway 1.

6.5 Requirements for Fire-resistant Elements and Smoke-proof Walls in Class 9c Buildings

A typical section through a mid-rise Class 9c Aged Care Building is shown in Figure 6.5. It comprises a below-ground reinforced concrete carpark above which are timber aged care general and resident use areas.

For the timber part of the building, typically timber frame construction may be adopted because individual rooms have closely spaced walls that in effect form a 'honeycombed' structure with many individual load paths and, as such, the use of lightweight timber-framed systems combined with fire protective coverings is an efficient form of construction. Alternatively, a solid massive timber system, or a mixture of massive and lightweight timber construction may be considered.

Post and beam construction for the main structural frame may be considered, allowing greater design flexibility.

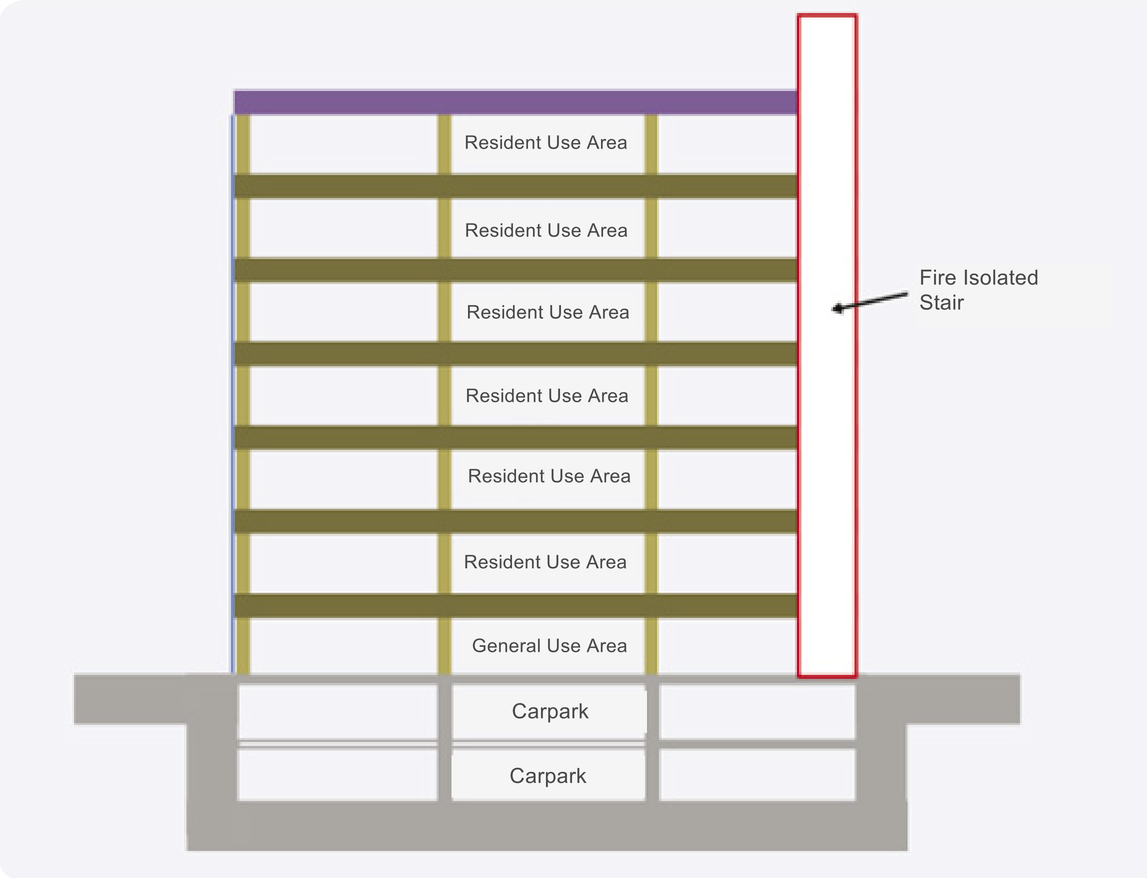


Figure 6.5: Typical Schematic Section through mid-rise Aged Care Building.

A typical floor plan of a residential floor is shown in Figure 6.6.

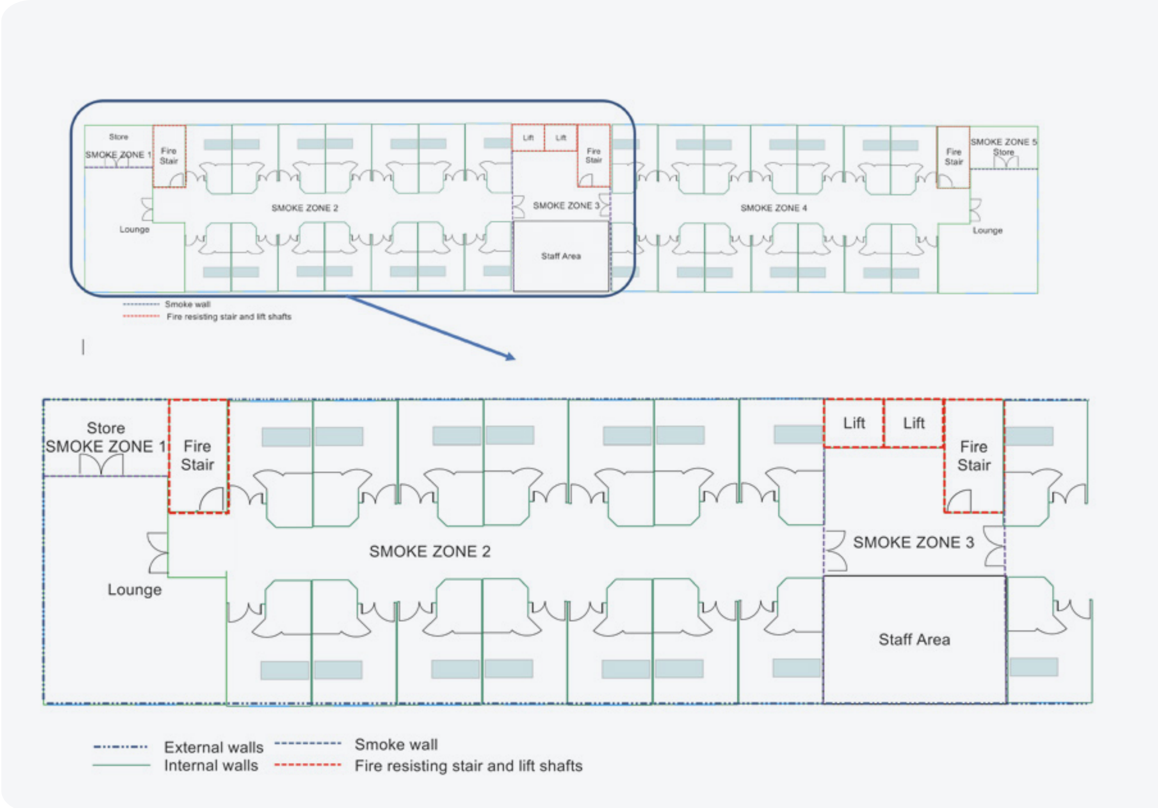


Figure 6.6: Typical Floor of a Class 9c Building.

Note: The requirements for fire-protected timber apply to all elements required to have an FRL or be non-combustible and to smoke-proof walls in addition to the prescribed FRLs and forms of construction.

An overview of the general FRL requirements for a Class 9c building and other classes that may form part of a Class 9c building are summarised in Table 6.2. Refer to the sections following the table for more detailed explanations and details of required smoke compartmentation.

Table 6.2: Overview of FRLs applicable to a Class 9c aged care building.

Description	FRL – Structural Adequacy /Integrity/Insulation (minutes)			
	Class 9c	Class 5, 7a or 9b	Class 6	Class 7b or 8
External wall – maximum[1]	120/120/120	120/120/120	180/180/180	240/240/240
Fire stair shaft	120/120/120	120/120/120	180/120/120	240/120/120
Service Shaft[2]	60/60/– or –/60/–	120/90/90	180/120/120	240/120/120
Internal loadbearing walls	60/–/–	120/–/–	180/–/–	240/–/–
Lift Shaft walls	120/120/120	120/120/120	180/120/120	240/120/120
Common Walls and Fire Walls	60/60/60	120/120/120	180/180/180	240/240/240
Door to fire Stair	–/60/30	–/60/30	–/60/30	–/60/30
Fire Door to service shaft	–/60/30	–/60/30	–/60/30	–/60/30
Lift door	–/60/–	–/60/–	–/60/–	–/60/–
Fire doors to services risers[3]	–/60/30	–/60/30	–/60/30	–/60/30
Floors	60/60/60	120/120/120	180/180/180	240/240/240
Roofs	120/ 60/ 30	120/ 60/ 30	180/ 60/ 30	240/ 90/ 60

Table 6.2 is a derivative of Specification C1.1 Table 3 of the National Construction Code 2019 Amendment 1 provided by ***https://www.abcb.gov.au/*** *Australian Building Codes Board © 2020.*

Note 1 External wall FRLs vary with distance to the fire source feature and whether the element is loadbearing.

Note 2 The NCC is open to interpretation in relation to treatment of service shafts. Check interpretation with the appropriate authority before implementing.

Note 3 Not required if service penetrations are protected between floors.

6.5.1 Fire and Smoke Compartmentation Mid-Rise Class 9c Buildings

Fire separation between floors

Generally, each floor forms a fire compartment. Levels within the Class 9c part of the building are required under NCC Clause C2.5(b) to be fire separated by floors with an FRL of not less than 60/60/60. The slab separating the Class 7a and 9c parts has to comply with NCC Specification C1.1 Table 3 for the lower storey in accordance with NCC Clause 2.9 which requires an FRL of 120/120/120.

Sub-compartments

NCC Clause C2.5(b) requires Class 9c buildings to be subdivided into smoke compartments having a maximum floor area of 500 m^2 and hazardous ancillary areas that contain equipment or materials that are a high potential fire hazard are also required to be separated from the rest of the patient care area by smoke-proof walls. These areas include but are not limited to;

- a kitchen and related food preparation areas with floor area of more than 30 m^2.
- a room containing a hyperbaric facility (pressure chamber).
- a room used for the storage of medical records having a floor area of more than 10 m^2.
- a laundry, where items of equipment are of the type that are potential fire sources.

In the example shown in Figure 6.6, the stores adjacent to the lounge area at the end of each wing contain high levels of combustibles and have a floor area greater than 10 m^2 and have therefore been treated as a hazardous ancillary area. As such, the store will be smoke separated from the remainder of the wing with smoke-proof walls. This requires one smoke wall since the store boundaries include external walls on two sides and a fire stair on the third side, subject to all walls being adequately sealed to prevent smoke spread.

Each of the wings was marginally over 500 m^2 in floor area but by enclosing the store with a smoke wall the area was reduced to less than 500 m^2. It is then practical to integrate the smoke-proof walls with the boundary separating the staff area from the resident wings creating five smoke zones per floor as shown in Figure 6.6 (smoke-proof walls shown as purple dashed lines).

This arrangement is considered a good solution since a lift lobby is created with a large volume facilitating a phased horizontal evacuation in an emergency and the location of the smoke walls ties in with the functional use of the spaces.

Note: When defining smoke compartments, consider the evacuation strategy for the building and potential fire locations to optimise life safety; in addition to consideration of the functional use of the building and access for maintenance and inspection of smoke-proof walls and associated service penetrations.

Shafts

Lift and stair shaft walls are required to achieve an FRL of at least 120/120/120, or –/120/120 if non-loadbearing, and may be constructed from masonry, concrete or fire-protected timber.

There is no specific statement regarding the treatment of walls forming ventilating, pipe, garbage shafts that are not used for the discharge of hot products of combustion however these shafts are grouped under internal walls in Table 3 of Specification C1.1 of the NCC. If the shafts are loadbearing, an FRL of 60/–/– would apply if a literal interpretation is made of Clause C2.5(b)(iii) of the NCC.

Clause C2.5(b)(vi) infers the intent of the NCC by requiring openings in fire walls, other than doorways and windows, to be protected by construction having an FRL not less than –/60/–.

A reasonable interpretation of the intent of C2.5 with respect to internal walls forming ventilating, pipe, garbage and the like shafts not used for the discharge of hot products of combustion would be:

- non-loadbearing service shaft walls require an FRL of at least –/60/–
- loadbearing service shaft walls require an FRL of at least 60/60/–
- service penetrations and other openings in the internal shaft walls are required to be protected by systems that will achieve an FRL not less than FRL of –/60/–
- service shafts should be of non-combustible construction or fire-protected timber construction
- if the option of fire-protected timber shafts is adopted, service penetrations must be protected by systems that will maintain the Resistance to the Incipient Spread of Fire (RISF) or modified resistance to the incipient spread of fire (MRISF) required for fire-protected timber elements.

This interpretation should be confirmed with the appropriate authority prior to documenting the required FRLs for service shafts and treatment of service penetrations.

Note: Where external walls are required to be of non-combustible or fire-protected timber construction, internal and external linings including rainscreens form part of the external wall and must be non-combustible.

Note: For non-sprinkler protected buildings the NCC DTS provisions require vertical separation of openings, but the NCC waives the requirements if automatic fire sprinklers are provided in accordance with Specification E1.5. The removal of requirements for spandrel panels or horizontal projections simplifies construction and provides greater design flexibility.

Note: Even though non-loadbearing external walls do not require an FRL if more than 3 metres from a fire-source feature, if timber external walls are used, the fire-protective coverings must be applied since the external wall would otherwise be required to be non-combustible. This is to address the risk from external fires on balconies or external areas adjacent to the building and the risk of vertical fire spread through openings if a fully developed fire occurs.

6.5.2 Fire Resistance of External Walls of Mid-Rise Class 9c Buildings

In addition to maintaining loadbearing capacity when subjected to fires within a building, the external walls also need to address the risk of fire spread via the building facade under the following scenarios:

- Fire spread from adjacent buildings (or the fire source feature as defined in the NCC) to the subject building. Under the DTS Solution pathway for mid-rise timber buildings this is addressed by means of specification of minimum separation distances, fire-resisting construction, and the requirement for external walls to be non-combustible or of fire-protected timber construction.
- Fire spread from the subject building to the fire source feature as defined in the NCC or adjacent buildings. Under the DTS Solution pathway for mid-rise timber buildings this is addressed by specifying minimum separation distances, fire-resisting construction, and the requirement for external walls to be non-combustible or of fire-protected timber construction and by providing automatic fire sprinklers.
- Fire spread from an external fire source adjacent to the façade other than adjacent fire sources such as balcony fires. Under the DTS Solution pathway for mid-rise timber buildings, this is addressed by specifying fire-resisting construction for loadbearing elements and the requirement for external walls to be non-combustible or of fire-protected timber construction. In addition, sprinkler protection of external balconies is required for some applications
- Vertical fire spread between openings from a fully developed fire within the subject building. Under the DTS Solution pathway for mid-rise timber buildings, this is addressed by the requirement for external walls to be non-combustible or of fire-protected timber construction, and by providing automatic fire sprinklers.

The FRLs required for external walls are nominated in NCC Specification C1.1 and depend on the Class of Building, Type of Construction and proximity to the boundary (fire source feature) or other buildings. The focus of this section is Class 9c buildings of Type A construction and the required fire-resistance levels are summarised in Table 6.3 Other classes have been included since they may apply to other parts of the building (e.g. Figure 6.5 where Class 7a applies to the carpark levels).

Table 6.3: FRLs for external walls of mid-rise Class 5 to 9 buildings of Type A construction.

Distance from fire source feature	Loadbearing (Y/N)	FRL – Structural Adequacy /Integrity/Insulation (minutes)		
		Class 5, 7a or 9a, b and c	Class 6	Class 7b or 8
<1.5 m	Y	120/120/120	180/180/180	240/240/240
	N	–/120/120	–/180/180	–/240/240
≥1.5 and <3 m	Y	120/90/90	180/180/120	240/240/180
	N	–/90/90	–/180/120	–/240/180
≥3 m	Y	120/60/30	180/120/90	240/180/90
	N	–/–/–	–/–/–	–/–/–
External columns	Y	120/–/–	180/–/–	240/–/–

Table 6.3 is a derivative of Specification C1.1 Table 3 of the National Construction Code 2019 Amendment 1 provided by ***https://www.abcb.gov.au/*** *Australian Building Codes Board © 2020.*

6.5.3 Structural Fire Resistance of Mid-Rise Class 9c Buildings

The requirements for structural fire resistance for Class 9c buildings are unusual in that Clause C2.5(b) provides a dispensation for floors and internal loadbearing walls reducing the period the structural adequacy has to be maintained to 60 minutes when subjected to a standard fire-resistance test for floors and internal loadbearing walls but retains the requirement for external loadbearing walls to maintain structural adequacy for a minimum of 120 minutes and for fire stair shafts and lift shafts to achieve FRLs of at least 120/120/120. To achieve this configuration the requirements of Specification C1.1, including the support for another part criteria, are waived for the elements requiring a FRL of 60/–/– and 60/60/60.

Note: The NCC Guide to Volume One indicates that the lower FRL allowed by Clause C2.5(b) (iii) recognises the effectiveness of the required sprinkler systems in Class 9c buildings. If a Performance Solution is being developed that varies some aspects of the DTS Solution, the analysis should have regard for the impact of the dispensation permitting lower Fire Resistance Levels.

6.6 Requirements for Fire-resistant Elements and Smoke-proof Walls in Class 9a Buildings

An indicative schematic section through a mid-rise Class 9a hospital is shown in Figure 6.7. It comprises a below-ground reinforced concrete carpark above which is a ground level of fire-protected timber construction comprising retail outlets and cafes, the emergency department and the main reception. Fire-protected timber construction is continued throughout the upper levels, which provide various functional areas including inpatient wards.

For the timber part of the building, timber frame construction may be preferred where individual rooms have closely spaced walls that in effect form a 'honeycombed' structure with many individual load paths. Alternatively, a solid massive timber system, or a mixture of massive and lightweight timber construction may be considered as well as using post and beam construction to provide larger open areas and greater design flexibility.

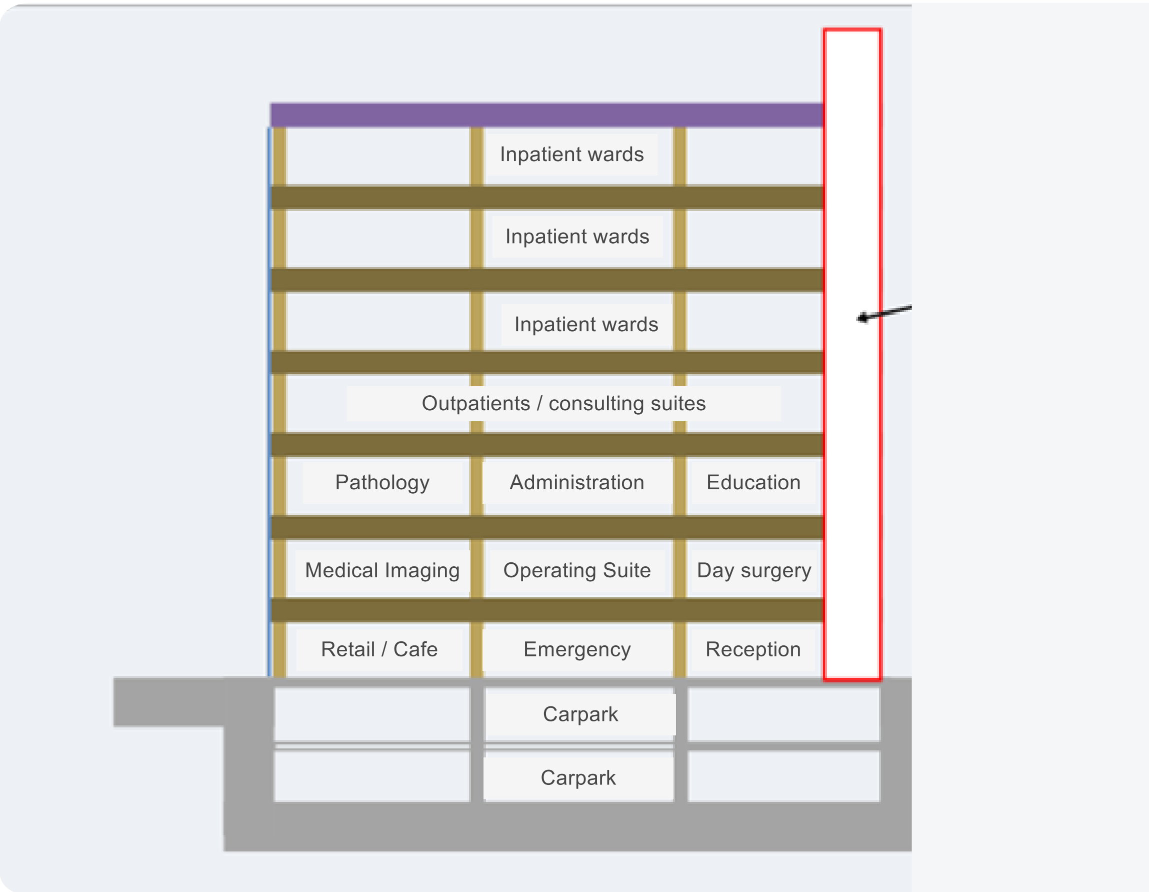


Figure 6.7: Typical Schematic Section through mid-rise hospital building.

A typical plan of a floor with inpatient wards is shown in Figure 6.8 to provide an example of the application of the fire and smoke compartmentation required for hospital buildings.

An overview of the general FRL requirements for a Class 9a building and other classes that may form part of a Class 9a building are summarised in Table 6.4.

Note: Since the required FRLs can vary significantly if the Class that applies to part of a hospital building is changed, it is important to clarify the classifications that the appropriate authority will be applying at an early stage in the project.

Note: The requirements for fire-protected timber apply to all elements required to have an FRL or be non-combustible and to smoke-proof walls in addition to the prescribed FRLs and forms of construction.

Table 6.4: Overview of FRLs applicable to a Class 9a hospital building.

Description	FRL – Structural Adequacy /Integrity/Insulation (minutes)			
	Class 9a	Class 5, 7a or 9b	Class 6	Class 7b or 8
External wall – maximum[1]	120/120/120	120/120/120	180/180/180	240/240/240
Fire stair shaft	120/120/120	120/120/120	180/120/120	240/120/120
Service Shaft[2]	120/90/90	120/90/90	180/120/120	240/120/120
Internal loadbearing walls	120/–/–	120/–/–	180/–/–	240/–/–
Lift Shaft walls	120/120/120	120/120/120	180/120/120	240/120/120
Common Walls and Fire Walls	120/120/120	120/120/120	180/180/180	240/240/240
Door to fire Stair	–/60/30	–/60/30	–/60/30	–/60/30
Fire Door to service shaft	–/60/30	–/60/30	–/60/30	–/60/30
Lift door	–/60/–	–/60/–	–/60/–	–/60/–
Fire doors to services risers[3]	–/60/30	–/60/30	–/60/30	–/60/30
Floors	120/120/120	120/120/120	180/180/180	240/240/240
Roofs	120/ 60/ 30	120/ 60/ 30	180/ 60/ 30	240/ 90/ 60

Table 6.4 is a derivative of Specification C1.1 Table 3 of the National Construction Code 2019 Amendment 1 provided by ***https://www.abcb.gov.au/*** *Australian Building Codes Board © 2020.*

Note 1 External wall FRLs vary with distance to the fire source feature and whether the element is loadbearing.

Note 2 The NCC is open to interpretation in relation to treatment of service shafts. Check interpretation with the appropriate authority before implementing.

Note 3 Not required if service penetrations are protected between floors.

Refer to the following sections for more detailed explanations and for details of smoke compartmentation and relevant sections of this Guide for additional criteria such as the resistance to the incipient spread of fire (RISF) requirements for fire-protected timber construction.

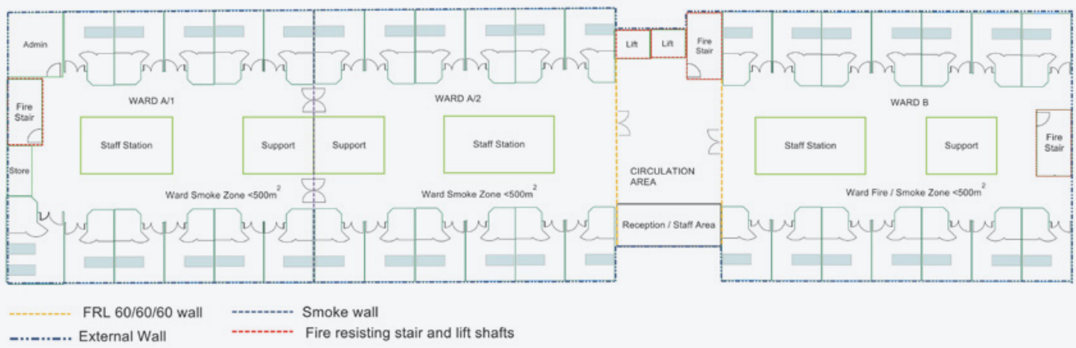


Figure 6.8: Typical ward level of a Class 9a building.

Refer to the following sections for more detailed explanations and for details of smoke compartmentation and relevant sections of this Guide for additional criteria such as the Resistance to the Incipient Spread of Fire (RISF) requirements for fire-protected timber construction.

6.6.1 Fire and Smoke Compartmentation Mid-Rise Class 9a Buildings

Fire separation between floors

Generally, each floor forms a fire compartment and the floor is required to achieve an FRL of 120/120/120 within Class 9a parts. (Refer Table 6.4 for examples of FRLs that apply to parts of a hospital building where more than one class may apply).

If a building has multiple classifications, determining the FRLs can become more complex and it is critical at an early stage that the classifications of the various parts of the building are determined and confirmed by the appropriate authority.

For the example shown in Figure 6.7, if the retail areas are small and considered ancillary to the hospital functions it may be determined that the entire building can be considered as a Class 9a building except for the carpark levels which would be treated as a Class 7a part. The slab separating the Class 7a and 9a parts has to comply with Specification C1.1 Table 3 for the lower storey in accordance with NCC Clause 2.9, which also requires an FRL of 120/120/120.

However, if the retail area is large it may be determined that it should be treated as a separate part of the building and Class 6 would be applied. This would require, among other things, the floor and fire wall separating the Class 9a and Class 6 parts to have an FRL of 180/180/180 and elements supporting the floor above the Class 6 part to have an FRL for structural adequacy of 180 minutes. The structural adequacy applicable to shafts also has to be increased from 120 minutes to 180 minutes.

This example illustrates the impact that the change of classification of part of a building can have on the building as a whole and the need for these matters to be resolved in the early stages of a project.

Compartments and sub-compartments

The maximum floor area of a fire compartment in a Class 9a building must not exceed 5,000 m2 (NCC Clause C2.2) and patient care areas must be divided into fire compartments not exceeding 2,000 m^2 (NCC Clause C2.5).

The example in Figure 6.8 has a patient care area/level less than 2,000 m^2 and therefore subdivision by fire walls in patient care areas is not required if each floor is fire separated from the floor above.

NCC Clause C2.5(a) requires additional fire and smoke compartmentation of Patient Care Areas in Class 9a buildings which are summarised in Table 6.5.

Table 6.5: Additional fire and smoke compartmentation for Class 9a patient care areas.

Part	Smoke Compartment (smoke-proof walls, NCC Spec C2.5)	Fire Compartmentation Max areas	
		Sub Compartment FRL 60/60/60	Fire Compartment FRL 120/120/120
Treatment Area	1,000m^2	–	2,000m^2
Ward Areas	500m^2	1,000m^2	
Hazardous Ancillary Areas within Patient Care Areas[1]	–	Fire separation from remainder of Patient Care Area	

Note 1 Hazardous Ancillary areas that contain equipment or materials that are a high potential fire hazard are therefore required to be separated from the rest of the patient care area by walls having an FRL of not less than 60/60/60 and include but are not limited to,

- a kitchen and related food preparation areas with floor area of more than 30 m^2
- a room containing a hyperbaric facility (pressure chamber)
- a room used for the storage of medical records having a floor area of more than 10 m^2
- a laundry, where items of equipment are of the type that are potential fire sources.

The application of these requirements for additional fire and smoke compartmentation within patient care areas are shown in Figure 6.8.

In this example, the area of the store in Ward A/1 is below 10 m^2 and is not anticipated to represent a hazardous area and therefore does not require fire separation (FRL 60/60/60) from the remainder of the ward. No other potentially hazardous ancillary areas were identified.

Ward A is a double ward with an area greater than 500 m^2 but less than 1,000 m^2. Smoke compartments each with an area less than 500 m^2 need to be provided. In this case the obvious location of the smoke wall is at the interface between the two standard-sized ward areas (A/1 and A/2). In addition, a fire sub-compartment is required to separate Ward A from the general circulation zone. The required FRL is 60/60/60.

Ward B has a floor area less than 500 m^2 and therefore the smoke compartmentation from the remainder of the building also needs to provide fire sub-compartmentation with a required FRL of –/60/60.

Note: Where external walls are required to be of non-combustible or of fire protected timber construction, internal and external linings including rainscreens form part of the external wall and must be non-combustible.

Note: For non-sprinkler protected buildings the NCC DTS provisions require vertical separation of openings, but the NCC waives the requirements if automatic fire sprinklers are provided in accordance with Specification E1.5. The removal of requirements for spandrel panels or horizontal projections simplifies construction and provides greater design flexibility.

Note: Even though non-loadbearing external walls do not require an FRL if more than 3 metres from a fire-source feature, if structural timber external walls are used, the fire-protective coverings must be applied. The external wall would otherwise be required to be non-combustible. This is to address the risk from external fires on balconies or external areas adjacent to the building and the risk of vertical fire spread through openings if a fully developed fire occurs.

The arrangement shown in Figure 6.8 is consistent with a typical progressive horizontal evacuation strategy. If a fire occurs in a ward area the occupants can be evacuated to the next smoke or fire sub-compartment initially and then, if necessary, progressively from the building. The large circulation area facilitates this phased evacuation process by providing adequate space for the patients and staff.

6.6.2 Fire Resistance of External Walls of Mid-Rise Class 9a Buildings

In addition to maintaining loadbearing capacity when subjected to fires within a building, the external walls also need to address the risk of fire spread via the building façade under the following scenarios:

- *Fire spread from adjacent buildings (or the fire source feature as defined in the NCC) to the subject building.* Under the DTS Solution pathway for mid-rise timber buildings this is addressed by means of specification of minimum separation distances, fire-resisting construction, and the requirement for external walls to be non-combustible or of fire-protected timber construction.
- *Fire spread from the subject building to the fire source feature as defined in the NCC or adjacent buildings.* Under the DTS Solution pathway for mid-rise timber buildings this is addressed by specifying minimum separation distances, fire-resisting construction, and the requirement for external walls to be non-combustible or of fire-protected timber construction and by providing automatic fire sprinklers.
- *Fire spread from an external fire source adjacent to the façade other than adjacent fire sources including balcony fires.* Under the DTS Solution pathway for mid-rise timber buildings, this is addressed by specifying fire-resisting construction for loadbearing elements and the requirement for external walls to be non-combustible or of fire-protected timber construction.
- *Vertical fire spread between openings from a fully developed fire within the subject building.* Under the DTS Solution pathway for mid-rise timber buildings, this is addressed by the requirement for external walls to be non-combustible or of fire-protected timber construction and by providing automatic fire sprinklers (or horizontal projections or spandrel panels if sprinkler systems are not provided).

The FRLs required for external walls are nominated in NCC Specification C1.1 and depend on the building use (Class of Building), Type of Construction and proximity to the boundary (fire source feature) or other buildings. The focus of this Section is Class 9a buildings of Type A construction and the required fire-resistance levels are summarised in Table 6.6. Other classes have been include since they apply to other parts of the building, as in the example shown in Figure 6.7 where Class 7a applies to the carpark levels and depending upon the determination of the appropriate authority Class 6 may apply to the retail parts of the ground floor.

Table 6.6: FRLs for external walls of mid-rise Class 5 to 9 buildings of Type A construction.

Distance from fire source feature	Loadbearing (Y/N)	FRL – Structural Adequacy /Integrity/Insulation (minutes)		
		Class 5, 7a or 9a, b and c	Class 6	Class 7b or 8
<1.5 m	Y	120/120/120	180/180/180	240/240/240
	N	–/120/120	–/180/180	–/240/240
≥1.5 and <3 m	Y	120/90/90	180/180/120	240/240/180
	N	–/90/90	–/180/120	–/240/180
≥3 m	Y	120/60/30	180/120/90	240/180/90
	N	–/–/–	–/–/–	–/–/–
External columns	Y	120/–/–	180/–/–	240/–/–

Table 6.6 is a derivative of Specification C1.1 Table 3 of the National Construction Code 2019 Amendment 1 provided by ***https://www.abcb.gov.au/*** *Australian Building Codes Board © 2020.*

6.6.3 Structural Fire Resistance of Mid-Rise Class 9a Buildings

The requirements for structural fire resistance for Class 9a buildings are mainly defined in Specification C1.1 and Clause C2.5(a) and are summarised in Table 6.4 and Table 6.5. However, where multiple classifications can apply to a building the requirements in NCC Specification C1.1 Clause 2.2 relating to support for another part can significantly impact on the required FRLs as demonstrated in the example included in sub-section 6.6.1 'Fire and Smoke Compartmentation Mid-Rise Class 9a Buildings'.

6.7 Cavity Insulation

Combustible cavity insulation can facilitate ignition of cavity fires and the rapid spread of fire through cavities. Therefore, if cavity insulation is provided within fire-protected timber elements, it is required to be non-combustible.

Typical solutions include mineral fibre or glass wool insulation with very low organic binder contents. It is important to check that Evidence of Suitability in the form of a current AS 1530.1 report from a NATA Accredited Testing Laboratory is available for the specific products selected.

6.8 Cavity Barriers

The purpose of this section is to describe where cavity barriers are required and what performance is to be achieved.

Although, the provision of cavity barriers may appear onerous and complex, once the principles are understood, a simple systematic approach can be adopted to identify the required locations and the cavity barriers can be readily incorporated within standard construction.

Practical details in relation to each of the locations where cavity barriers are required are illustrated in Step 5

Cavity barriers are barriers placed in a concealed space, formed within or around the perimeter of fire-protected timber building elements.

They are required to be provided by the following NCC clauses as part of a Deemed-to-Satisfy Solution:

- Clause C1.13
- Clause 3.1d(iii) of Specification C1.1
- Clause 4.1e(iii) of Specification C1.1.

Specification C1.13 prescribes the requirements for cavity barriers that are intended to restrict the spread of fire, smoke and hot gases to other parts of the building through cavities in conjunction with other measures such as the use of non-combustible cavity insulation.

Since the use of fire-protected timber requires the presence of a sprinkler system, cavity barriers are provided as a further measure of limiting fire and smoke spread within the building in the unlikely event of sprinkler failure, ignition of timber framing within the wall or fire ignition within the wall cavity.

The risk of fire spread via cavities and voids in designs that use massive timber can be addressed by prohibiting designs that incorporate cavities and voids. Hence the level of protection to the timber element can be reduced under certain circumstances.

6.8.1 Determining the Positions of Cavity Barriers/Compartment Boundaries

Note: Typical cavity barrier details and interface details are shown in Step 5.

Note: All interfaces between fire-resisting elements or smoke-proof elements, and walls/ceilings not providing a fire- or smoke-separating function, must be detailed to ensure the performance of the fire-resisting or smoke-proof element is not compromised.

Cavity barriers are required at the following positions where fire protected timber is used in any of the listed elements of construction unless massive timber construction has been adopted:

- junctions between fire-resisting floor/ceiling assemblies and fire-resisting walls
- junctions between fire-resisting floor/ceiling assemblies and fire-resisting or non-combustible external walls
- junctions between fire-resisting walls and fire-resisting or non-combustible external walls
- around the perimeter of door and window openings in fire-resisting construction.

Smoke-proof walls should also be provided with cavity barriers with the cavity barrier positions determined as they would be for fire-resisting construction.

Additional cavity barriers shall be provided if the following distances between cavity barriers are exceeded:

- Horizontal cavity barriers – 5 m centres.
- Vertical cavity barriers – 10 m centres.

Typical positions of cavity barriers are shown for representative Class 9a and Class 9c buildings or parts of buildings of timber-frame or Hybrid construction in Figure 6.9 to Figure 6.11.

Figure 6.9 shows a typical schematic section through a mid-rise Class 9a building which incorporates fire-protected massive timber columns supporting a fire-protected timber-frame floor assembly with fire-protected timber-framed construction for fire and smoke compartment walls, shaft walls and external walls.

Class 9a construction was selected for Figure 6.9 to demonstrate the broad range of smoke and sub-fire compartments in ward areas, and fire compartments separating hazardous areas and parts of the building having a classification other than Class 9a. The compartmentation of Class 9c tends to be simpler/more consistent.

Cavity barriers are required at the interface of the floor/ceiling assembly (see Figure 6.9):

- external walls
- shaft walls
- fire compartment walls
- FRL 60/60/60 sub-fire compartment walls
- smoke-proof walls.

In addition, cavity barriers are required around the perimeter of external windows (shown in Figure 6.9) and doors fitted into fire-resisting and smoke-proof walls (omitted from Figure 6.9).

Floor to floor heights are less than 5 m and therefore no supplementary cavity barriers are required to provide horizontal subdivision of vertical walls.

The intersection between the massive columns and fire-resisting floor/ceiling is highlighted to indicate that detailing is required to ensure that the fire resistance of the ceiling or column is not compromised where they intersect. Although not shown in Figure 6.9, careful detailing is also required at the junction of non-fire-resisting walls and the ceiling assembly to ensure the fire-resistance performance of the ceiling is not compromised.

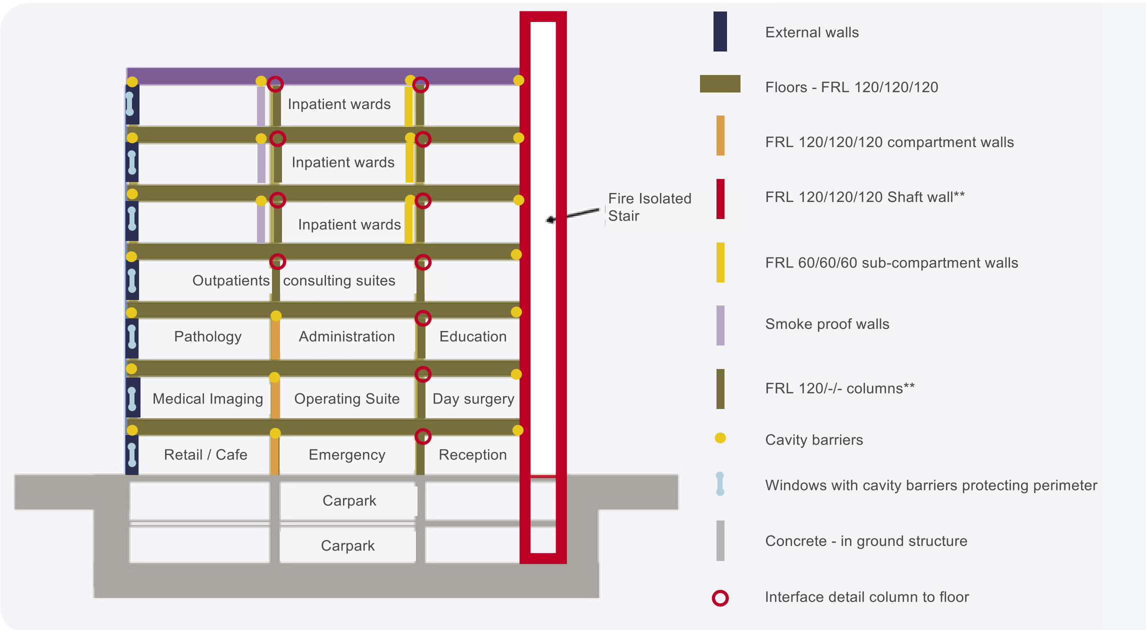


Figure 6.9: Vertical section through a Class 9a hospital building.

Figure 6.10 shows a typical section through a wing of a floor containing ward areas. The ward is divided into smoke compartments less than 500 m² by a smoke-proof wall and separated from the main circulation area by an FRL 60/60/60 wall.

Note: When defining smoke compartmentation, there can be significant advantages if the locations of the smoke-proof walls are consistent with functional areas and evacuation strategies.

A smoke-proof wall separates the two ward areas and a smoke-proof/fire-resisting wall separates the wards from a central circulation area that is large enough to hold the occupants from a whole wing and is therefore consistent with the functional areas and a phased evacuation facilitating an initial horizontal evacuation from the area most at risk.

The stair locations have been selected to avoid dead-end details, maximising the opportunity for occupants to move away from the seat of a fire. The area of the store is small and is not classified as a hazardous area and does not require fire and smoke separation.

Individual room walls are non-loadbearing and are not required to be fire resisting or smoke proof.

It is helpful to adopt the following approach to identify the required positions for cavity barriers.

a) Locate cavity barriers at the following positions:
   - junctions between fire-resisting floor/ceiling assemblies and fire-resisting/smoke-proof walls
   - junctions between fire-resisting floor/ceiling assemblies and fire-resisting or non-combustible external walls
   - junctions between fire-resisting walls and fire-resisting or non-combustible external walls
   - around the perimeter of door and window openings in fire-resisting or smoke-proof construction.

b) Identify junctions between non-fire-resisting and fire-resisting construction that require special treatment.

c) Check horizontal barriers are located within walls at maximum of 5 m centres (typically not required if floor-to-floor height is less than 5 m since cavity barriers are provided at junction between floor and walls).

d) Check vertical cavity barriers are located within walls at maximum of 10 m centres along the walls. If this is not achieved, provide additional cavity barriers. It is often most practical to locate these additional barriers coincident with junctions between fire-resisting and non-fire-resisting construction.

The same principles for determining cavity barrier positions apply to Class 9c residential aged care buildings as shown in Figure 6.11 but with a greater emphasis on smoke-proof construction. Some specific features of the layout include a large store that requires smoke separation from the remainder of the resident area, which conveniently reduces the remainder of the resident area in the wing to less than 500 m^2. Therefore, it is only necessary to smoke separate the resident area from the general staff area and circulation space. The example assumes the structure is predominantly of post and beam construction. If lightweight timber-frame construction is applied, generally the individual room walls will become loadbearing, as shown in the pulled out detail, and additional cavity barriers are required.

For the Class 9c building, the selection of the stair at the end of the wing was not straightforward because the layout dictated that either a dead-end (complying with the DTS provisions of the NCC) was accepted or occupants would have to travel through the lounge room to reach the exit stairs, potentially having to navigate various obstacles. Other details of the compartmentation are similar to the Class 9a example and are consistent with the expected evacuation strategy.

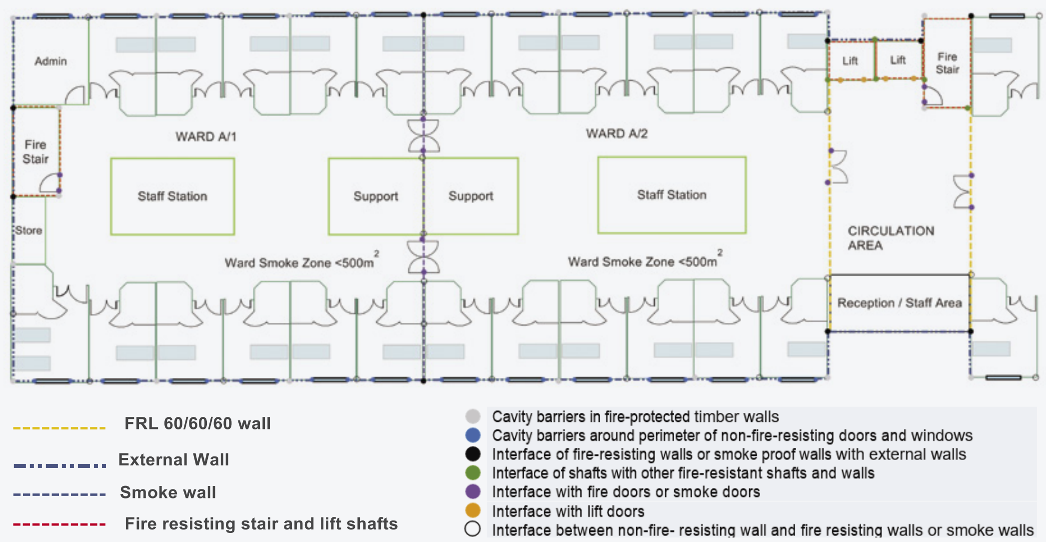


Figure 6.10: Floor plan section of a Ward area of a Class 9a building showing typical cavity barrier locations.

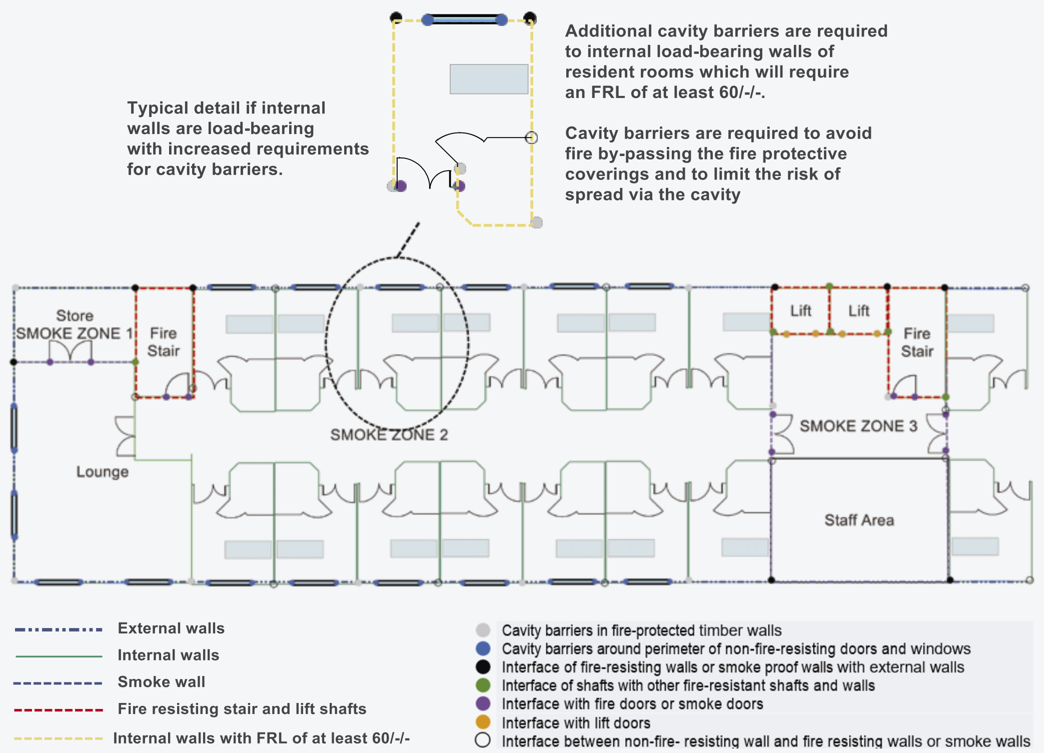


Figure 6.11: Floor plan of residential area of a Class 9c building showing typical cavity barrier locations.

6.8.2 Specifying Cavity Barrier Requirements for Building Elements

Essentially, there are two levels of performance required for cavity barriers prescribed by the NCC.

- Cavity barriers with FRLs of –/45/45 for building elements with FRLs not exceeding 90/90/90
- Cavity barriers with FRLs of –/60/60 for building elements with FRLs greater than 90/90/90.

The FRL –/45/45 criteria should also be applied to smoke-proof walls.

For each case, the NCC prescribes Deemed-to-Satisfy Provisions based on minimum thicknesses of timber or non-combustible mineral fibre in the direction of heat flow as summarised in Table 6.7 as an alternative to evaluating proprietary systems by testing in accordance with AS 1530.4.

Table 6.7: NCC-prescribed Deemed-to-Satisfy Solutions for cavity barriers.

Prescribed solution options	Fire-protected timber FRL	
	–/60/60 or –/90/90	–/120/120, –/180/180, –/240/240
FRL for cavity barrier	–/45/45	–/60/60
Timber required minimum thickness*	45 mm	60 mm
Mineral wool required minimum thickness*	45 mm	60 mm

** Minimum thickness measured in the direction of heat flow – refer Appendix B.*

*Table 6.7 is a derivative of Specification C1.13 Table 1 of the National Construction Code 2019 Amendment 1 provided by **https://www.abcb.gov.au/** Australian Building Codes Board © 2020.*

6.8.3 Interfacing fire-protected timber with external façade systems

In commercial building applications, it is common to use glazed curtain walling systems secured to floor plates particularly where the building is more than 3 m from the allotment boundary since non-loadbearing external elements do not require an FRL. In these applications, any openings (i.e. horizontal gaps, when viewed in plan, between the edge of the fire-resistant floor and the curtain wall) need to be protected to maintain the same FRL as that required for the floor system.

These perimeter seals are sometimes also referred to as cavity barriers; however, the performance levels and Deemed-to-Satisfy Solutions provided in Specification C1.13 for cavity barriers within timber-frame construction should not be used since, among other things, higher FRLs are required at the perimeter of a floor plate.

If a combustible façade is proposed using verification method CV3 as Evidence of Suitability for a performance solution, the cavity barriers forming part of the external façade system are required to be evaluated by one of the full-scale test methods nominated by AS 5113 and alternative cavity barrier systems cannot be substituted.

6.9 Lift Shafts

Some timber building designs adopt a hybrid approach and incorporate concrete or masonry shafts. Where this approach is adopted, it is important that the potential for differential movement between the timber structure and shaft be considered when detailing connections and interfaces. When designing lift shafts, the lift supplier should be involved at an early stage to ensure the shaft will satisfy their design requirements and applicable regulations.

The remainder of this Section addresses the fire safety performance of lift shafts of fire-protected timber construction.

6.9.1 Timber-framed Lift Shaft Construction

Table 6.8 shows the NCC requirements that are applicable to timber-framed lift shafts in mid-rise timber Class 9a and 9c buildings. Other commercial classes of buildings have been included for applications where a hospital building contains parts having different classifications.

Table 6.8: Requirements for fire-protected timber-framed lift shafts. The wall FRL and RISF requirements are applicable from both inside and outside the shaft.

Criteria	Required Performance		
	Class 5, 7a or 9a, b and c	Class 6	Class 7b or 8
FRL for loadbearing lift shaft walls	120/120/120	180/120/120	240/120/120
FRL for non-loadbearing lift shaft walls	–/120/120	–/120/120	–/120/120
RISF for lift shaft walls	45 mins		
FRL Lift landing doors	–/60/–		

To minimise sound transmission to adjoining areas, double stud construction may be employed and/or an independent support structure provided within the shaft.

The fire-resistance of lift landing door assemblies should be determined by fire tests in a representative wall construction type. At the time this Guide was prepared, Evidence of Suitability for lift landing doors directly fixed to timber-framed wall assemblies could not be obtained.

A practical way to address this is to transition the shaft wall construction around the door opening to a form of non-combustible construction having FRLs with which the performance of the lift door has been verified.

An example of transitioning to a steel shaft wall system from a fire-protected timber wall shaft is shown in Figure 6.12 and Figure 6.13 (refer to Step 5 for further details). These interface details have been assessed by an Accredited Testing Laboratory (Regulatory Information Report (RIR) 37401400, available from the WoodSolutions website), which determined that the interface details will not reduce the FRL, RISF or MRISF of the base wall system or the lift landing doors up to the lesser of 120/120/120 or the FRL of the element.

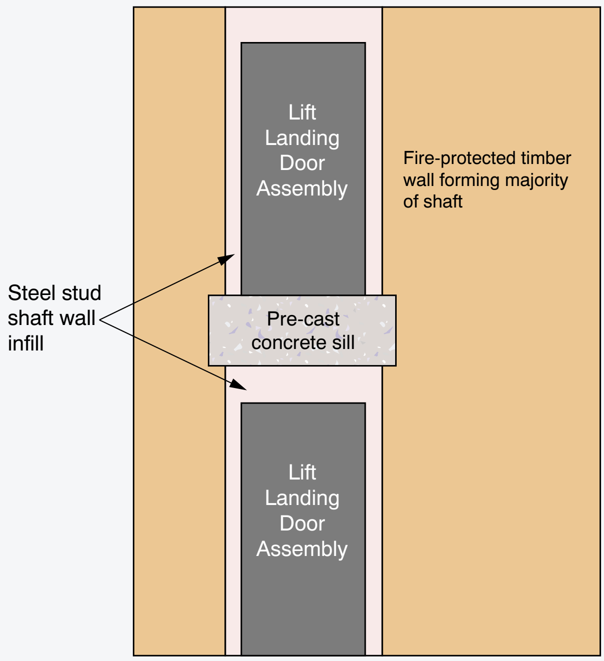


Figure 6.12 (19): Elevation showing wall transition around lift landing doors.

Evidence of Suitability for the specific proprietary lift door, steel stud shaft wall and timber shaft wall, in accordance with Clause A5.2 and A5.4 to A5.6 as appropriate of the NCC, should be submitted to the relevant regulatory authority in addition to RIR 37401400.

Note: RIR 37401400 is available from the WoodSolutions website

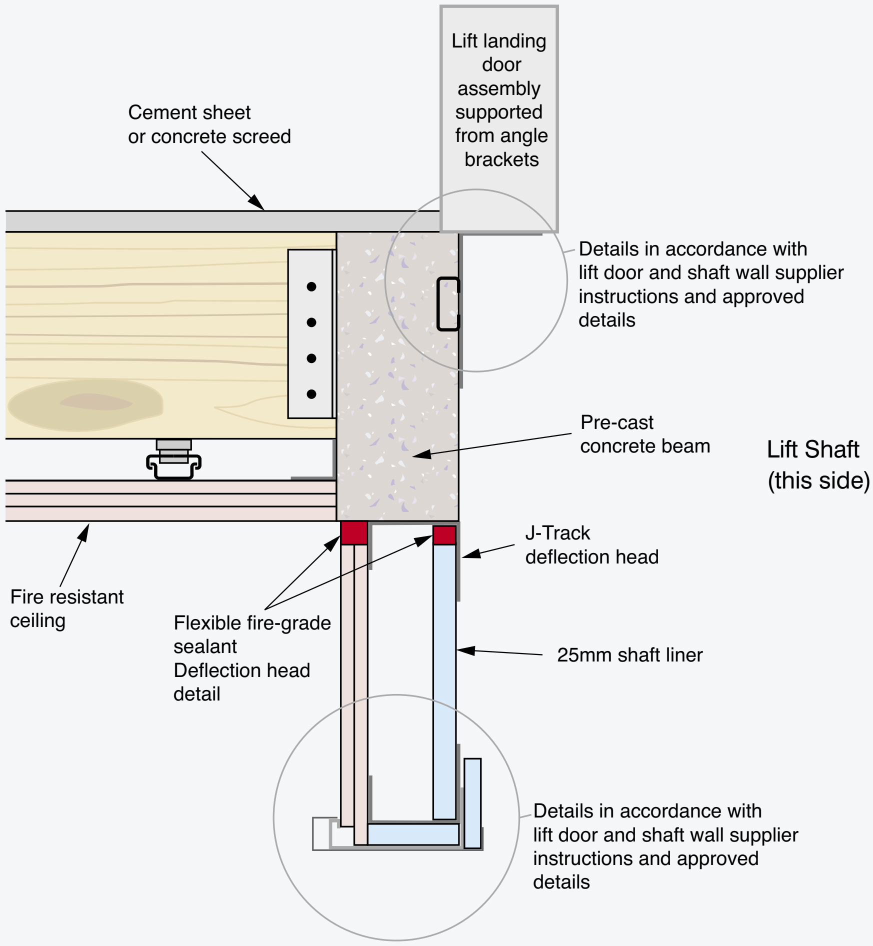


Figure 6.13: Generic detail for sill and head mounting.

6.9.2 Massive Timber Lift Shaft Construction

Table 6.9 shows the NCC requirements that are applicable to massive timber lift shafts in mid-rise Class 9a and 9c buildings. Other commercial classes of buildings have been included for applications where a hospital building contains parts having different classifications.

Table 6.9: Requirements for fire-protected timber lift shafts if using massive timber.

Criteria	Required Performance		
	Class 5, 7a or 9a, b and c	Class 6	Class 7b or 8
FRL for loadbearing lift shaft walls	120/120/120	180/120/120	240/120/120
FRL for non-loadbearing lift shaft walls	–/120/120	–/120/120	–/120/120
RISF for lift shaft walls	30 mins outside face; 20 mins inner face		
FRL Lift landing doors	–/60/–		

If utilising massive timber construction, the MRISFs are reduced from 30 to 20 minutes within the lift shaft. This relaxation reflects the lower probabilities of severe fires occurring within these areas, but a basic level of protection is retained to address the small potential of fires occurring within these areas; where fire may spread to evacuation paths which could be quickly compromised due to rapid fire spread in the early stages of a fire. The outer faces still require an MRISF of 30 minutes. This configuration is shown in Figure 6.14.

To minimise sound transmission to adjoining areas, double skin construction may be employed and/or an independent support structure provided within the shaft for a single skin option. If double skin construction is employed, it should be noted that the NCC does not permit an unfilled cavity between the massive timber skins when using the massive timber provisions. If unfilled double-skin construction is preferred, there is still an option to use the General Requirements (timber-framed construction) rather than the massive timber requirements. The General Requirements require the inner and outer faces to achieve a RISF of 45 minutes. This can be achieved by applying two layers of 13 mm thick fire-protective grade plasterboard to both the inner and outer faces of the shaft.

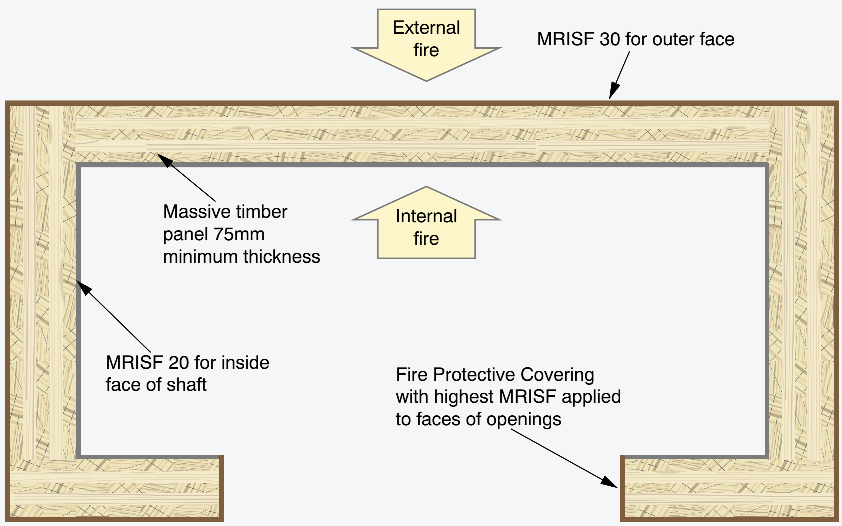


Figure 6.14: MRISF requirements for typical stair and lift shaft construction for single skin massive timber panel construction.

6.10 Fire Isolated Stairs and Passageways

The FRL, RISF or MRISF required for Fire-Isolated Stairs and Passageways are the same as those required for lift shafts described above, without the complication of lift landing doors.

6.10.1 Fire Doors to Fire-isolated Stairs or Passageways

Fire doors to fire-isolated stairs or passageways are required to achieve an FRL of –/60/30. Several proprietary fire door systems have been tested when mounted in timber construction. Installation details for fire doors capable of achieving the required FRLs should be obtained from the supplier as they may vary. Figure 6.15 shows a typical interface detail with a fire-protected timber wall. These interface details have been assessed by an Accredited Testing Laboratory (RIR 37401400) which determined that the interface details will not reduce the FRL, RISF or MRISF of the base wall system or the fire doors up to the lesser of 120/120/120 or the FRL of the element. Evidence of Suitability for the specific proprietary door, and timber shaft wall, in accordance with Specification A5.4 of the NCC, should be submitted to the relevant regulatory authority in addition to RIR 37401400.

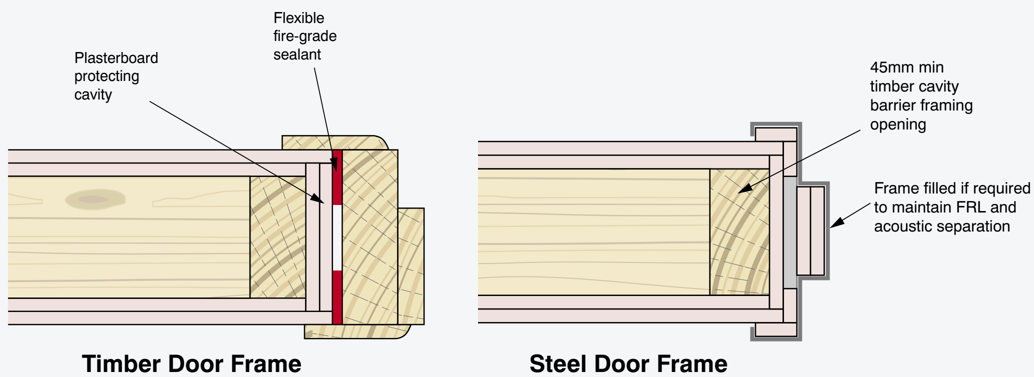


Figure 6.15: Typical fire door installation details.

6.10.2 Timber Stairways Concession

NCC Clause D2.25 provides a concession allowing timber treads, risers, landings and associated supporting framework to be used within a required fire-isolated stairway or fire-isolated passageway constructed from fire-protected timber in accordance with Specification C1.13a subject to:

- timber having a finished thickness of not less than 44 mm
- an average timber density of not less than 800 kg/m^3 at a moisture content of 12%
- the building being protected throughout by a sprinkler system complying with Specification E1.5, other than FPAA101D and FPAA101H systems, that is extended to provide coverage within the fire-isolated enclosure
- the underside of flights of stairs and landings at or near the level of egress or direct access to a car park being protected by a single layer of 13 mm fire-protective grade plasterboard fixed to the stringers with fixings at not greater than 150 mm centres.

Fires starting in fire-isolated stairs are rare. When they do occur, they generally involve stored or introduced materials and often the cause is malicious. Even though it is not permitted to store goods in fire-isolated stairs and passageways, areas under the lowest flight of stairs form a convenient dry area for temporary storage. These areas may also not be secured, further increasing the risk of malicious fire starts.

While it could be argued that the extension of the sprinkler system to fire-isolated stairs and passageways addresses this issue, as an additional precaution, the underside of the lower stairs where combustibles can be stored are required to be protected by a fire-protective covering of 13 mm fire-protective grade plasterboard.

Step 5 provides further details of the requirements for timber stairways.

Careful planning and design of building services and distribution paths, at all stages of the design process, can greatly simplify construction and subsequent maintenance through the life of the building.

6.11 Building Services

6.11.1 Selection of Building Services and Distribution Paths

Building services and associated distribution paths need to be selected and refined during the design process to ensure that installation and maintenance of the services, including reinstatement of the fire and smoke compartmentation and structural fire resistance of elements if affected by the services, can be undertaken safely, causing minimal disruption to the operation of the building and its occupants. Maintaining the availability and efficacy of fire safety systems through the life of the building and managing the risk of fire ignitions and smoke and fire spread associated with services are also critical considerations.

Key principles for consideration with respect to fire safety are:

- Minimise service penetrations through fire-protected timber construction and fire-resisting construction. This can be achieved by measures such as self-contained air-conditioning systems serving each fire compartment (where practicable), and false ceilings and wall facings allowing services to run behind the non-fire-rated facing without penetrating fire-resisting elements.
- If service penetrations through fire-resisting construction cannot be avoided, the services should penetrate shaft or service duct walls rather than fire-resisting walls or floors separating occupied areas as far as practicable. This approach limits the consequences if a penetration protection system fails, as smoke and fire spread will initially be limited to the service ducts.
- Where practical, shafts, service risers and service ducts should be readily accessible to facilitate maintenance and inspection. It may be appropriate in some applications for access hatches/ panels or doors to be secured to prevent unauthorised access and tampering with fire protection systems and the services.
- If service penetrations through fire-protected timber construction cannot be avoided they should be grouped together, where practicable, and pass through a framed-out opening which is then fire-stopped using a proprietary system such as non-combustible batts, board, pillow systems or proprietary multiple transit systems. This approach substantially reduces the risk of fire spread to cavities at a point of weakness and ignition if hot works are being undertaken on the services.
- If service penetrations through fire-protected timber elements cannot be avoided, the fire resistance of the element including the service penetration system should be reinstated such that the resistance to the incipient spread of fire (RISF) or modified resistance to the incipient spread of fire (MRISF), prescribed in Specification C1.13a of the National Construction Code, is maintained.

- Services and connection details should be designed to avoid or minimise the need for hot works.
- For fire services, such as sprinkler systems, the design, installation, and distribution layout should be selected to minimise the time the system will be unavailable during maintenance and/or renovations.
- Precautions should be taken to address the fire hazards associated with the storage and distribution of medical gases. This includes consideration of the increased flammability of combustible materials in oxygen-rich environments in addition to the flammability of the gases.
- Where practical the risk of fire spread across the surfaces of services should be minimised. For example, non-combustible pipe insulation materials should be considered in lieu of more combustible options and limiting the flammability of cable insulation and sheathing can reduce the risk of fire spread.

In some applications these principles may conflict with other project drivers and constraints, but with careful design, suitable solutions can be developed in most cases. For example, the use of CPVC piping for sprinkler systems can reduce hot works but if the pipework needs to be adjusted the system will be unavailable while the glue sets. A better option to avoid hot works and minimise down time may be to use mechanical joiners for metal pipes.

Further details on the application of some of the above principles are provided in the following sections.

6.11.2 Evidence of Suitability for Systems Protecting Service Penetrations

Clause C3.15 of the NCC generally requires that openings for service installations penetrating a building element required to have an FRL, with respect to integrity or insulation or a Resistance to the Incipient Spread of Fire (RISF), be protected such that installation must achieve the required FRL or RISF.

For most applications, Evidence of Suitability with this requirement can be demonstrated by a report from an Accredited Test Laboratory complying with the requirements of AS 4072.1 and AS 1530.4, as appropriate, that indicates the installation has achieved the required FRL or resistance to the incipient spread of fire (RISF/MRISF) in a fire-resistance test; or if it differs from a prototype, the modified installation will achieve the nominated FRL, RISF or MRISF with the nominated variations.

Further explanations of the test procedures are provided in Appendix A.

Typical solutions to address RISF/MRISF criteria include:

- boxing out openings with plasterboard or other non-combustible board achieving the required RISF, MRISF and FRL performance
- filling the area around the service penetration with non-combustible mineral fibre insulation
- transitioning to a different wall type where service penetrations are required.

Some typical examples are provided in Step 5.

6.11.3 Minimising Service Penetrations and Grouping Service Penetrations

Large volumes of building services run throughout Class 9a and 9c buildings for medical purposes and to provide facilities for patients and residents. Class 9a and 9c buildings are generally broken down into fire and smoke compartments in ward areas of Class 9a buildings and resident areas in class 9c buildings. It is prudent to group services together, as far as practical, and use multi-penetration sealing systems to protect locations where they penetrate fire and smoke compartment boundaries. These locations should be located in readily accessible positions with access provided by access panels to facilitate safe and easy access for reinstatement and inspection.

It can be relatively straightforward to apply these principles to electrical and communication systems in Class 9a and 9c buildings where one or more structural cores are used to achieve both lateral load resistance and stability. These cores are commonly used to house lift and stair shafts, service risers and kitchens and toilets which are included in the core or located next to the core. It is then relatively easy to distribute power, lighting communications and install the sprinkler system piping for a whole floor of the building above a false ceiling so that it is not necessary to penetrate the fire protective coverings or fire-resisting elements except for floor to floor penetrations at the building core positions and at fire and smoke compartment boundaries. A schematic of this arrangement is shown in Figure 6.16.

Often patients or residents are provided with their own room with a dedicated ensuite. It can be impractical to fully consolidate services such as drain, waste and vent (DWV) pipes around the central core due to the need for minimal falls on horizontal runs and therefore service shafts may also need to be distributed around the floor within a compartment for these applications. Individual arrangements may also be required for penetrations of the HVAC systems, active smoke control systems and the distribution of medical gases.

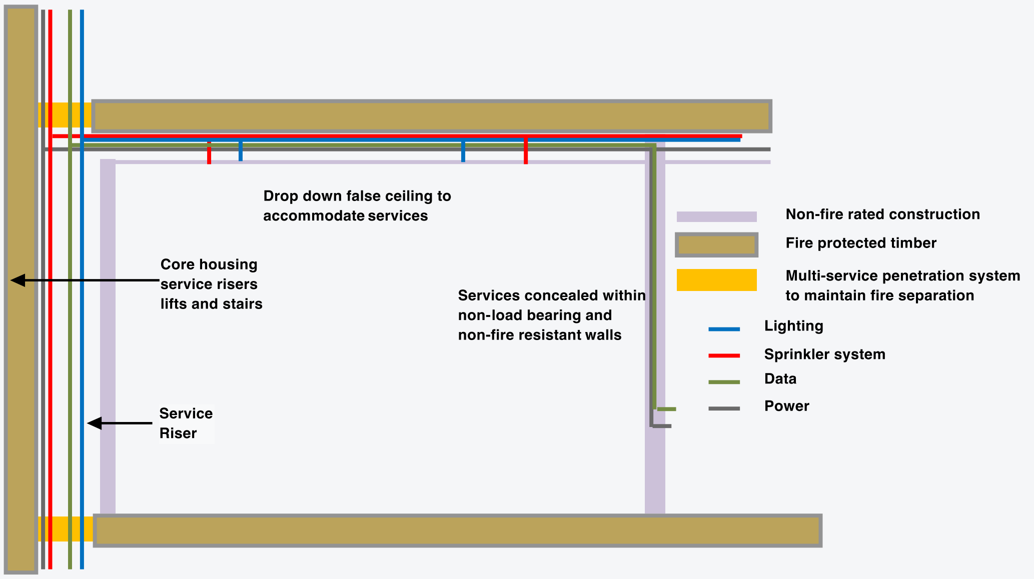


Figure 6.16: Schematic showing distribution of services from a central core.

6.11.4 Service Shaft Construction

The requirements for fire-protected timber service shafts used for ventilation, pipes, garbage or similar purposes are summarised in Table 6.10 for buildings of Type A construction.
Shafts must also be enclosed at the top and the bottom with a floor/ceiling system of the same FRL and RISF ratings as the walls; except where the top of the shaft is extended beyond the roof or the bottom of the shaft is of non-combustible construction laid directly on the ground.

Table 6.10 Requirements for fire-protected service shafts in mid-rise timber buildings

Criteria	**Required Performance**				
	Class 9a	**Class 9c**	**Class 5, 7a or 9b**	**Class 6**	**Class 7b or 8**
FRL for loadbearing service shaft walls	120/90/90	60/–/–[1]	120/90/90	180/120/120	240/120/120
FRL for non-loadbearing service shaft walls	–/90/90	–/60/–[1]	–/90/90	–/120/120	–/120/120
RISF for service shaft walls	45 minutes				
MRISF for service shaft walls (Massive Timber)	30 minutes				

Note 1 The NCC is open to interpretation in relation to treatment of service shafts. Check interpretation with the appropriate authority before implementing.

In many instances, it is more practical to construct non-loadbearing shafts from laminated board systems (i.e. unframed non-combustible board systems achieving the required FRL) or steel frame shaft wall construction in lieu of fire-protected timber construction. For non-loadbearing shaft walls in Class 9a and 9c buildings, the required FRL is reduced to –/90/90 or –/60/–, which can make this form of construction more attractive

Details on how to construct shafts in timber-framed construction and how to interface fire-protected timber walls with laminated board shafts or steel shaft wall construction are given in Step 5 and below.

6.12 Interfacing with Other Forms of Construction

There can be advantages in adopting hybrid forms of construction in buildings. For example, ground floor and basement areas may be constructed from concrete to minimise the risk of water penetration, minimise potential damage in flood-prone areas or address the risk of termites.

The relatively lighter weight of timber structures also makes timber construction ideally suited to the upward extension of existing buildings facilitating infill developments and recycling existing buildings. For example, it may be possible to add wards above existing Class 9a or 9c buildings without having to undertake extensive foundation works.

There can also be advantages in using forms of construction other than timber for elements such as shafts under certain circumstances.

6.12.1 Separation of Different Classes of Buildings

The NCC addresses the separation of classifications within a building in Clauses C2.8 and C2.9.

For different classifications on the same storey, parts having different classifications should be separated by a fire wall having the higher FRL of the two, in accordance with Specification C1.1.

For different classifications in different storeys in a Type A building (most mid-rise buildings), the floor between the adjoining parts must have an FRL not less than that prescribed by Specification C1.1 for the lower storey.

A typical building layout is shown in Figure 6.17 with concrete-framed construction for the carpark below timber healthcare levels. For the fire-protected timber concession to apply, the whole building must be sprinkler protected in accordance with NCC Specification E1.5; excluding FPAA101D and FPAA101H systems.

Retail use is assigned to Class 6 buildings unless considered a minor ancillary area within a Class9a part for example. From Table 3 of Specification C1.1, the floor separating the retail and office levels would require an FRL of 180/180/180 therefore it is important to clarify the classifications throughout the design process.

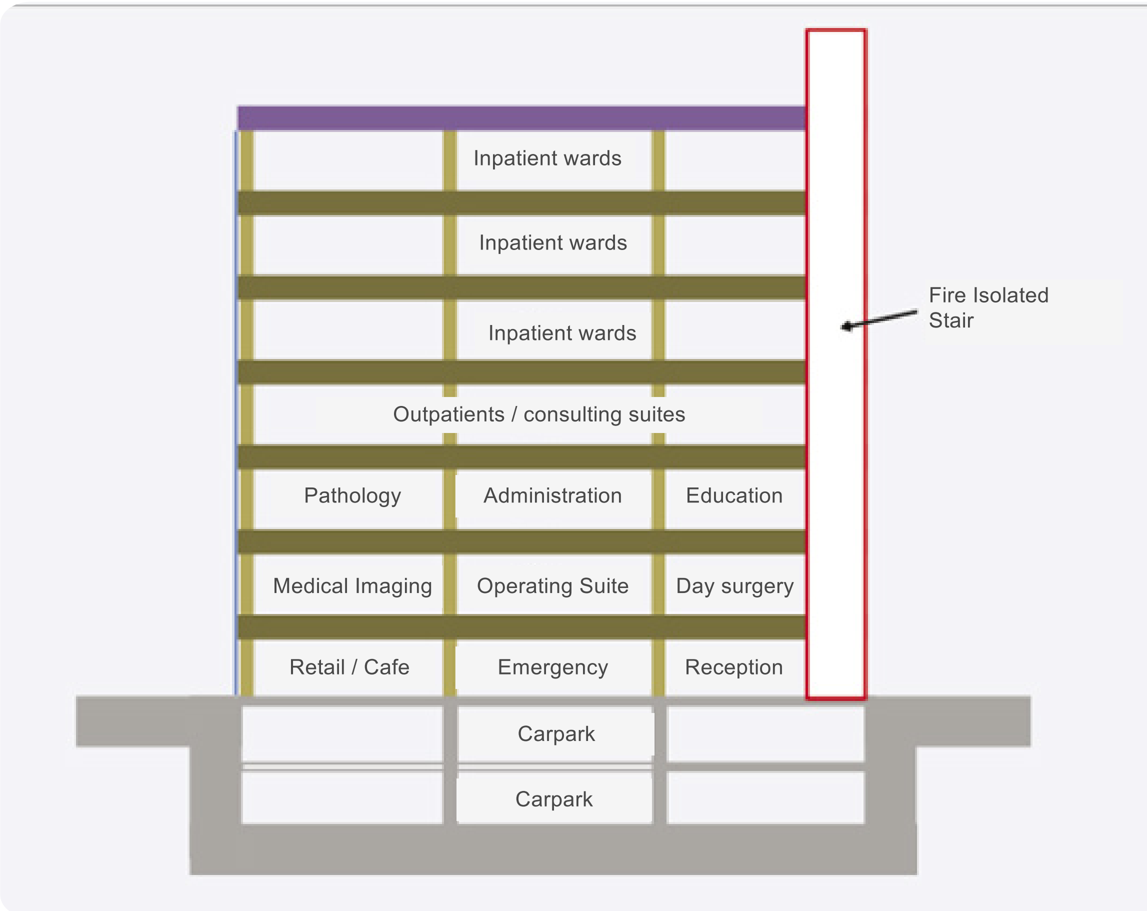


Figure 6.17: Example of multi-class building.

6.12.2 Use of Alternate Forms of Construction for Shafts

In addition to the provision of fire protected timber loadbearing shafts, there are other design options that can be adopted.

For example, concrete or masonry shafts may be adopted for the structural core of a building; particularly for taller mid-rise buildings to provide resistance to lateral loads in which case the core may be used to house lift and stair shafts. There may be the potential for differential settlement to occur between concrete and masonry shafts and the remainder of a timber building and this will need to be addressed in the detailing of the interfaces.

Other options include:

- The use of massive timber framing for the shafts for structural purposes in conjunction with non-loadbearing infill sections (this may be compatible with a post and beam design for the structural frame). The infill sections may be timber-framed or of non-combustible construction.
- The use of a self-supporting lift assembly or internal framing to support the lift and enclosure of the shaft in non-loadbearing timber-frame construction or other forms of non-combustible non-loadbearing shaft construction

In all the above cases the structural design of the building may influence the selection of shaft construction.

6.13 Special Fire Issues

When designing, constructing, commissioning, and using mid-rise timber healthcare buildings, special issues arise, particularly as the buildings become larger and more complicated. Some issues are addressed through technical provisions and regulations other than the technical provisions of the NCC and some matters may only be partially addressed through the NCC (e.g. fire precautions during construction).

Additional fire hazards may be introduced associated with procedures being undertaken and the healthcare services provided, such as the storage and distribution of medical gases.

Although this Guide does not attempt to provide information to suit all circumstances, general information is provided relating to some typical examples that are highlighted in the following sections and are relevant to timber construction. This list is not comprehensive and it is strongly recommended to involve key stakeholders and the design team in a Design Brief process at an early stage of the project to ensure all project drivers and constraints have been identified; to identify essential design criteria before the proposed design is prepared. Refer Figure 1.2 for a flow chart showing a typical process.

6.13.1 Fire Precautions During Construction

Fires may occur on building construction sites due to the nature of the works. Typical causes include:

- hot works (cutting and welding)
- heating equipment
- smoking materials
- other accidental fires
- arson.

Timber construction covered with fire-protective linings is a safe and economical building system. The fire-protective coverings play an important role in providing this fire safety but, due to the construction sequencing, there may be a period where the timber is not protected. This is when timber buildings are at their highest risk from construction fires.

The NCC requires a suitable means of fire-fighting to be installed in a building under construction to allow initial fire attack by construction workers and for the fire brigade as detailed below.

A building under construction that is less than 12 metres in effective height must have one fire extinguisher to suit Class A, B and C fires, as defined in AS 2444, and electrical fires provided at all times on each storey adjacent to each exit, or temporary stairway or exit.

After the building has reached an effective height of 12 metres, the following additional measures are required:

- the required fire hydrants and fire hose reels must be operational in at least every storey that is covered by the roof or the floor structure above, except the two uppermost storeys
- any required booster connections must be installed.

In this instance, 'required' means satisfying the NCC performance requirements as if the building had been completed using either the performance or Deemed-to-Satisfy pathways.

As the scope of the NCC does not fully address Work Health and Safety (WHS) issues, and the NCC prescribes minimum levels of compliance, builders and building owners need to consider what is actually required for the building site. Typical matters that should be considered include:

- progressive installation of fire-fighting services
- progressive installation of fire-protective grade covering of timber members (i.e. installation of fire-protective coverings) and compartmentation of the building
- prefabrication and delivery to site with full or partial encapsulation of timber
- access for fire fighters and egress provisions for staff and visitors on the building site
- selection of materials and work methods that minimise the need for hot works.

WoodSolutions Technical Design Guide #20 Fire Precautions During Construction of Large Buildings provides additional information that can be applied to the design and planning stages as well as the actual construction phase.

Note: The regulatory requirements for health-care buildings to address the bushfire risk vary between the States and Territories and currently the NCC does not provide requirements for Class 9a and Class 9c buildings. It is likely that provisions for Class 9a and 9c buildings may be introduced in future editions and users should check the current status. Notwithstanding the above, if the building is located in a high bushfire risk area, additional mitigation measures should be considered to provide adequate protection of vulnerable occupants.

6.13.2 Bushfire-prone areas

The requirements for healthcare buildings to address the risk of bushfires vary between States and Territories and may fall under different jurisdictions to standard building works. The need to consider bushfire exposures should be determined early in the design processes and addressed accordingly.

The NCC requires external walls to be of non-combustible or fire-protected timber construction in mid-rise buildings. The fire-protected timber provisions require timber elements to be protected by non-combustible fire- protective coverings providing a good basis for the building to resist bushfire attack.

6.13.3 Lightweight Construction Structural requirements – Specific Applications

The NCC requires elements that have Fire Resistance Levels (FRLs), or that form a lift, stair shaft, an external wall bounding a public corridor, non-fire-isolated stairway or ramp, comply with Specification C1.8, if they are made out of lightweight materials such as timber-framing faced with plasterboard.

Specification C1.8 defines a structural test for lightweight construction and, in most parts, is directly related to the performance of the linings used. Appropriate Evidence of Suitability should be obtained from suppliers of lining materials used to verify compliance during the design phase.

6.13.4 Medical Gases

Medical gas storage, distribution and use are required for the day-to-day operation and provision of healthcare services in hospitals and may also be provided within aged care facilities.

The storage, distribution and use presents a significant fire hazard. For example, the use of oxygen can significantly increase the flammability of materials, increasing the risk of ignition and accelerating fire spread. If compressed gas cylinders are exposed to heat, an over pressure condition may occur potentially further increasing the consequences from a fire.

Although specific mitigation measures relating to medical gases are not included in the NCC, work health and safety legislation, among other things, requires that appropriate mitigation measures be taken to address the hazard.

These mitigation measures can include operational controls such as:

- removal/reduction as far as practicable of potential fuel and ignition sources from enclosures where an oxygen-rich environment may form
- avoidance of any form of lubricant/oil coming in to contact with oxygen fittings and hoses
- ensuring gas cylinders are not placed near heat sources

AS 2896-2011 provides guidance on the installation and testing of medical gas pipeline systems.

This includes requirements for the storage of medical gases summarised below:

- A recommendation that the quantity of gas in use and storage should be as low as possible.
- Where oxygen is stored in liquid form, the area around the depot (where liquid oxygen is likely to be spilled) shall be paved with smooth concrete.
- Controlled access should be provided with measures to limit the risk of vehicular impact and the storage areas must be ventilated or in the open air.
- Where storage and manifolds are located outdoors, vertical and lateral separation from other buildings and other fire hazards should be according to the requirements of the local fire authority.
- Where cylinders are stored inside a building and/or manifolds provided within a building, the following measures are prescribed:
  - cylinders and manifolds in a separate area constructed from impervious non-combustible materials with an FRL of 120/120/120.
  - ventilation provided at high or low levels directly to the outside of the building
  - fire doors provided that comply with AS 1905.1 having an FRL of −/60/30
- the stored gases and manifolds must not be located:
  - close to exposed electrical conductors, transformers, or other source of electrical arcing, or
  - close to oil storage tanks
  - in an area where temperatures may exceed 55°C
- the floor should be of concrete construction with a trowelled finish
- appropriate signage should be provided
- appropriate access to facilitate safe delivery and removal of cylinders should be provided.

For mid-rise timber buildings, practical implementation of the above requirements can be achieved by:

- locating the storage and manifolds in a separate location outside the hospital building or
- extending the concrete sub-ground structure to the ground floor level such that the storage/manifold enclosure can be constructed from masonry and/or concrete.

Pipelines for distribution of medical gases should as far as practicable be separated from ignition sources and combustible materials. To achieve this in a fire-protected timber building, medical gas distribution pipes should:

- Not be run through cavities within fire-protected timber construction. (Note: in addition to direct fire safety issues, some timber fire-retardant treatments may accelerate pipe corrosion if the pipework is in contact with the fire-retardant treated timber).
- As far as practical, be run within dedicated shafts or ducts constructed from impervious non-combustible materials with adequate ventilation but pipe entries and other penetrations should be sealed to prevent gas escape by routes other than the vents or openings into the user space. The FRLs for the shafts should as a minimum be in accordance with the NCC requirements for service shafts.
- Have an allowance for free expansion of the pipes.

Where pipes pass through walls, partitions or floors, they should be provided with sleeves of copper pipe that will be required to be protected where the pipes penetrate fire-resisting or smoke-proof elements. The fire protection system of the penetration should be non-combustible and any openings through fire protected elements must be framed out to further reduce the risk of fire spread or leakage of gases into the fire-protected timber element.

Pipe jointing, when undertaken in an occupied facility, can represent a significant fire hazard because of the risk of increased flammability due to excess oxygen in the area where hot works may be undertaken, the risk of contamination with oils and similar materials that may readily ignite within an oxygen rich atmosphere and high temperatures required for brazing. A risk assessment should be undertaken, and appropriate measures implemented to address these hazards which may include purging pipelines with inert gases.

The framing out of openings in fire-protected timber and use of non-combustible fire protection systems for medical gas service penetrations will reduce the risk of ignition and spread through cavities in fire protected timber construction.

6.13.5 Robust Structural Design

The NCC, under Part B1 Structural Provisions (BV2), provides a verification method for structural robustness as a means of verifying compliance with performance requirement BP1.1(a)(iii). The Verification Method states:

Compliance with BP1.1(a)(iii) is verified for structural robustness by:

(a) assessment of the structure such that upon the notional removal in isolation of -

- (i) any supporting column; or
- (ii) any beam supporting one or more columns; or
- (iii) any segment of a loadbearing wall of length equal to the height of the wall, the building remains stable and the resulting collapse does not extend further than the immediately adjacent storeys; and

(b) demonstrating that if a supporting structural component is relied upon to carry more than 25% of the total structure a systematic risk assessment of the building is undertaken and critical high-risk components are identified and designed to cope with the identified hazard or protective measures chosen to minimise the risk.

The structural design of mid-rise timber buildings must comply with these requirements and the design guidance provided in *WoodSolutions Design Guide #39 Robustness in Structures* to ensure the building is adequately robust in the event of localised failure of elements during a fire.

7

Step 5 Integrate Architectural, Structural and Building Service Designs (Detailed Design)

This step brings together the previous Steps 1 to 4 to develop an integrated design. A hospital with basement carparking and retail at ground level is used to demonstrate the process, including interfacing a fire-protected timber building with other forms of construction and parts of a building with a different Class.

A key focus of this Step is coordinating the various design disciplines so that:

- Timber elements and protection systems are optimised to satisfy the NCC requirements in a practical and cost-effective manner by focusing on the synergies between elements designed to satisfy the following criteria:
  - fire-protected timber
  - sound transmission and insulation
  - thermal resistance
  - weatherproofing
  - structural tests for lightweight construction.
- Interfaces between building services and the structure, fire-protected timber elements and acoustic barriers are designed:
  - to minimise building service penetrations through fire-protected timber elements and acoustic barriers as far as practical
  - such that where services have to penetrate fire-protected timber elements the fire safety performance of the element is not compromised, and fire separation is maintained
  - so that if services have to penetrate acoustic barriers the positions are selected to minimise negative impacts on amenity
  - so that service penetration systems can accommodate any differential movement between elements
  - to allow for maintenance and additions/modifications to the building services.
- Structural design is efficient and robust.
- Other fire safety principles for mid-rise buildings are satisfactorily implemented including:
  - cavity barriers
  - automatic fire sprinkler systems.
- Other design requirements are addressed such as termite management and resistance to ground water/moisture penetration.

7.1 Optimising the Performance of Elements of Construction

Elements of construction in a modern building may have to serve a number of functions including:

- restricting fire spread
- limiting sound transmission from adjacent enclosures (and in some instances external noise)
- limiting heat loss and/or heat gain through external elements
- weather resistance of external facades and roofs
- impact resistance to reduce the risk of damage to lightweight construction.

The elements also need to achieve levels of durability appropriate for the application. Further advice on durability is provided in: *WoodSolutions Timber Design Guide #5 Timber service life design – Design guide for durability.*

Efficient designs can be achieved by selecting combinations of materials and configurations that work together to satisfy the design objectives summarised in the following Sections.

Typical examples include:

- Cavity barriers required by the NCC Deemed-to-Satisfy for mid-rise timber buildings to reduce the risk of fire spread through concealed spaces can also be used to minimise flanking noise transmission around the perimeters of elements of construction and reduce heat loss via leakage through the structure.
- Non-combustible cavity insulation will:
  - reduce the risk of fire spread through cavities
  - reduce sound transmission through elements of construction
  - reduce heat loss and/or gain through external walls.

7.1.1 Fire-protected Timber

Fire-protected timber has timber structural members with non-combustible fire-protective coverings. The fire-protective coverings:

- prevent or delay the ignition of the timber members so that the response to an enclosure fire will be similar to non-combustible elements such as masonry or concrete during the growth period and prior to fire brigade intervention
- ensure the fire-protected timber element achieves the Fire Resistance Level (FRL) prescribed for the particular element.

Any insulating materials provided within cavities must be non-combustible to reduce the risk of fire spread through cavities and voids.

The NCC contains some Deemed-to-Satisfy (DTS) Solutions for fire-protective grade plasterboard coverings but there are many opportunities for the use of optimised proprietary systems. For example, combinations of high-performance non-combustible fire-resisting claddings and mineral fibre insulation could provide lighter-weight, more cost-effective options.

The NCC DTS Solutions recognise that massive timber panels have a relatively high inherent fire resistance and, if there are no concealed cavities or voids, the risk of fire spread through concealed spaces will be substantially reduced or removed. Therefore, provided the minimum dimensions prescribed for massive timber panels are satisfied and there are no internal cavities and voids, the NCC allows some relaxations to the requirements for fire-protective coverings (see Section 6.3.2).

Note: The use of timber cladding and other combustible fire protection systems such as intumescent paints in lieu of non-combustible fire-protective coverings is not permitted under the NCC DTS Solutions for mid-rise timber buildings due to the potential increase in risk of fire spread to the structural element as the combustible materials are consumed.

7.1.2 Cavity Barriers

The primary objective of cavity barriers is to prevent uncontrolled spread of fire through cavities in the low probability the protective covering fails, or fire starts within the cavity.

The NCC provides DTS Solutions using solid timber or mineral fibre but also specifies FRLs for cavity barriers encouraging the development of proprietary systems optimised for specific applications.

Careful detailing can provide opportunities for efficient design. Typical examples include:

- in a single leaf, timber-framed stud wall, the top and bottom plates can be dimensioned such that they can act as cavity barriers
- if a cavity is filled with non-combustible mineral fibre insulation to achieve a nominated R-value or enhanced acoustic separation, the mineral fibre may also satisfy the requirements for a cavity barrier.

7.1.3 Sound Transmission and Insulation

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

- ***Increasing mass (e.g. increasing the thickness of wall linings).*** This can be particularly useful in reducing airborne sound transmission. For instance, like fire-grade linings, the greater the number of layers, the greater 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 (discontinuous construction) and can reduce 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 and should generally only be used at changes in floor level (Figure 26).
- ***Using absorptive materials to fill 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.

There are also simple techniques that can be incorporated into the building design that can dramatically improve the sound performance of timber wall and floor/ceiling systems. The following systems provide examples that can be used to enhance sound performance of walls and floors.

Note: Timber wall and floor/ceiling systems shown in this Guide are typically of generic systems. Actual systems must comply with the required fire and sound provisions in the NCC for the class of building being considered.

Wall Systems

Battened-out 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 achieving this is to batten out the wall (after fire/sound resisting linings have been applied) and then provide an additional lining over the top (Figure 7.1). 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 wall cavity. This arrangement also substantially reduces the risk of compartmentation being compromised during refurbishment activities. For example, if the additional lining boards are removed or replaced, the fire-protective covering can be left in place, maintaining the required fire separation.

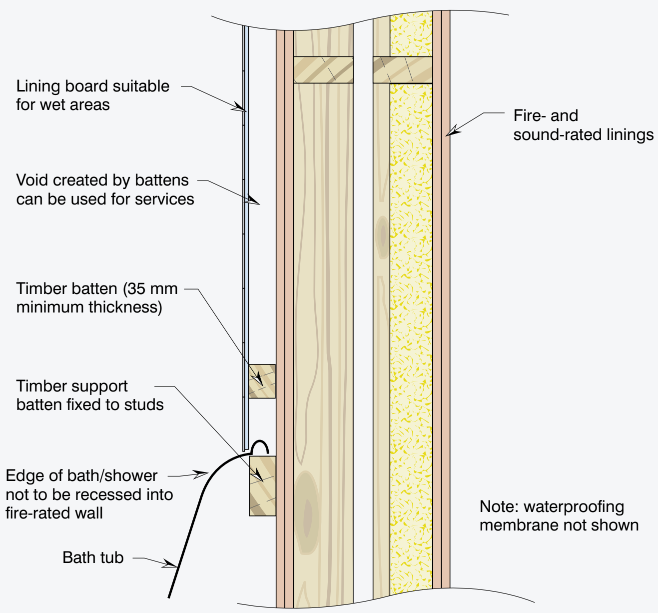


Figure 7.1: Batten detail of wet area walls – elevation view.

Floor Systems

Floor joists parallel to sound rated wall. By running floor joists parallel rather than perpendicular to the sound rated wall, the ability of impact sound from the floor being transferred across the wall to the adjoining SOU is lessened (Figure 7.2).

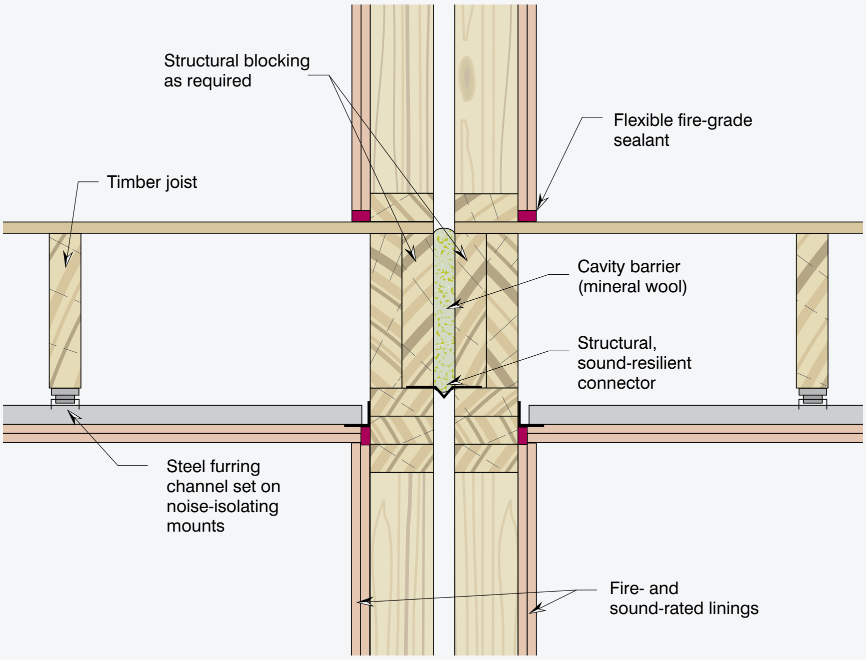


Figure 7.2: Joists running parallel to bounding wall – elevation view.

Upgrade sound-resilient ceiling mounts.

Ceiling mounts are commonly used to reduce the transmission of noise from the floor to the ceiling below. They help reduce sound transfer between the bottom of the floor joist and the ceiling lining. To improve performance, some ceiling mounts now provide an isolating and damping effect (Figure 7.3). 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. Sound-resilient mounts are not all the same and different systems have different performance.

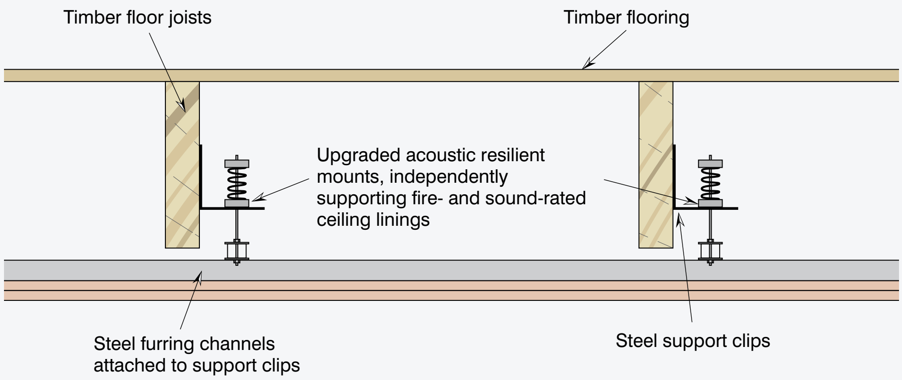


Figure 7.3: Upgraded sound-resilient ceiling mounts – vertical section.

Increase 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 – sand, concrete topping or additional floor sheets.

Quantifying the improvement is difficult as the acoustic performance aims to improve the low frequency performance of the floor, a phenomenon not measured by tested systems. Unless evidence of suitability is available it is suggested that the base floor system be designed to comply with the NCC's sound requirements, and the additional floor mass provides enhanced performance.

Note: When height is added to a floor, consideration of the effect this has in other areas (such as wet areas, corridors, stairs, doors and windows) is needed at the planning stage.

Sand: This increases the mass of the upper layer of the floor element. The air spaces between the sand particles help reduce the vibration and energy created by impact sound from footfalls. Typically, this is achieved by placing 45 mm thick (high) timber battens directly over a normal acoustic floor system at typical 450 or 600 mm centres (dependent on floor sheet spanning capacity). A dry sand layer is placed between the battens and levelled just below the surface of the final floor sheet. The final floor sheet is fixed in the normal manner, and desired floor covering placed on this (Figure 7.4).

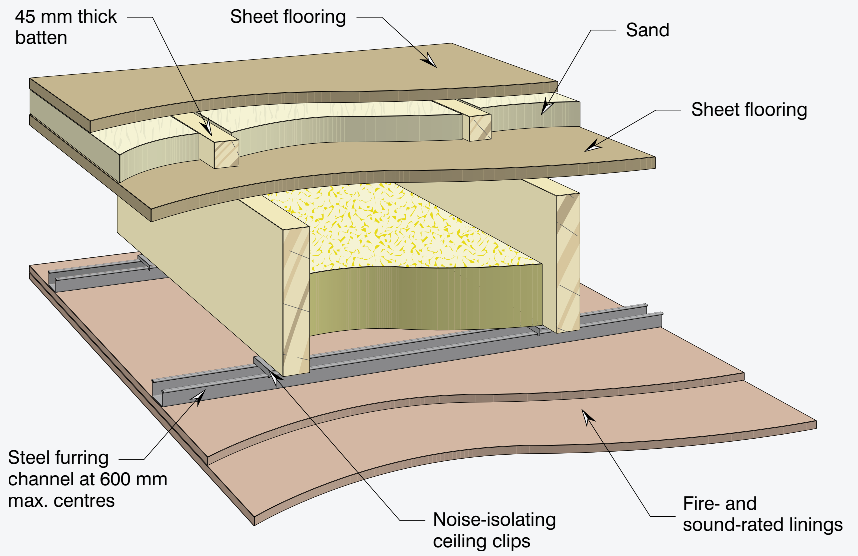


Figure 7.4: Adding mass to floor system – sand.

Concrete topping: This increases the sound performance of the floor system, and typically can be achieved with a 35 to 45 mm thick layer of concrete placed over an isolating acoustic mat. Care is required to turn the isolating acoustic mat up at the perimeter of the topping adjacent to the wall, otherwise the effect of the topping is negated (Figure 7.5).

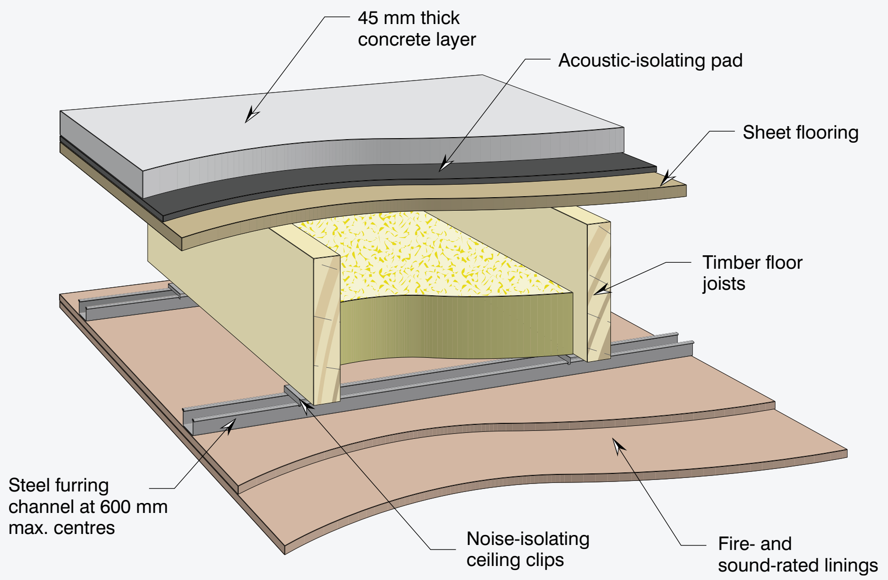


Figure 7.5: Adding mass to floor system – concrete topping.

Extra sheet flooring: This method utilises standard sheet flooring on an isolating mat. This system does not perform as well as the higher mass products, sand or concrete (Figure 7.6).

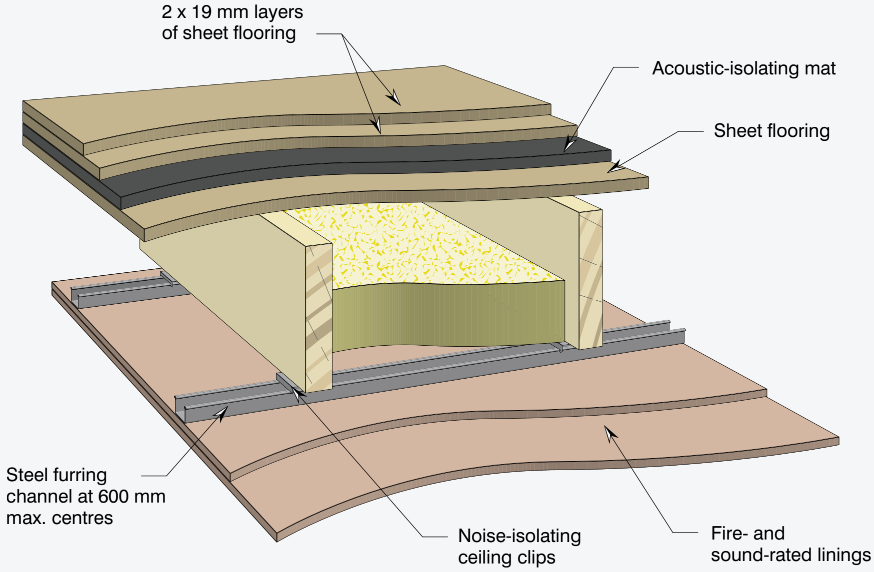


Figure 7.6: Adding mass to floor system – additional floor sheets.

Separate floor and ceiling frame.

By having two sets of joists (separate floor and ceiling joists) that 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. 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 onto strips of acoustic isolating mat (Figure 7.7).

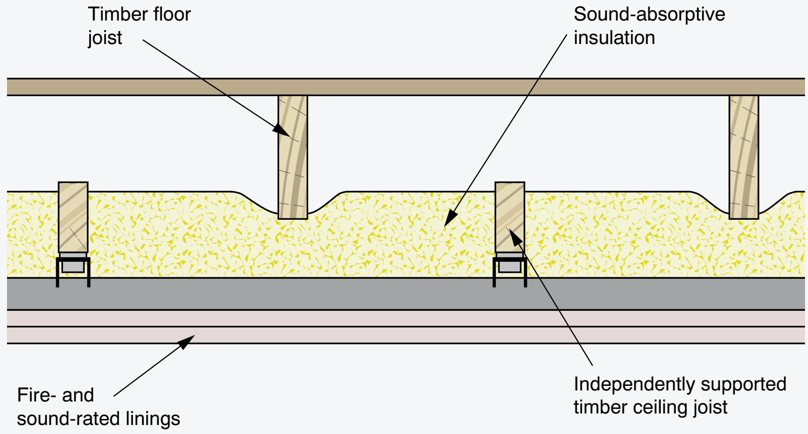


Figure 7.7: Separate ceiling and joist construction.

7.2 Establish Architectural Layout

The basic architectural layout of a building is determined by considering many drivers and constraints, the relative importance of which will vary from project to project. Typically, these include:

- the project brief
- site conditions
- sustainable construction
- aesthetics
- economics
- planning, building and other regulations.

The design should then be refined with input from the various disciplines involved in the design team in consultation with other stakeholders.

This process is demonstrated for a mid-rise hospital building with basement car parking and ground level retail as shown in Figure 7.8.

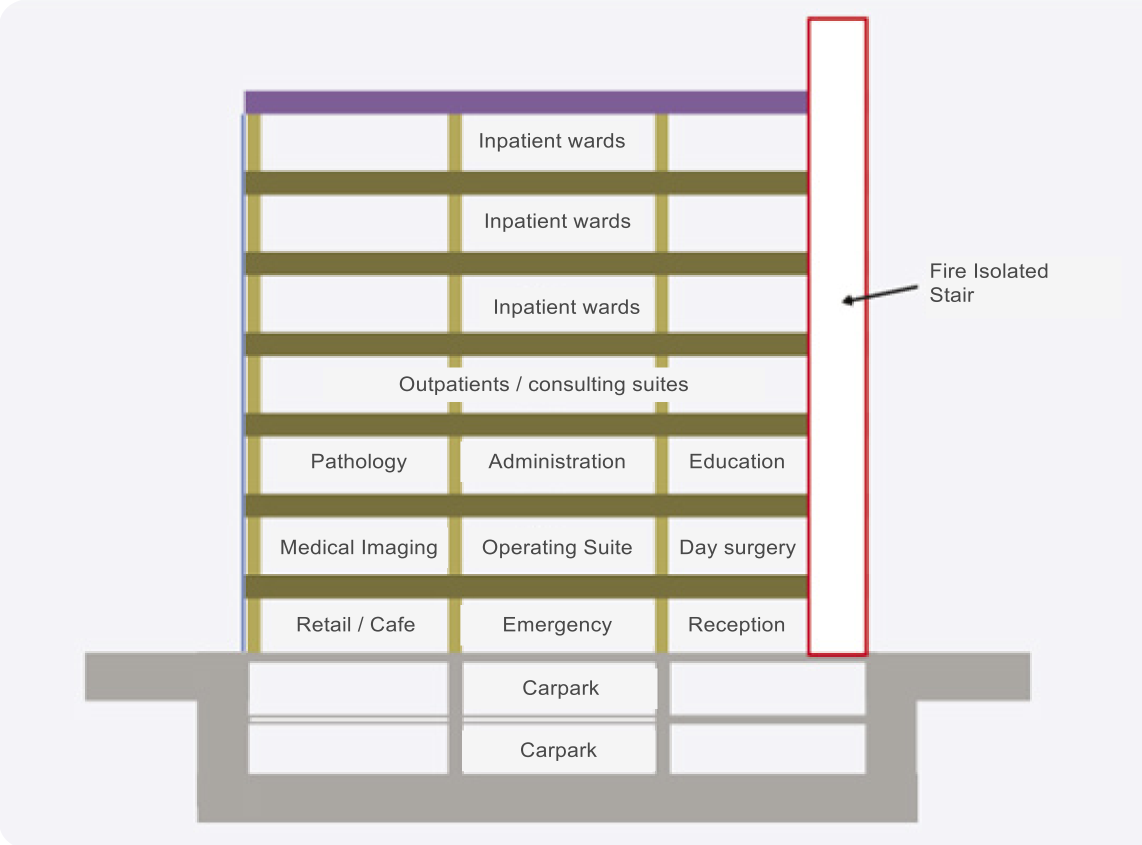


Figure 7.8: Typical Schematic Section through mid-rise hospital building.

A typical ward level plan is shown in Figure 7.9.

7.2.1 Optimising Building Layout – Provisions for Escape

As part of the strategy for evacuation of occupants during a fire emergency, the NCC prescribes DTS provisions for escape in Part D1.

The following is a brief overview of the DTS requirements that are relevant to the optimisation of the building layout of a ward-level in a Class 9a hospital building. Similar principles apply to resident levels in Class 9c Residential Care Buildings. Refer to part D of the NCC for further details.

While some mid-rise buildings (effective height less than 25 m) with a small footprint are permitted to provide one exit under the DTS provisions, Clauses D1.2(d) and D1.2(e) (summarised below) apply to Class 9a and Class 9c buildings which generally require at least two exits from each floor and in many cases more than two exits are required.

D1.2 Number of exits required

(d) Class 9 buildings — In addition to any horizontal exit, not less than 2 exits must be provided from the following:

(i) Each storey if the building has a rise in storeys of more than 6 or an effective height of more than 25 m.

(ii) Any storey which includes a patient care area in a Class 9a healthcare building.

(iii) Any storey that contains sleeping areas in a Class 9c building.

(iv) Each storey in a Class 9b building used as an early childhood centre.

(v) Each storey in a primary or secondary school with a rise in storeys of 2 or more.

(vi) Any storey or mezzanine that accommodates more than 50 persons, calculated under D1.13.

(f) Exits from Class 9c buildings and patient care areas in Class 9a healthcare buildings — In a Class 9a healthcare building and a Class 9c building, at least one exit must be provided from every part of a storey which has been divided into fire compartments in accordance with C2.2 or C2.5.

Clause D1.4 also applies limits to the distance to a point on the floor where travel in different directions to two exits is available and on the maximum distance to one of the exits, which in some circumstances may require additional exits to be provided..

For Class 9c buildings (similar to commercial buildings), the NCC DTS provisions require no point on a floor to be more than 20 m from an exit or a point of travel in different directions, in which case the maximum distance to one of those exits must not exceed 40 m.

For Class 9a patient care areas (including wards) the following additional criteria apply:

- no point on the floor must be more than 12 m from a point from which travel in different directions to two of the required exits is available; and
- the maximum distance to one of those exits must not be more than 30 m from the starting point.

Clause D1.5 applies the following additional criteria to the distances between alternative exits:

- the exits are distributed as uniformly as practicable in positions where unobstructed access to at least two exits is available from all points of the floor including lift lobby areas
- the exits are not less than 9 m apart and not more than 45 m in patient care areas in healthcare buildings (in other areas this is increased to the default value of 60 m)
- paths of travel to exits do not converge within 6 m of each other.

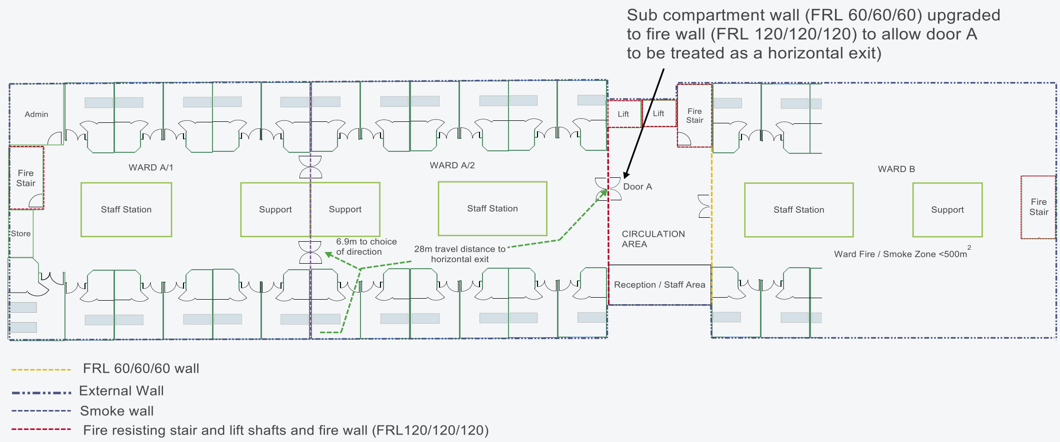


Figure 7.9: Typical ward level of a Class 9a Building.

The fire and smoke compartmentation requirements for Class 9a and 9c buildings are more extensive than most classes of building to facilitate progressive horizontal evacuation where practicable; particularly from ward, patient care and resident areas in Class 9c buildings. This may allow patients and residents close to a fire who require high levels of assistance to be quickly moved to an adjacent fire or smoke compartment to await further assistance. A fire and smoke compartmentation arrangement compliant with the NCC is shown in Figure 7.9.

One fire-isolated exit is to be incorporated into the structural cores adjacent to the lifts with additional stairs at the end of each wing addressing the need for exits to be distributed around the floor.

It is then necessary to check travel distances to exits. The critical ward enclosure was identified in Figure 7.9 and the nearest fire stair door (exit) was found to be more than 30 m away. An additional stair would be costly and a much more effective solution using a DTS Solution is to increase the FRL of the ward wall from 60/60/60 to 120/120/120 so that Door A can be treated as a horizontal exit, reducing the distance to the nearest exit to approximately 28 m (i.e. less than the maximum of 30 m that is permitted).

This highlights the need to consider compartmentation, structural design and egress provisions in combination to identify practical solutions that are compatible with the evacuation strategy for the building.

7.3 Select Structural Form

There are several structural forms that can be adopted to suit the preferred architectural layouts, including various timber forms, other materials and hybrid systems.

Where more open forms of construction are preferred, or the option to change internal layouts is needed, post and beam type construction may be preferred over lightweight framed construction.

In some cases, a mix of structural forms may be the most practical solution. For example, post and beam timber construction may be selected as the primary structural elements with lightweight timber-frame construction being used for pre-fabricated floor cassettes and lightweight timber framing for wall systems carrying lower loads or non-loadbearing wall systems.

While subsequent sections consider both options, the proprietary nature of massive timber panels, columns and beams manufactured from engineered products such as Laminated Veneer Lumber (LVL) and Cross-Laminated Timber (CLT) limits the number of generic details that can be included in this Guide.

For this example, timber is the preferred structural material for all levels above the carpark. It may have been selected for many reasons, including:

- lightweight construction (useful if ground conditions are difficult)
- speed of construction
- sustainable construction
- prefabrication of elements.

The primary reasons for selecting reinforced concrete construction for the basement were to address potential ground water penetration and also as part of the strategy to manage termite risk. In some instances, there may be advantages to extending the concrete construction to the ground floor. Typical examples include:

- Where parts of the building ground floor level are close to or below the external ground level the extension of concrete construction may be appropriate to address moisture penetration and manage termite risk.
- Part of the carpark extended to the ground floor (it is usually practicable to retain concrete construction for all levels that include carparking).
- Medical gas storage is provided within the building instead of being stored in a separate structure/ compound (see 6.13.4 Medical Gases).
- If higher levels of fire resistance are required for the ground floor or part of the ground floor compared to other parts of the building and concrete trades are on site.

7.3.1 Determine the Fire Resistance Levels Required for Structural Elements within Fire Compartments

Generally, each part of a building must be classified according to its purpose and comply with all the appropriate requirements for its classification.

The Structural Adequacy component of the FRLs required for the various fire compartments should be derived from Specification C1.1 of the NCC based on the required Type of Construction and Building Class for the relevant part of the structure. The distance from the allotment boundary and adjacent buildings also needs to be considered for external walls, external columns and other elements that could be exposed to fire from adjacent buildings. This generally defines the highest FRLs required within a fire compartment with relaxations or concessions being applied to some elements of construction particularly with respect to the integrity or insulation criteria.

It is common for hospital buildings to include parts to which different classifications apply. A simple example is shown in the schematic section in Figure 7.10.

If there are different classifications in different storeys in a Type A building, the floor between the adjoining parts must have an FRL not less than that prescribed by NCC Specification C1.1 for the lower storey (NCC C2.9).

If there are different classifications on the same storey the parts must be separated in that storey by a fire wall having the higher FRL required by specification C1.1 (NCC C2.8)

The example in Figure 7.10 shows the general layout and required structural adequacy levels for each of the floors and fire compartments within a floor having different classifications. The example building includes Class 9a (hospital), 6 (retail) and Class 7 (carpark) parts. The retail part of the building requires maximum FRLs up to 180/180/180 compared to 120/120/120 required for the hospital and carpark parts.

Integrity and insulation criteria depend on the role of the element of construction.

The requirements may require further adjustments to account for other provisions and concessions within the NCC such as the support of another part requirements in NCC Specification C1.1 Clause 2.2.

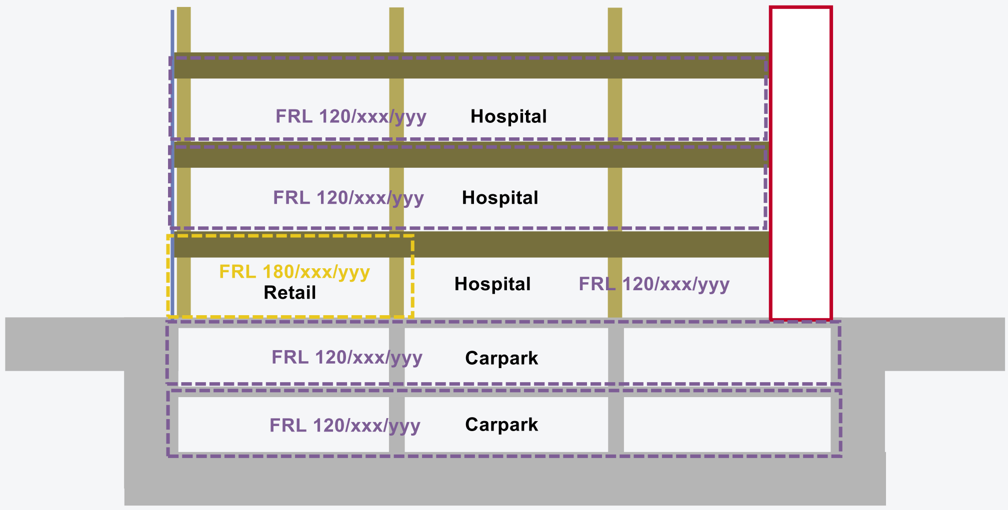


Figure 7.10: Example of a hospital building with parts of different classifications.

There is an exemption provided in NCC A6.0 where a part of a building has been designed, constructed or adapted for a different purpose and is less than 10% of the floor area of the storey it is situated on, where the classification of the other part of the storey may apply to the whole storey.

In the above example, if the retail area on the ground level was less than 10% of the floor area it can be deemed to be an ancillary area within a Class 9a building and not a separate part of the building. Under these circumstances, the FRLs within the retail area can be reduced from a maximum of 180/180/180 to 120/120/120 and a fire wall need not be provided to separate the retail and hospital parts.

Note: It is critical to liaise with the regulatory authority in the early stages of a project to obtain a clear understanding of the classifications that will apply to the structure since it may impact on the structural form and other fundamental design decisions which will be costly to change later in the project.

7.3.2 Select Basement and Ground Level Structural Forms

The NCC 2019 Deemed-to-Satisfy Provisions allow the use of fire-protected timber in all building Classes or parts of buildings with an effective height not greater than 25 m. However, concrete is commonly selected for construction below ground level to address ground water penetration and as part of the system providing protection from termites as noted in the previous sections.

The Class 6, 7 and 9 parts should be fire-separated in accordance with Clause C2.9 (or Clause C2.8 if different classes share the same floor).

The general Structural Adequacy FRL requirements for the carpark levels are 120 minutes and an FRL 120/120/120 fire separation is required by Specification C1.1 between the carpark level and retail level or hospital area on the ground floor.

From Specification C1.1, the retail (Class 6) ground floor level requires a general Structural Adequacy FRL of 180 minutes and an FRL of 180/180/180 for firewalls and the floor above unless the retail area can be treated as an ancillary area (typically less than 10% of the floor area) . Figure 7.11 and Figure 7.12 show typical options for fire separation from the carpark and between the retail level and hospital parts.

Refer EWFA report RIR 55945800.1B, available from the WoodSolutions website, for the assessment of timber frame wall systems for FRLs up to 180/180/180 or evidence of suitability for other proposed systems

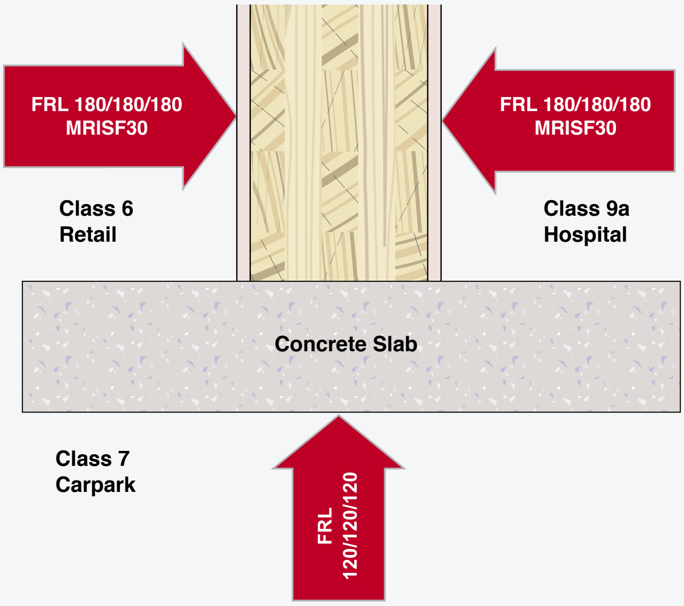


Figure 7.11: Typical massive timber detail for separation of different parts of the example building.

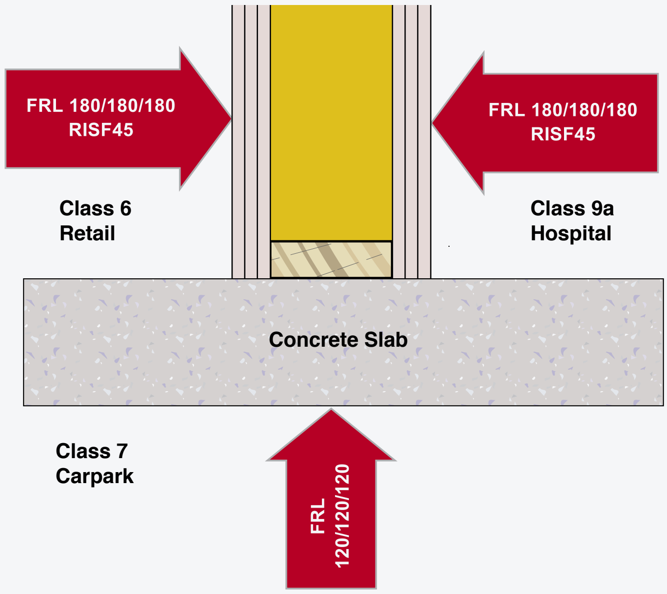


Figure 7.12: Typical timber frame detail for separation of different parts of the example building.

For the massive timber fire wall option, due to the large inherent fire resistance of the massive timber, the fire protective coverings are provided to comply with the minimum MRISF requirements of 30 minutes with the outer face exposed to fire and, if necessary, to supplement the inherent fire-resistance performance of the massive timber so that an FRL of at least 180/180/180 can be achieved with an appropriate thickness and design of the massive timber element. Evidence of suitability should be obtained from material suppliers.

For the timber-frame fire wall option, substantially greater reliance is placed on the fire-protective coverings which greatly exceed the minimum RISF requirements of 45 minutes and supplementary protection within the frame cavities may be required. Further details of a system that has successfully achieved an FRL 180/180/180 and RISF of 120 minutes are provided in report RIR EWFA 55945800.1B and is available from the WoodSolutions website.

For the floor separating the retail area from the hospital areas above, an FRL of 180/180/180 is required, which normally leads to the selection of massive timber elements to provide a practical timber option. A fire protective covering is required to satisfy the minimum prescribed MRISF of 30 minutes for massive timber elements, but this may need to be increased to achieve an FRL 180/180/180 depending on the massive timber system that is selected.

Substantial simplifications and standardisations to the design can be made if the retail area is sufficiently small and treated by the authority having jurisdiction as an ancillary area. Then, other than the parking levels, the example building will be treated as Class 9a, allowing the fire wall separating hospital and retail areas on the ground floor to be deleted and the FRL of the floor element above the retail area to be reduced to an FRL 120/120/120.

7.3.3 Select Structural Forms and Fire-resistance Construction for Hospital Parts of the Building

The structural form selected for the upper levels in the example hospital building is fire-protected timber construction using a DTS Solution. This will require a maximum FRL 120/120/120 in addition to the need to comply with the RISF and MRISF requirements.

These FRLs can be satisfied using lightweight timber-framed construction or massive timber construction depending upon the specific circumstances; as shown in Figure 7.13 and Figure 7.14. Depending on the applied loads and availability of evidence of suitability, the thicknesses of the fire-protective coverings for the massive timber option may be determined based on the required MRISF; whereas for the lightweight timber-frame option the dominant requirement is likely to be the FRL.

Obtain evidence of suitability from product suppliers and WoodSolutions website, for FRLs up to 120/120/120 and RISF of 45 mins or MRISF of 45 mins as appropriate.

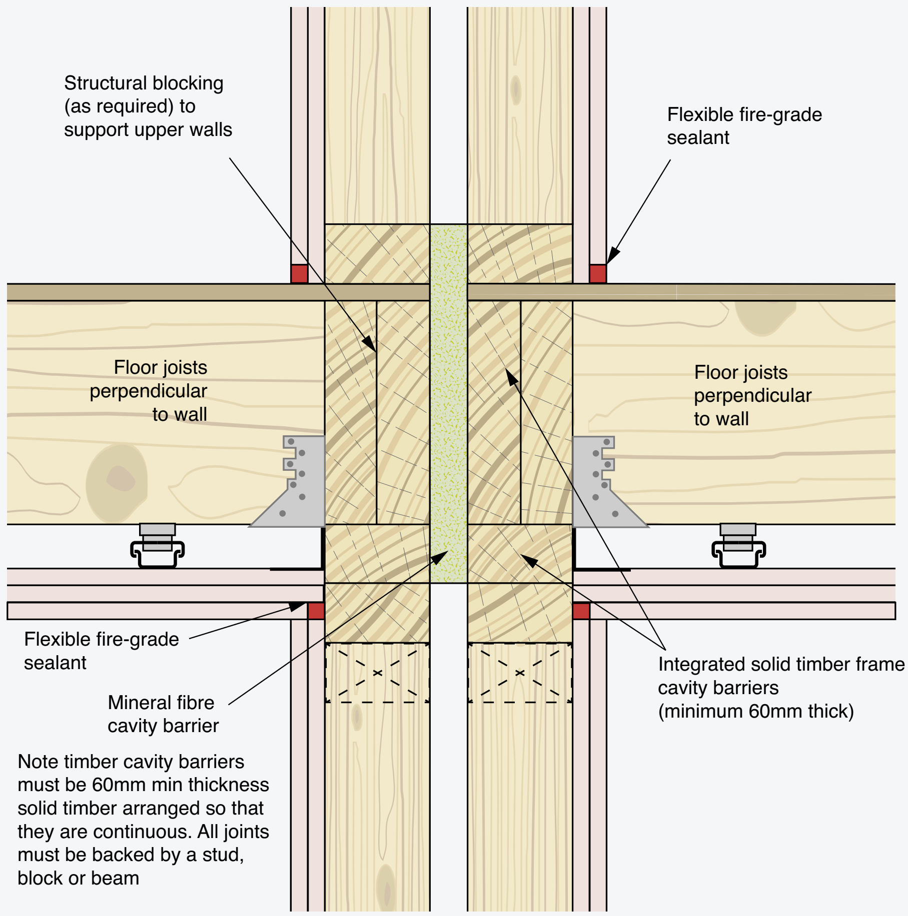


Figure 7.13: Typical FRL 120/120/120 Light-weight timber frame walls and floors.

Obtain evidence of suitability from product suppliers and WoodSolutions website, for FRLs up to 120/120/120 and RISF of 45 mins or MRISF of 45 mins as appropriate.

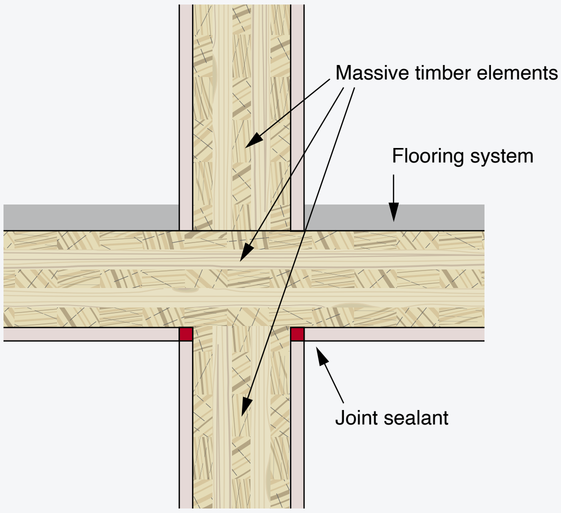


Figure 7.14: Typical FRL 120/120/120 Massive timber walls and floors.

If this detail is subjected to high vertical loads, reinforcement of wall/floor interfaces may be required.

7.3.4 Select Lift and Fire Stair Shaft Construction

Lift and fire stair shafts in mid-rise timber buildings can be of timber, masonry or concrete construction. The choice will depend on the structural design of the building and numerous other factors.

If concrete or masonry shaft construction is adopted, it is important that the detailing can accommodate the possibility of differential movement between the timber structure and masonry/concrete shafts. Further information relating to masonry and concrete shaft construction lies outside the scope of this Guide.

Fire-protected timber shafts can be timber-framed construction or massive timber panel systems. Both options will be considered in subsequent sections.

An independent structural frame can be provided within the shaft as part of the lift installation, effectively isolating the lift system from the shaft walls and providing adequate acoustic separation.

If an independent steel frame is used within a fire-protected timber shaft, the possibility of differential movement between the timber and steel frame will need to be addressed. Typically, this can be addressed if the lift system can be readjusted for differences in floor levels.

7.3.5 Structural Design

Issues that should be considered in the structural design of mid-rise timber buildings include:

- The design must comply with the relevant NCC requirements including design to sustain local damage, with the structural system as a whole remaining stable and not being damaged to an extent disproportionate to the original local damage – refer NCC Clause BP1.1(a)(iii) (structural robustness). A first principles performance pathway can also be adopted that addresses both fire and structural performance. Further guidance is provided in *WoodSolutions Technical Design Guide #39 Robustness in Structures.*
- The lighter mass of timber to that of masonry/concrete construction – greater attention needs to be given to resistance against overturning.
- The greater effect from wind loads than expected on smaller structures. This is due to a greater height-to-width ratio, resulting in a need for attention to resistance to overturning.
- Potential for movement (and differential shrinkage in buildings of hybrid construction) in taller timber buildings. Movement 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 or allowing articulation to absorb the differential movement
  - allowing for differential movement with respect to plumbing and other services.

A professional structural engineer with appropriate skills will be needed to ensure the above issues and structural performance in general are adequately addressed. Guidance is provided in *WoodSolutions Technical Design Guide #50 Mid-rise Timber Building – Structural Engineering*.

The following standards should be called on where appropriate:

- AS 1170.0 – Structural design actions – General Principles
- AS 1170.1 – Structural design actions – permanent, imposed and other actions provides 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 1720.1 – Timber structures – Design methods
- AS 1720.5 – Timber structures – Nail plated timber roof trusses

In addition:

- Select details that minimise the effects of shrinkage (especially since differential shrinkage may have an adverse impact on the function of fire-resisting wall and floor elements).
- Check walls and columns are capable of supporting multi-storey load paths from above. Enlist internal fire-resisting walls and columns if required.
- Check that any elements supporting loads (including bracing elements) are treated as fire-resisting construction and designed accordingly.

7.4 Establish Service Plant Areas, Service Runs, Risers and Shafts

7.4.1 Service Plant Areas

Service plant rooms are generally located away from public areas, either in basements or on roof tops.

Clauses C2.12 'Separation of Equipment' and C2.13 'Electricity Supply System' generally require certain types of equipment to be fire separated from the rest of the building by construction having an FRL 120/120/120 with doorways protected by self-closing fire doors with an FRL not less than –/120/30.

For hospital buildings, some plant areas and related storage areas such as medical gas storage and distribution systems have additional safety requirements that lie outside the scope of the NCC and the preferred option may be for these services to be in a different building/compound. If they have to be stored within the building, the most practical solution would be to house plant rooms in the basement with areas such as medical gas storage located at ground level to provide safe access. The concrete sub-ground structure should then be extended so that these areas can be constructed from concrete as appropriate. Refer Section 6.13.4 Medical Gases for further information relating to medical gases.

Emergency power generators may also need to be located in plant areas and particular attention needs to be paid to fuel storage and supply. A preferred option may be for fuel storage to be located in a dedicated building or compound independent of the main hospital building.

7.4.2 Service Runs

In fire-protected mid-rise timber buildings, the timber elements are protected by fire-protective coverings and services tend to be concealed in a similar manner to conventional building designs using service risers, ducts and fitting cabling and pipes behind false wall and ceiling linings.

While the use of cavities within fire-protected timber construction to run cables and pipes can appear to be a simple solution, this choice presents several issues including:

- difficulty in maintaining the RISF or MRISF ratings of the elements at points of service penetrations
- risk of acoustic separation being compromised
- risk of fire protection systems not being correctly installed after modifications or additions to existing installations
- risk of disruption of concealed cavity barriers during modifications or additions
- risk associated with medical gases (e.g. oxygen which can increase the flammability of materials significantly). Refer Section 6.13.4 Medical Gases for further information relating to medical gases.

A more reliable option is to plan the layout of required services and potential future services carefully utilising service risers, service shafts and ducts, and additional (false) linings to conceal services minimising penetrations through fire-protected timber elements as far as practicable. In addition, the services should be run, and penetrations through fire and smoke resistant elements located, such that they are readily accessible for maintenance and servicing without significantly disrupting the operation of a healthcare facility. This approach is described in the following sections.

Most loadbearing members are required to achieve an FRL even if they are not part of a fire-resisting wall.

Adding/modifying services is simplified if services are protected at each floor level by framing out the opening and using a multi-service penetration system that can be easily reinstated

7.4.3 Service Risers and Horizontal Distribution of Services

Figure 7.15 shows part of a typical ward area of a hospital and has been used to provide a typical example of planning the location of service shafts and service runs. The same general principles apply to other healthcare facilities and parts of the hospital although the mix and complexity of services will vary.

Services such as electricity, water and telecommunications/data systems are normally distributed between floors through service risers/shafts that are commonly located close to the structural cores. These may be consolidated in a single location or distributed depending on the size and complexity of the building. Two general service riser locations adjacent to the fire stairs are shown, highlighted in green in Figure 7.15.

Fire compartmentation can be maintained by protecting the service penetrations at each floor level or using fire-resisting construction for the risers (shafts), fitting fire doors or fire-rated access panels to the risers and fire protecting each service where it penetrates the riser wall (refer Figure 7.17).

Generally, the option of protecting the service penetrations at each floor level is the most practical solution. This can be achieved by forming an opening in the floor such that no timber is exposed, the FRL and RISF or MRISF is not compromised and services can be run through the opening. The opening can be protected by a multi-service penetration system such as a pillow, mineral fibre batt, or other proprietary fire protection system that can be readily reinstated if additional services need to be run. A typical example is shown in Figure 7.16.

Using a framed opening also avoids the need to expose cavities and timber members if additional services need to be run substantially reducing the risk of cavity fires and premature ignition of timber members. Refer to Section 7.13 Service Penetration Treatments for further details on the selection of service penetration systems.

For the hospital building example, the services have been distributed from the risers above a false ceiling as shown schematically in Figure 7.17.

Services can be run through internal walls within a fire or smoke compartment without the need for protection provided the wall is not required to be of fire-resisting or of smoke-proof construction.

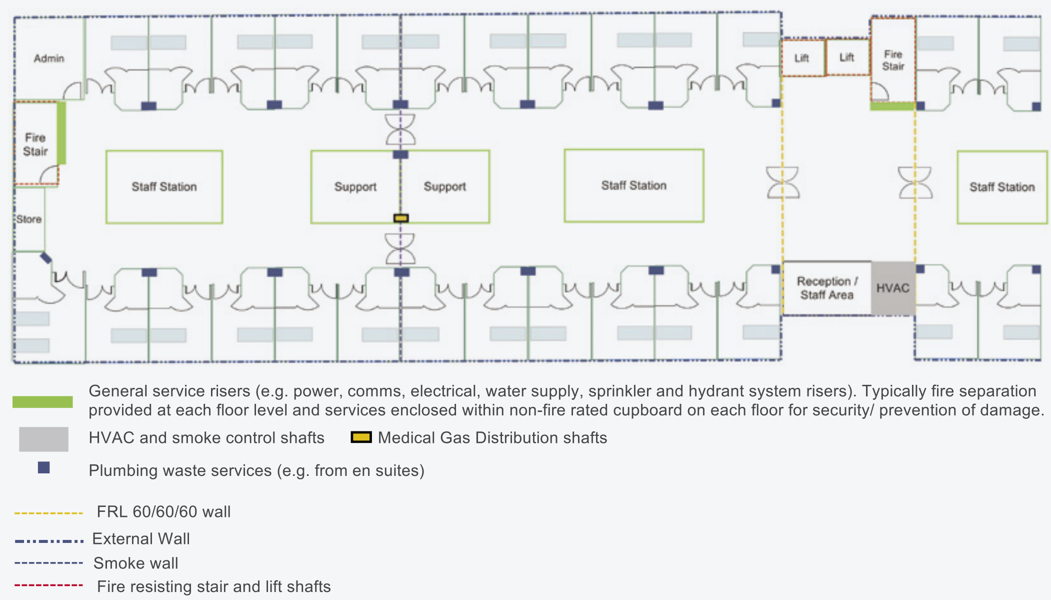


Figure 7.15 Typical riser locations for a ward level in a hospital

The face of openings within fire-protected timber elements need to be protected so that no timber is exposed. The required RISF or MRISF and the FRL of the fire-protected timber must also be maintained. Continuing fire protective coverings around the opening is a typical solution.

Walls that are not required to achieve an FRL or be smoke-proof can be a practical option for the location of services such as power outlets.

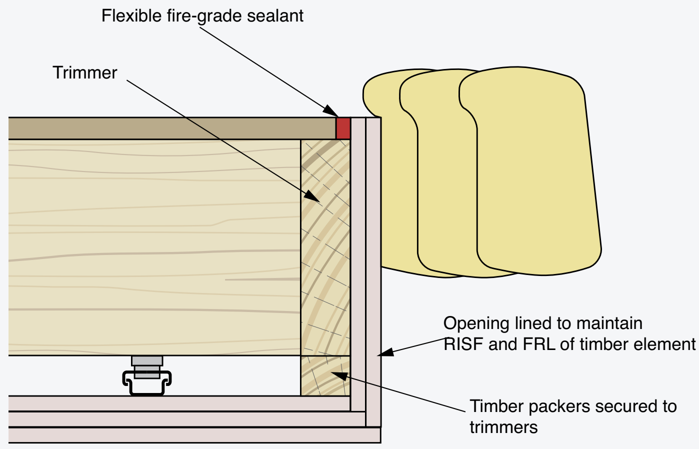


Figure 7.16: Typical riser penetration detail through a fire-protected timber floor.

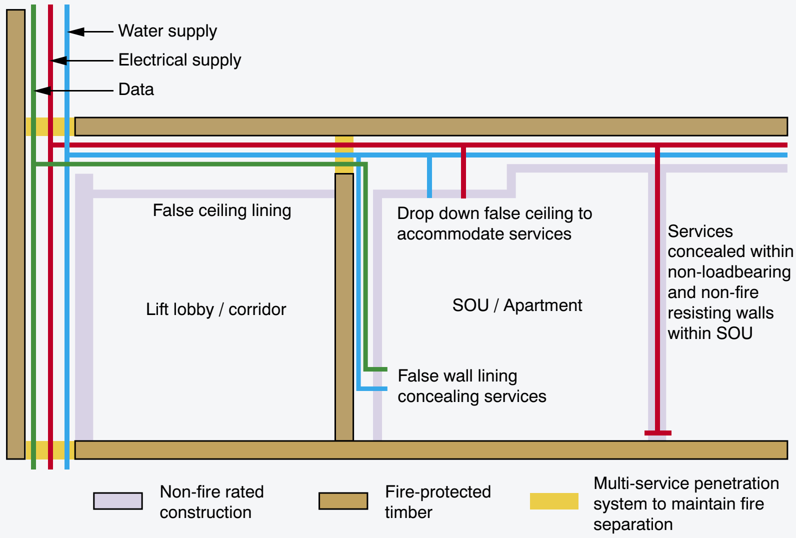


Figure 7.17: Typical distribution of general services.

The use of false ceiling linings to conceal services can provide a number of advantages including a significant improvement in the reliability of fire-protection systems by:

- avoiding large numbers of individual service penetrations within fire-protected timber elements for services such as power outlets, lighting and plumbing services, including fire sprinklers
- concealing pipework and cable runs
- allowing reconfiguration of services without disrupting fire-protected timber elements
- reducing the risk of cavity fires during maintenance activities and the risk of fire spread to cavities if the fire protection of services is not reinstated after reconfiguration or repair to services
- enabling services to be grouped together and protected by a single multi-service penetration system fitted above the false ceiling (access panels can be provided to facilitate access for inspection and/or adding or modifying existing services).

To manage waste services from ensuites and other areas, where pipe falls are required to ensure adequate flow, it may be impractical to use small numbers of centralised shafts and distributing shafts close to ensuites can present a practical solution as shown shaded dark blue (plumbing waste services) in Figure 7.15. For this application, services are normally fire-protected at the point where the shaft wall is penetrated rather than providing protection at floor level and therefore the shaft is required to have an FRL of –/90/90 if non-loadbearing and 120/90/90 if loadbearing.

Refer Section 6.13.4 Medical Gases for further discussion and seek specialist advice regarding requirements of the healthcare building operators and regulatory requirements applicable within the relevant jurisdiction.

HVAC and smoke hazard management systems are generally run within service shafts, but the horizontal distribution details will vary depending on the application, as will the distribution of shafts across a floor. For simple HVAC systems that are required to shut down in the event of a fire emergency, horizontal distribution can be achieved above a false ceiling with fire and/or smoke dampers being provided where fire-resisting walls and smoke-proof walls are penetrated. For complex smoke management systems reference should be made to the NCC and AS 1668.1.

Treated of medical gases requires consideration of additional protection measures that lie outside the scope of the NCC and additional requirements relating to combustibility of shafts and ducts together with requirements for ventilation of shafts and ducts, controls of materials used for distribution and service penetration fire protection systems, etc. In some instances, it may be practicable to provide medical gas shafts to serve each smoke and fire compartment and, if the horizontal pipe runs are to be covered, enclosing them in dedicated ducts with required ventilation.

7.4.4 Service Shafts

There are advantages (space, economy and design options and reduced risk to critical structural elements) in ensuring that service shafts are non-loadbearing.

The integrity and insulation criteria for non-loadbearing service shafts are –/90/90 for Class 9a and 9c buildings but an FRL of 120/90/90 is required if the shaft is loadbearing; further encouraging the use of non-loadbearing service shafts.

Where timber framing is used to support the shaft linings, fire-protective coverings must be applied to both sides of the timber frame and service penetrations will be required to satisfy the RISF criteria. A more practicable alternative is to use laminated plasterboard or shaft wall systems. These systems are proprietary, developed by fire-protective covering manufacturers, and reference to their details is required. The number of layers, type and thickness of plasterboard (or other fire-protective covering) and fixing methods selected depend on the required FRL and Evidence of Suitability that is available.

Figure 7.18 and Figure 7.19 show details of typical fire-resisting laminated shaft details and their connection to fire-protected timber elements.

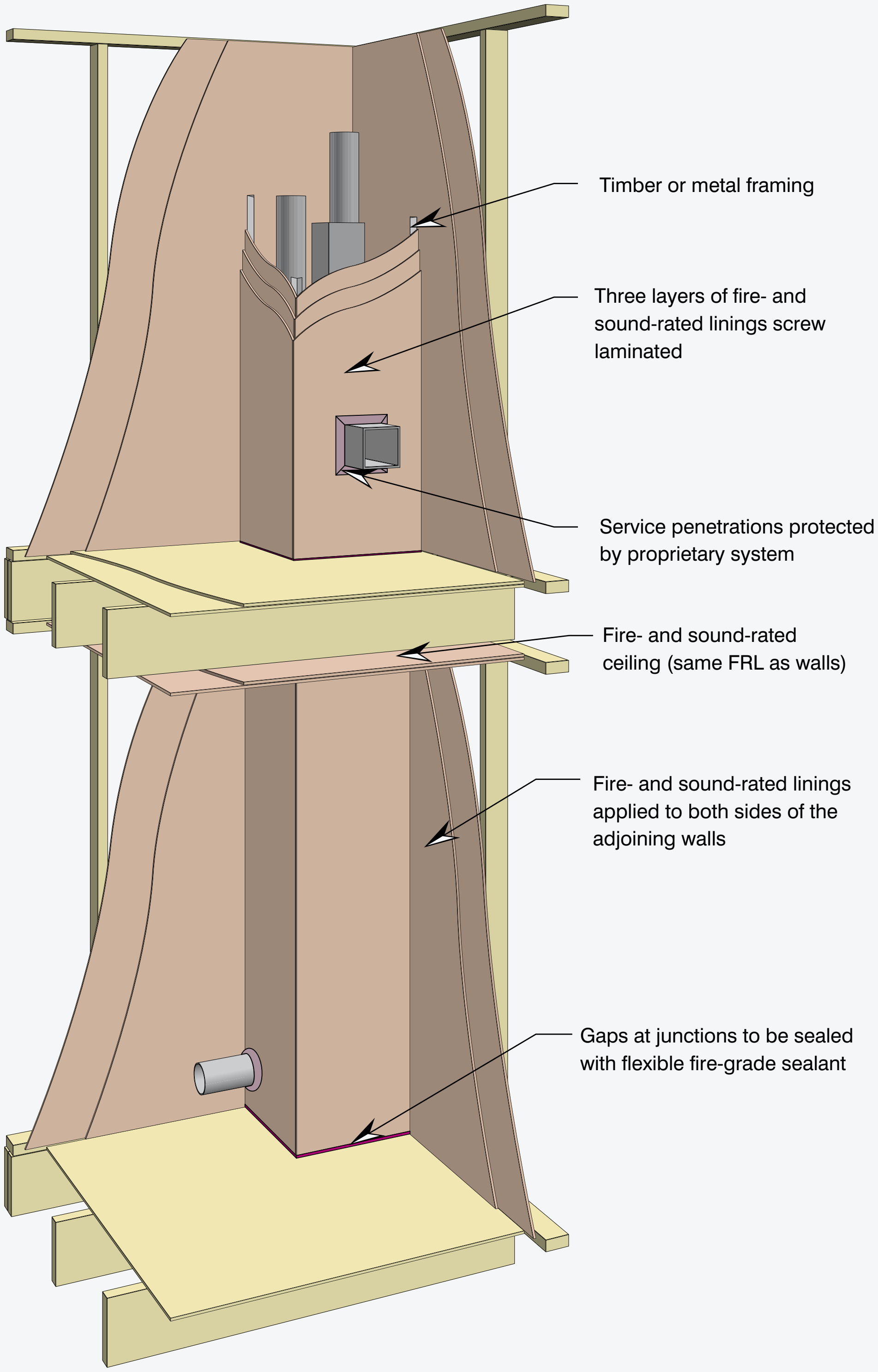


Figure 7.18: Typical fire-resisting service riser/shaft.

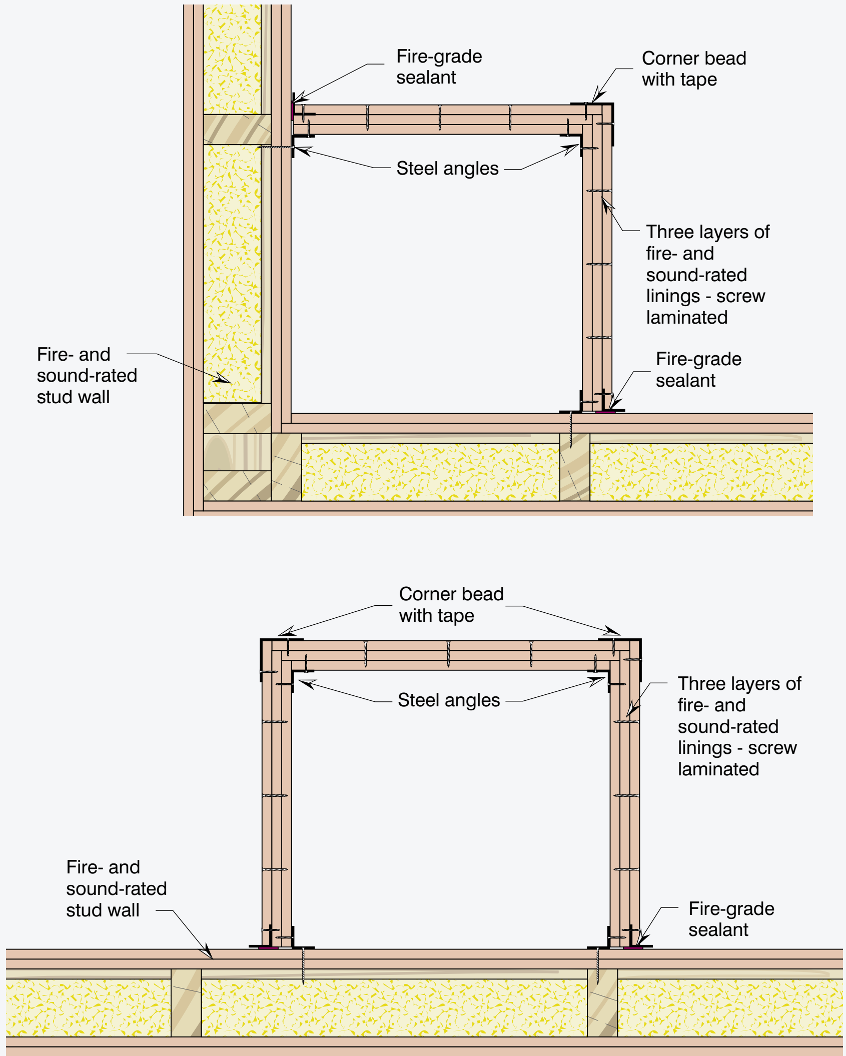


Figure 7.19: Laminated fire-grade plasterboard used to create shafts.

7.5 External Walls

External walls must be designed to satisfy a range of criteria including:

- fire performance
- structural performance (for safety and serviceability)
- weather resistance (resistance to water penetration)
- light and ventilation (including condensation control)
- energy efficiency (thermal insulation)
- durability
- acoustic separation (the control of transmission of sound from external sources is not required by the NCC but may be part of a design brief or planning control).

7.5.1 Fire Performance of Fire Protected Timber External Walls

The external face of the wall may form the fire-protective covering of a fire-protected timber element. An example is the brick veneer construction shown in Figure 7.20.

If this option is used, the specification will need to address, among other things, the installation of cavity barriers to ensure correct placement and so moisture is not transported from the internal brickwork face to the timber frame through the cavity barrier.

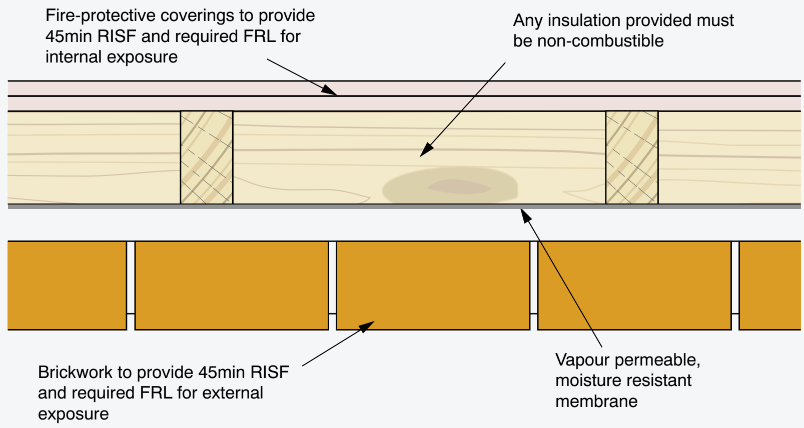


Figure 7.20: Fire-protected timber brick veneer external wall.

Alternatively, a cladding system may be fixed to a fire-protected timber element to prevent water penetration and serve other non-fire related functions. The cladding system could be a direct fix system or ventilated systems as shown schematically in Figure 7.21 and Figure 7.22 for lightweight timber-frame and massive timber construction, respectively. These figures may not show all components that form part of proprietary systems.

Many massive timber panels are proprietary products. Fire (and other) properties depend on the adhesives used and manufacturing processes, which are currently not fully standardised. Evidence of Suitability for massive timber external wall systems will tend to be product specific in most instances and configurations will tend to vary to satisfy the relevant NCC and other design requirements.

Fixings for the cladding system must be detailed so that the performance of the fire-protective coverings is not compromised.

The NCC DTS provisions require the external walls to be of non-combustible construction or of fire-protected timber construction. Therefore, any cladding systems applied to fire-protected timber external walls in mid-rise buildings must be non-combustible to comply with the NCC DTS provisions.

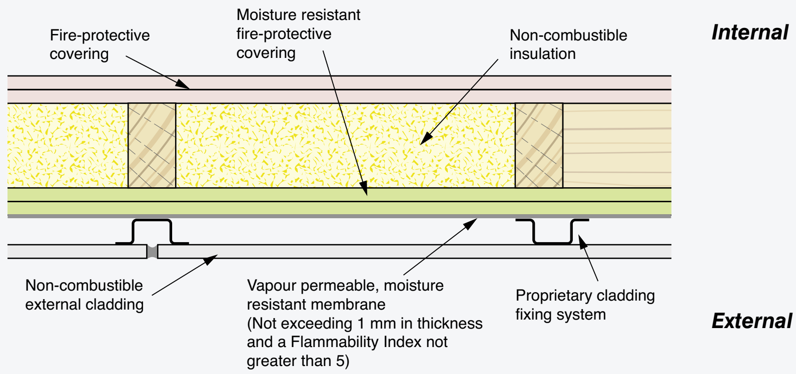


Figure 5.19: Fire-protected timber frame external walls with lightweight cladding.

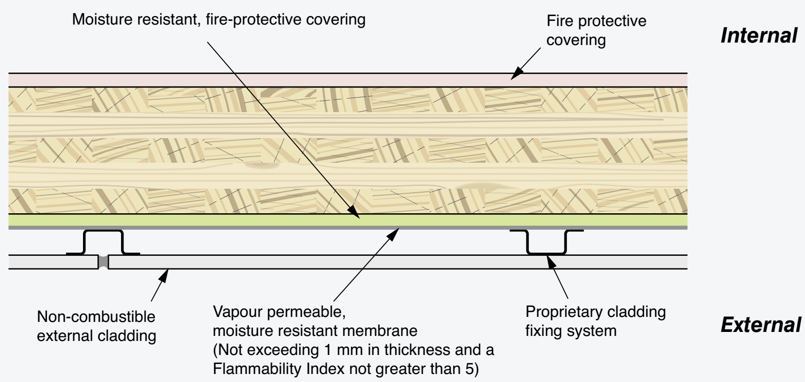


Figure 5.20: Fire-protected massive timber external wall with external lightweight cladding.

If combustible cladding systems are to be used, the Performance Solution pathway must be adopted to demonstrate compliance of the external wall system with the relevant NCC performance requirements. Verification method CV3, in conjunction with verification methods CV1 and CV2, and the classification standard AS 5113 define an appropriate method for demonstrating compliance in most States and Territories.

Table 7.11 summarises the required FRLs and RISF or MRISF based on the distance from the boundary for Class 9 buildings. Refer to NCC Specification C1.1 Table 3 for other classes.

Table 7.11: Fire-resistance requirements for external walls for a Class 9 building of Type A construction

Distance from fire source feature	**FRL – Structural Adequacy /Integrity/ Insulation – minutes**		**General Timber**	**Massive Timber**
	Loadbearing	Non-Loadbearing	RISF (minutes)	MRISF (minutes)
≤1.0 m	120/120/120	–/120/120	45	45 external 30 internal
<1.5 m	120/120/120	–/120/120	45	30
≥1.5 and <3 m	120/90/90	–/90/90	45	30
≥3 m	120/60/30	–/–/–	45	30
External Columns	120/–/–-	–/–/–	45	30

Table 7.11 is a derivative of Specification C1.1 Table 3 and Specification C1.13a of the National Construction Code 2019 Amendment 1 provided by **https://www.abcb.gov.au/** *Australian Building Codes Board © 2020.*

While there are significant reductions in the required FRLs for non-loadbearing elements as the distance from the fire source feature increases, the design of the external walls will not vary significantly because the required RISF or the MRISF, in combination with the minimum thickness requirement of 75 mm for massive timber, will become the dominant design factors.

If the subject building is of massive timber construction and is not more than 1 metre from a fire source feature, the required MRISF is increased to 45 minutes externally to minimise the risk of fire spread from adjacent structures.

Table 7.11 indicates that an FRL of –/–/– is applicable to an external wall system that is non-loadbearing and more than 3 m from a fire source feature. In these applications, a common solution is to use curtain walling system (which must be non-combustible) secured to floor plates Any openings between the floor plate and the curtain walling systems need to be protected to maintain the same FRL as that required for the floor system. These perimeter seals are sometimes also referred to as cavity barriers, but the performance levels and Deemed-to-Satisfy Solutions provided in Specification C1.13 for cavity barriers within timber frame construction should not be used since, among other things, higher FRLs are required at the perimeter of a floor plate. For the example building, the opening between the edge of the floor plate and curtain walling system would need to be protected by a system capable of achieving an FRL –/120/120. These are available from some specialist passive fire protection system suppliers but the evidence of suitability should be checked for each application.

7.5.2 External Noise

Currently, there are no NCC requirements to provide external noise attenuation for buildings. However, Government authorities have regulatory or legislative powers to require control of noise entering buildings and market forces may generate requirements.

WoodSolutions Technical Design Guide #11 Timber-framed Systems for External Noise provides examples of lightweight external wall systems that can be used as guidance.

7.5.3 Weatherproofing

At the time of writing there were no Deemed-to-Satisfy Provisions in the NCC in relation to the weatherproofing of external walls and so suppliers of waterproofing products/membranes are relied on to demonstrate compliance with the NCC Performance Requirement (FP1.4). A weatherproofing Verification Method (FV1.1) is described in the NCC to enable compliance with FP1.4 via a tested prototype. It is important that installed waterproofing membranes/systems for timber construction are vapour permeable (i.e. allowing timber building components to breathe) but do not permit water to penetrate through to the structural timber building elements (moisture resistant).

7.6 Fire-protected Timber Floors

Floor systems must be designed to satisfy a range of criteria including:

- structural performance (for safety and serviceability)
- fire performance
- acoustic separation
- durability.

Common structural elements used for timber floors include:

- solid timber beams
- LVL beams
- I-section beams with OSB or plywood webs
- parallel chord steel web trusses
- parallel chord timber web truss
- I-section with Steel Web
- massive timber panel systems (e.g. CLT or LVL).

These structural members can be used with a range of flooring systems, internal insulation systems and soffit/ceiling lining systems in keeping with the building finishes and to achieve the required fire and acoustic performance.

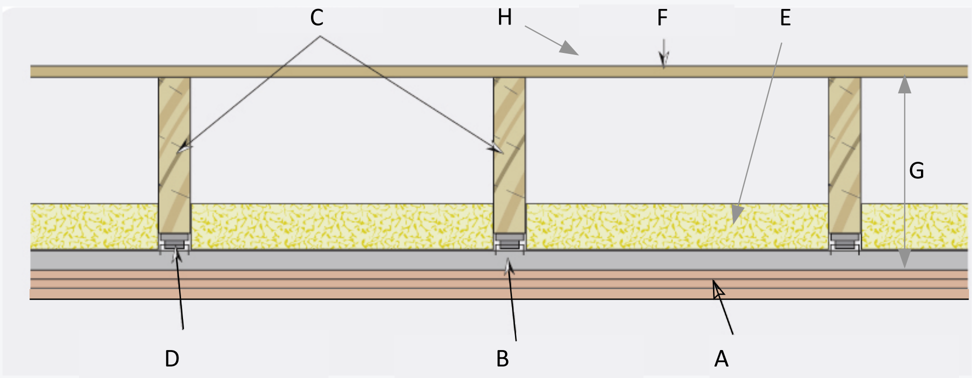
7.6.1 Fire Performance of Flooring Systems Protected by Typical Ceiling Systems

Typical floor systems that satisfy the fire related NCC DTS fire requirements for typical Class 9a or 9c healthcare building are shown in Figure 7.23 for lightweight timber-frame construction and Figure 7.24 for a CLT floor system for applications where a considerable reliance is placed on the fire-resistance contribution from the ceiling.

The system incorporates a ceiling system comprising three layers of 16 mm thick fire-protective grade plasterboard secured to steel furring channels supported from the structural element. Since the ceiling provides the largest contribution to the FRL of the floor/ceiling systems, and the performance will be largely independent of the structural members prior to structural failure, the results can be applied to a large range of combinations of structural element, cavity insulation and flooring systems to which additional finishes may be applied, provided compliance with other NCC requirements is not compromised.

For lightweight timber-framed floor systems, the required thickness of the fire-protective coverings tend to be dominated by the FRL criteria rather than the RISF criteria of 45 minutes and the above construction could be considered a practical solution.

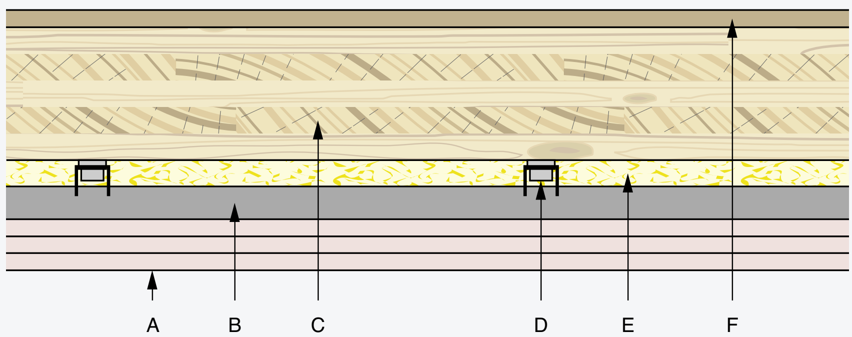
The fire performance of CLT systems depends on many factors, including adhesives, number of layers and thicknesses of lamella, manufacturing process, timber species and grade, and applied loads. For massive timber panel floor systems and beams, thicknesses greater than 150 mm are commonly used to achieve adequate structural performance. Under these circumstances it is likely the required thickness of fire-protective coverings will be dominated by the MRISF or RISF criteria rather than FRL criteria because of the high inherent fire resistance of the massive timber panels. Since variables such as adhesives and maximum gaps between lamella are not fully standardised in Australia, evidence of suitability in the form of fire-resistance test reports from Accredited Testing Laboratories should be obtained from the suppliers of the specific CLT system to confirm the FRL of fire-protected CLT members if a significant reliance is placed on the inherent fire resistance of the panels.



Construction
A Linings 3 x 16 mm fire-protective grade plasterboard
B Steel furring channels at 600 mm max centres
C Timber Beams
Solid timber joists
LVL beams
I-section beams with OSB or LVL webs
I-section with steel web
Parallel chord steel web trusses
Parallel chord timber web truss
D Furring Channel Fixings
Direct fixing clips
Acoustic (resilient) mounts
Suspended ceiling (hanger support)
Suspended ceiling (acoustic hanger)
E Non-combustible cavity insulation may be added
F Flooring (minimum thickness)
Plywood – 15 mm
Cement sheet – 15 mm
Particle board – 18 mm
T& G flooring – 15 mm
Engineered flooring – 15 mm
Concrete applied over plywood
AAC – 50 mm
Calcium silicate sheets – 15 mm
G Minimum Cavity Depth – 288 mm from fire protective grade plasterboard.
H Floor finishes such as carpet, acoustic treatments may be added

Performance
FRL 120/120/1200 (verify with supplier and/or WF report FAS190034-RIR 1.0)
RISF 120 mins (verify with supplier and/or WF report FAS190034-RIR 1.0) or RISF 45 mins (NCC Spec C1.13a DTS)

Figure 7.23: Typical timber-framed floor – FRL 120/120/120.



Construction
A Ceiling linings 3 x 16 mm fire-protective grade plasterboard
B Steel furring channels at 600 mm max centres
C Massive Timber Panel (min 75 mm thick)
D Furring Channel Fixings
Direct fixing clips
Acoustic (resilient) mounts
Suspended ceiling (hanger support)
Suspended ceiling (acoustic hanger)
E Cavity minimum 40 mm (must be filled with non combustible insulation if massive timber ‘concession’ applied otherwise may be unfilled)
F Floor finishes such as carpet, acoustic treatments may be added

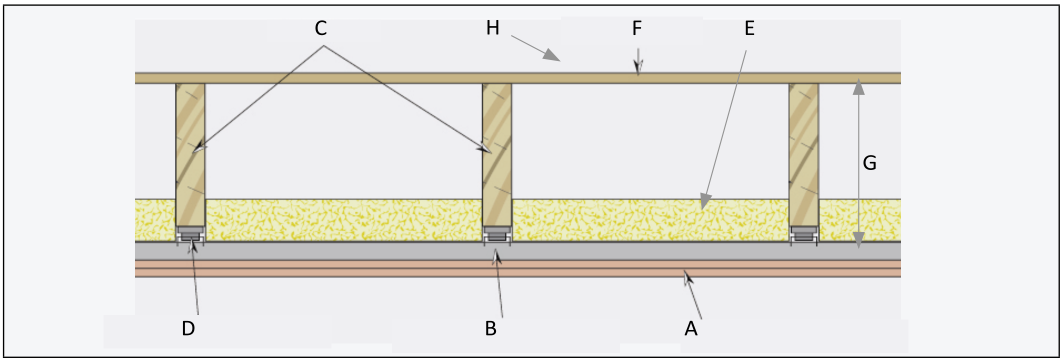
Performance
FRL 120/120/120 (verify with supplierand/or WF report FAS190034-RIR 1.0) Note higher FRLs may be achieved depending upon massive timber element design
MRISF/RISF 120 mins (verify with supplier and/or WF report FAS190034-RIR 1.0) or MRISF/RISF> 45 mins (NCC Spec C1.13a DTS)

Figure 7.24: FRL 120/120/120 Massive timber floor system. Plasterboard is not direct fix and therefore massive timber concession does not apply and RISF 45 is applicable.

7.6.2 Sound

The sound performance of a floor/ceiling system depends on a number of elements including: the density of the floor covering (tile, timber, carpet), isolation from the structure (acoustic underlay), ceiling insulation (density), ceiling installation (acoustic mounts) and layers and thicknesses of ceiling plasterboard. The objective is to minimise both airborne (Rw+Ctr) and impact sound (Ln,w) transmission through the floor/ceiling system and the performance of the floor/ceiling system should be verified with the plasterboard supplier for DTS Solutions.

There are a range of flooring products (e.g. timber overlay, carpet) that can be used and achieve the minimum NCC acoustic requirements. The use of a hard flooring surface will influence the impact performance (Ln,w) of the floor/ceiling system. Acoustic performance is not an NCC mandatory requirement for Class 9a buildings but is for Class 9c buildings. The following provides an example of a typical timber-framed floor/ceiling system performance.



Construction **A Linings 2 x 16 mm fire-protective grade plasterboard** **B Steel furring channels at 600 mm max centres** **C Timber Beams** Solid timber joists LVL beams I-section beams with OSB or LVL webs I-section with steel web Parallel chord steel web trusses Parallel chord timber web truss **D Furring Channel Fixings** Direct fixing clips Acoustic (resilient) mounts Suspended ceiling (hanger support) Suspended ceiling (acoustic hanger)	**E Non-combustible cavity insulation may be added** **F Flooring (minimum thickness)** Plywood – 15 mm thick Cement sheet – 15 mm Particle board – 18 mm T& G flooring – thickness 15 mm Engineered flooring – 15 mm Concrete applied over plywood AAC – 50 mm Calcium silicate sheets – 15 mm **G Minimum Cavity Depth – 288 mm from fire protective grade plasterboard.** **H Floor finishes such as carpet, acoustic treatments may be added**
Performance FRL 90/90/90 (verify with supplier)[xxv] RISF 60 mins (verify with supplier) or RISF 45 mins (NCC Spec C1.13a DTS) **Acoustics** (Verify with supplier): Above system incorporates: 10 mm overlay solid strip	flooring, 4.5 mm acoustic underlay on top of flooring products (F), R2.5 ceiling insulation (E), Acoustic (resilient) mounts (D). $R_w+C_{tr} \geq 50$ $L_{n,w} \leq 62$ (bare floor) $L_{n,w} \leq 50$ (carpet and underlay)

Figure 7.25: Sound performance of typical timber-framed floor/ceiling system.

The acoustic performance of various tested CLT floor/ceiling system configurations can be found in *WoodSolutions Technical Design Guide #44 CLT Acoustic Performance.*

7.7 Service Shafts

While service shafts can be constructed from fire-protected timber walls, in many instances there are substantial advantages in using either steel stud shaft wall or laminated shaft wall construction, particularly if the shafts are in locations where sound transmission is not a significant consideration.

The advantages include:

- ease of construction
- smaller footprint (more usable space)
- simplification of treatment of service penetrations
- greater selection of proprietary fire protection systems for service penetrations that already have Evidence of Suitability to demonstrate the FRLs of the systems.

Evidence of Suitability in accordance with NCC requirements should be obtained from the product suppliers.

It is important that the fire performance is not compromised at the interfaces between the shaft and fire-protected timber walls and floors. Figure 7.26 and Figure 7.27 shows typical interface details for steel framed shaft construction and Figure 7.28 shows typical interface details for laminated shaft construction. These interface details have been assessed by an Accredited Testing Laboratory (WFA report reference RIR 37401400) and found not to compromise the performance of the wall or shaft systems provided the FRL performance of the shaft system is not exceeded.

Report RIR 37401400 available from the WoodSolutions website assesses the impact of the interface details on the FRL, RISF and MRISF of the systems

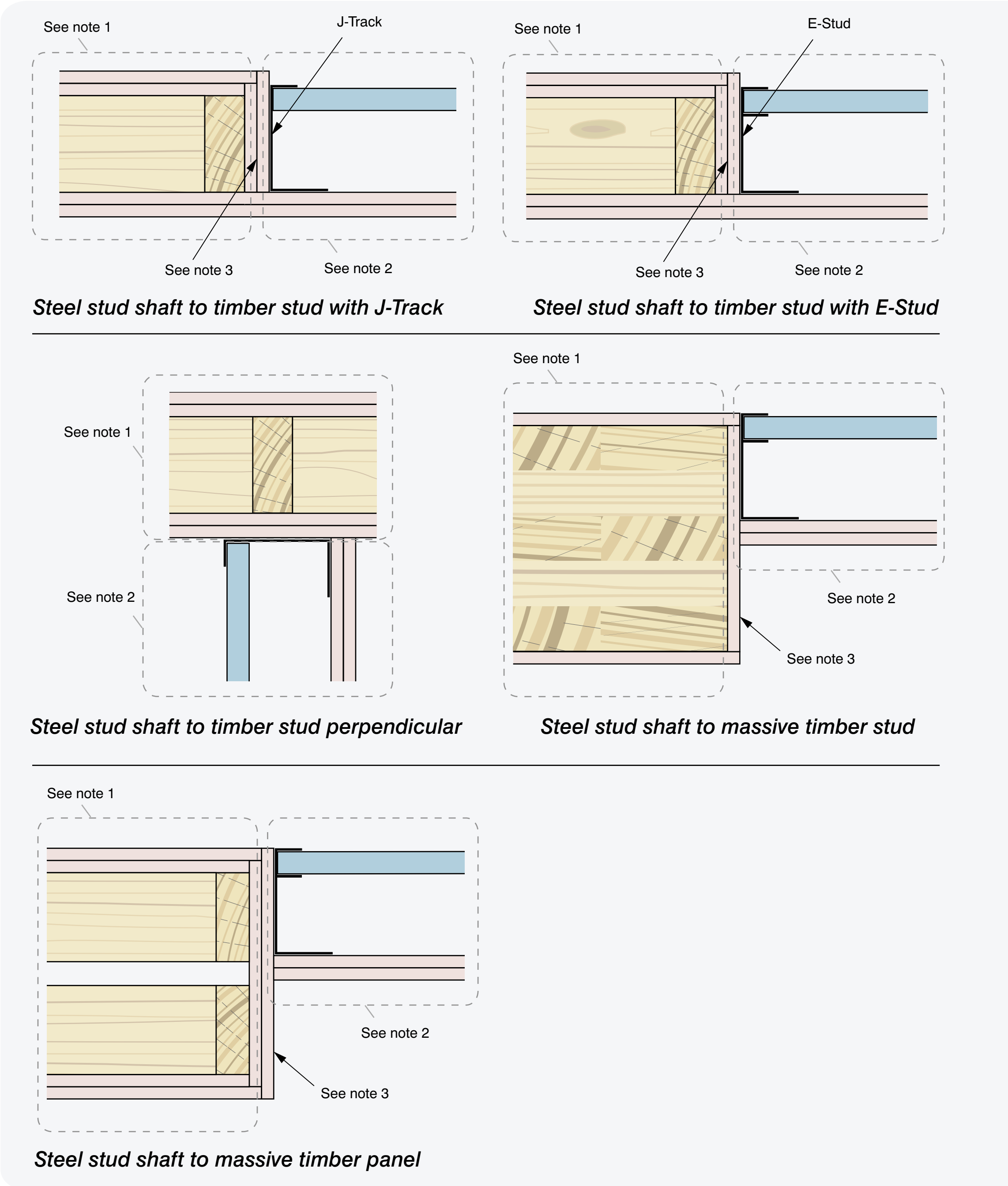


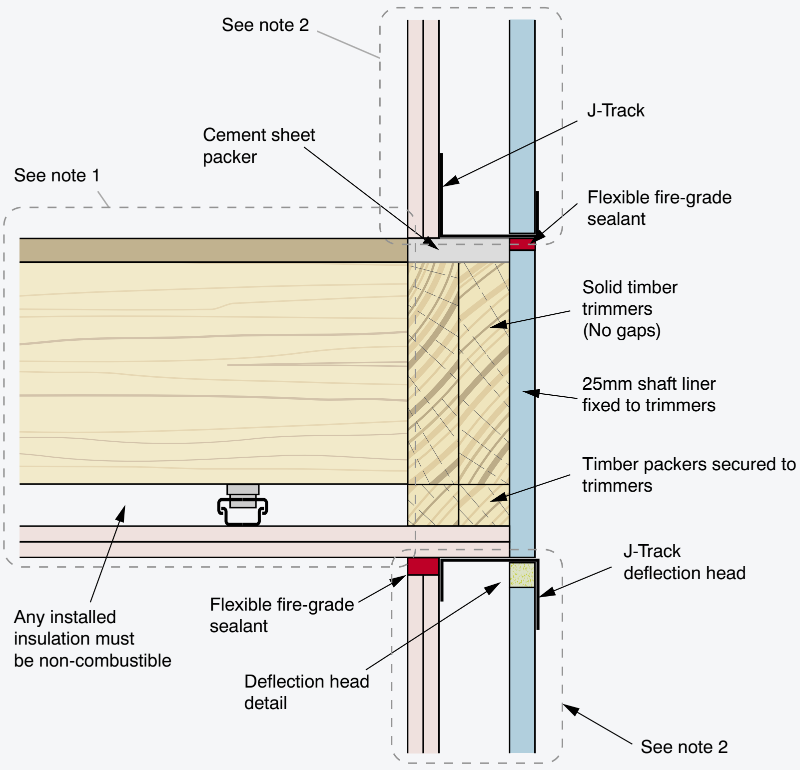
Figure 7.26: Interfaces between fire-protected timber and steel stud shafts.

Note 1: Fire-protected timber element having the required FRL and RISF or MRISF as appropriate. Any cavity insulation must be non-combustible.

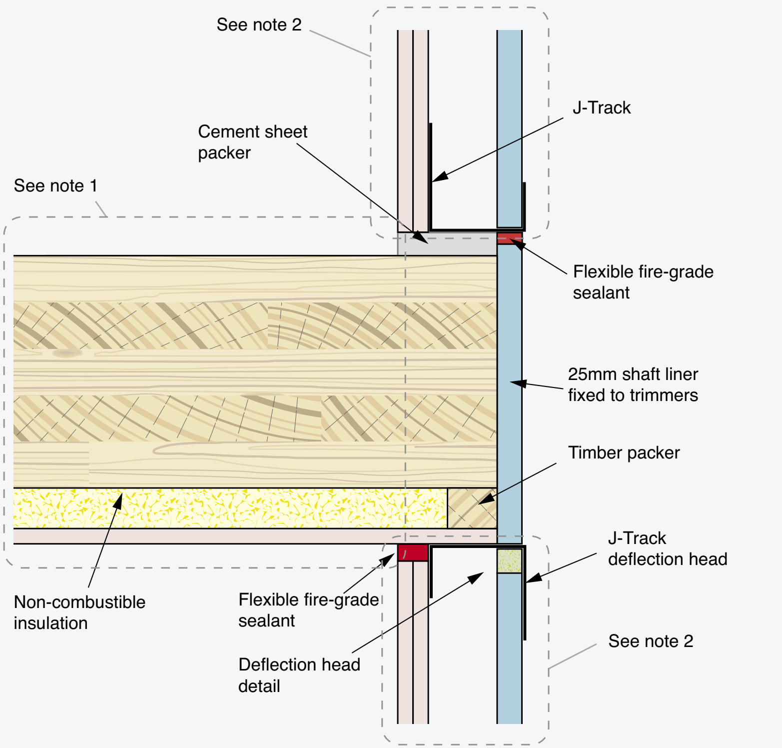
Note 2: Shaft wall construction having the required FRL.

Note 3: Interface protected with the same fire protective coverings that are applied to the fire-protected timber element face. Shaft wall tracks are to be screw fixed to timber elements at 300 mm maximum centres with 62 mm long screws

Report RIR 37401400 available from the WoodSolutions website assesses the impact of the interface details on the FRL, RISF and MRISF of the systems



Shaft continuity at timber framed floor



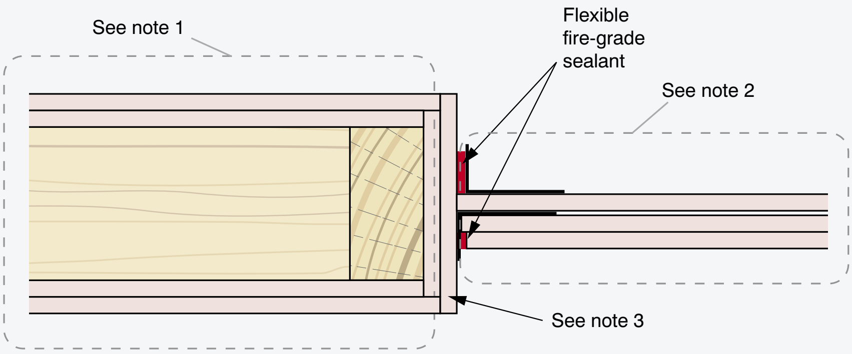
Shaft continuity at massive timber panel floor

Figure 7.27: Interfaces between fire-protected timber and steel stud shafts.

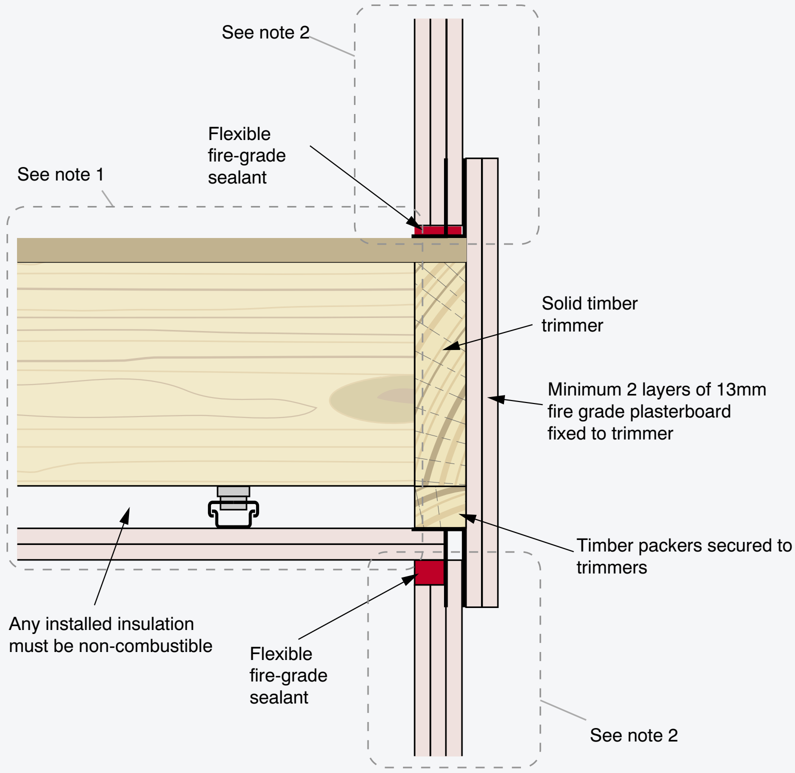
Note 1: Fire-protected timber element having the required FRL and RISF or MRISF as appropriate. Any cavity insulation must be non-combustible.

Note 2: Shaft wall construction having the required FRL.

Report RIR 37401400 assesses the impact of the interface details on the on the FRL, RISF and MRISF of the systems



Laminated shaft to timber stud wall



Shaft continuity at timber framed floor opening. (Massive timber detail similar)

Figure 7.28: Interfaces between fire-protected timber and laminated board shafts..

Note 1: Fire-protected timber element having the required FRL and RISF or MRISF as appropriate. Any cavity insulation must be non-combustible.

Note 2: Shaft wall construction having the required FRL.

Note 3: Interface protected with the same fire protective coverings that are applied to the fire-protected timber element face. Shaft wall tracks are to be screw fixed to timber elements at 300 mm maximum centres with 62 mm long screws.

7.8 Fire Doors in Fire-protected Timber Walls

Fire door assemblies are required to comply with AS 1905.1 as appropriate in addition to achieving the required FRL. Generally, fire doors are required to be tested when mounted in a wall of representative construction. Evidence of suitability should therefore be provided from the supplier that relates to the performance of their fire doors when mounted in representative timber elements of construction.

In addition, the fire doors must not compromise the RISF or MRISF performance of the wall. The frame-fixing details shown in Figure 7.29 have been assessed by an Accredited Testing Laboratory to determine that the details will not reduce the RISF or MRISF to below 45 minutes for the timber-frame systems and 30 minutes for the massive timber panel systems (Refer report reference RIR 37401400). Other details may be adopted if appropriate Evidence of Suitability to demonstrate compliance with the NCC requirements for fire doors and fire-protected timber elements is provided.

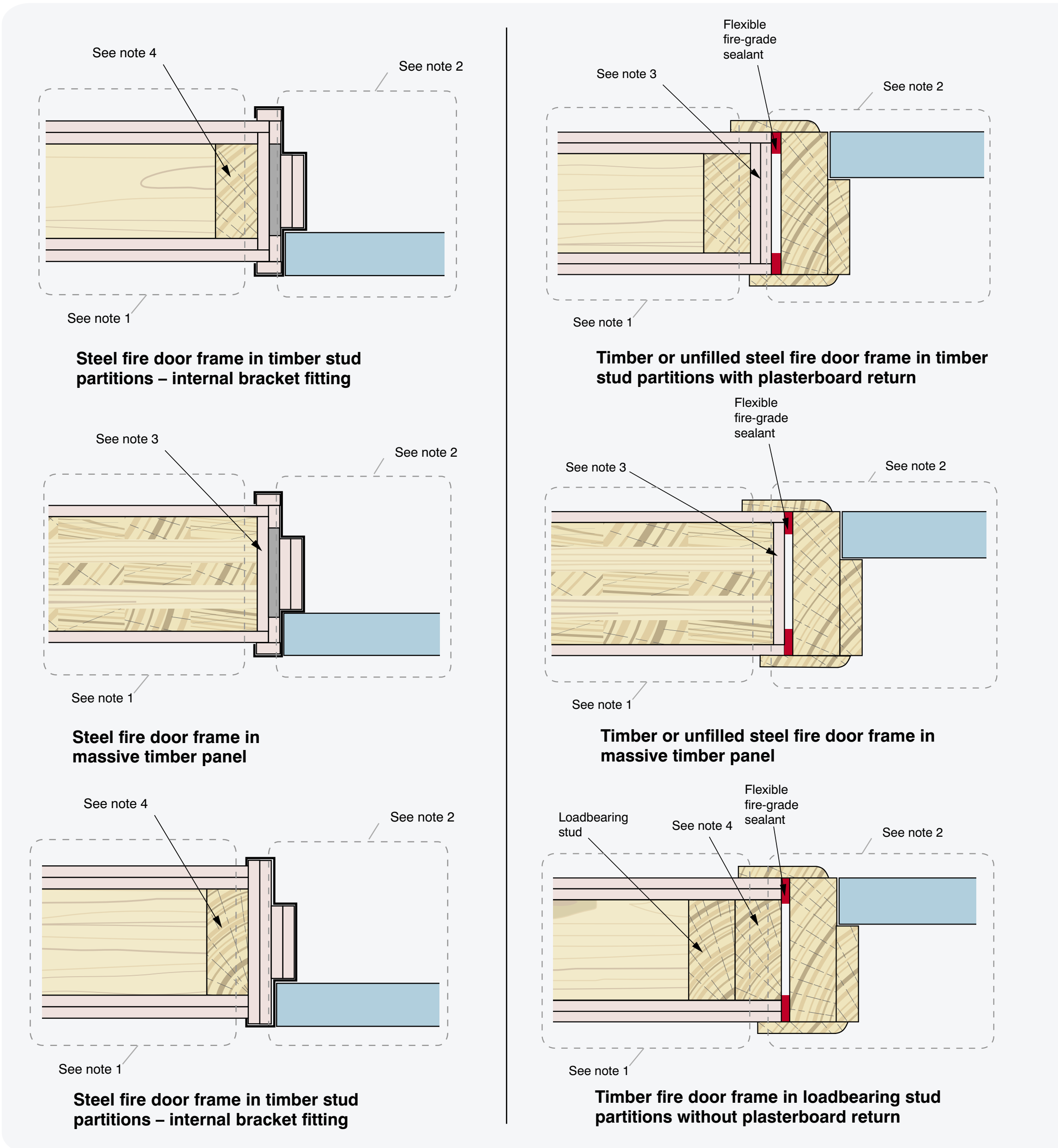


Figure 7.29: Fire door interface details.

Note 1: Fire-protected timber element having the required FRL and RISF or MRISF as appropriate. Any cavity Insulation must be non-combustible.

Note 2: Fire Door Assembly with the required FRL determined in accordance with AS 1530.4 and AS 1905.1 as appropriate.

Note 3: Interface protected with the same fire protective coverings that are applied to the fire-protected timber element face.

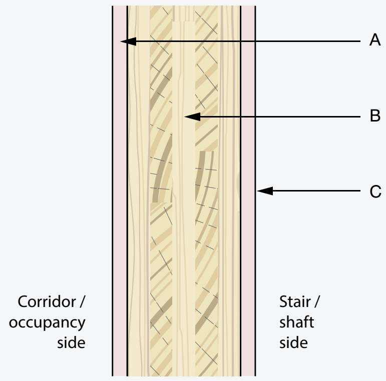
Note 4: Minimum of 45 mm thick non-loadbearing solid timber cavity barrier framing the cavity opening around the door.

7.9 Construction of Fire-isolated Shafts

Fire-isolated stair shafts can be constructed from fire-protected timber, concrete masonry and other non-combustible non-loadbearing materials or a hybrid construction may be adopted. The selection will depend on the structural design of the building, construction programming and other factors. The required FRL for fire-isolated stair shafts in healthcare buildings is 120/120/120 unless modified by other parts of the building having a different Class.

Where concrete or masonry shafts are used the design will need to account for differential movement between the shaft and timber structure.

A concession is provided for massive timber panels in that the fire-protective covering for the internal face of the shaft is permitted to achieve a MRISF of 20 minutes rather than the 30 minutes required for the outer face (see Figure 7.30 and Figure 7.31). The fire protective coverings around the face of openings for doors and access panels should be the greater of that required for the external facing or to achieve the required FRL.



Construction
A Linings min 1 x 16 mm fire-protective grade plasterboard (corridor/occupancy side)
B Massive timber min 75 mm thick ***(note greater thickness may be required to achieve required FRL unless additional fire protective coverings applied)***
C Linings min 1 x 13 mm fire-protective grade plasterboard (internal shaft side)

Performance
FRL 90/90/90 obtain Evidence of Suitability from supplier
MRISF 30 mins (1 x 16 mm fire-protective grade plasterboard) – NCC Spec C1.13a DTS
MRISF 20 mins (1 x 13 mm fire-protective grade plasterboard) – NCC Spec C1.13a DTS

Figure 7.30: Typical stair and lift shaft construction for single skin massive timber panel construction.

Although a minimum panel thickness of 75 mm is permitted, in most instances substantially greater thicknesses will be required as part of the structural design and/or to achieve the required FRLs. The FRL should be checked to ensure the load levels during the test were comparable to the loads that will be applied under fire conditions.

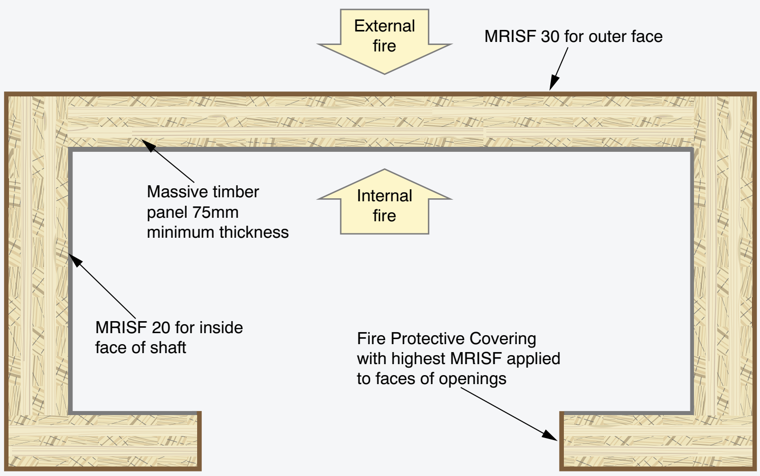


Figure 7.31: MRISF requirements for typical stair and lift shaft construction for single skin massive timber panel construction.

7.10 Construction for Stairways within Fire-isolated Stairs

NCC Clause D2.25 provides a concession allowing timber treads, risers, landings and associated supporting framework to be used within a required fire-isolated stairway or fire-isolated passageway provided the timber used:

- has a finished thickness of not less than 44 mm with an average timber density of not less than 800 kg/m^3 (at 12% moisture content).
- the building is protected throughout by a sprinkler system complying with Specification E1.5 (other than a FPAA101D or FPAA101H system) that is extended to provide coverage within the fire-isolated enclosure
- the underside of flights of stairs directly above landings providing access to ground level or car parking levels being protected by a single layer of 13 mm fire-protective grade plasterboard fixed to the stringers with fixings at not greater than 150 mm centres (Figure 7.32).

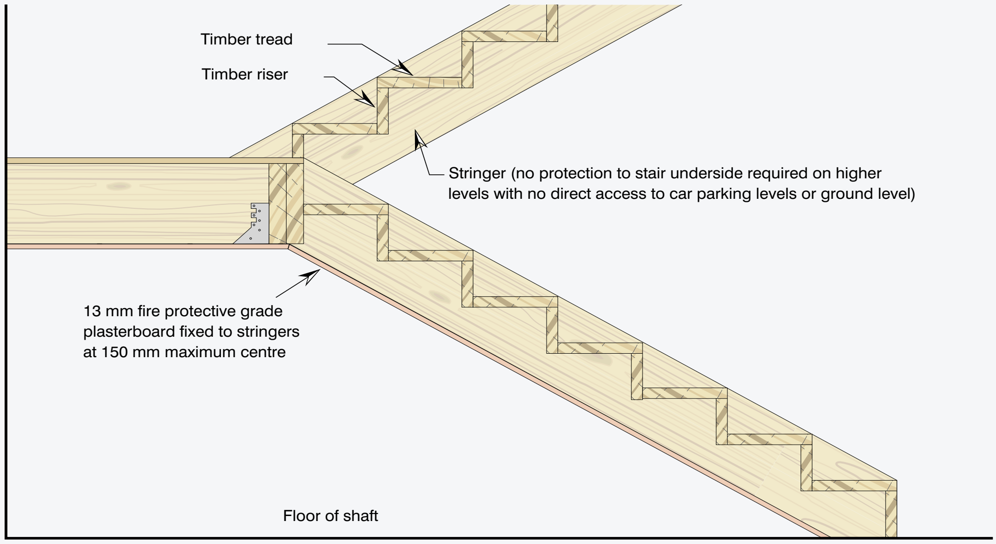


Figure 7.32: Stairway fire protection.

Impact sound from stair usage may vibrate the stair shaft walls, creating a pathway for sound transmission. A practical way to prevent this is by isolating the support for the stair structure by using stringers to support the stairs (top and bottom) rather than the wall adjoining areas requiring sound isolation (see Figure 7.33). In some instances, newel posts to support the stringers may be necessary.

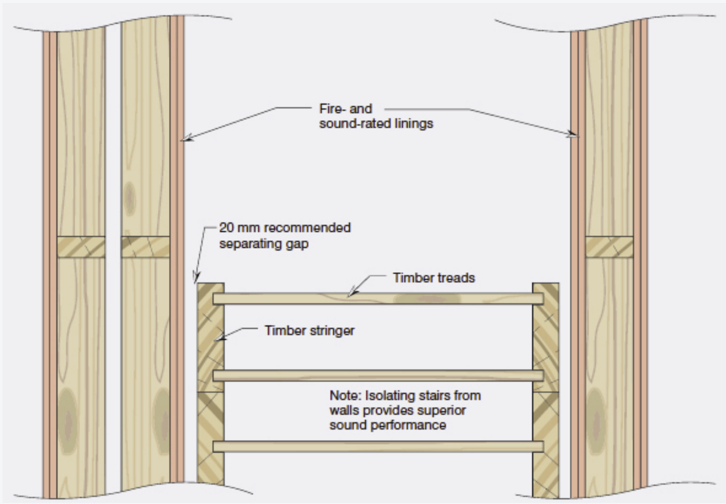


Figure 7.33: Sound isolation of stairway.

If a non-combustible stair (e.g. steel) is installed within the fire-protective timber stair shaft, the sprinkler system does not require extending to provide coverage in a fire-isolated stair.

7.11 Construction of Lift Shafts

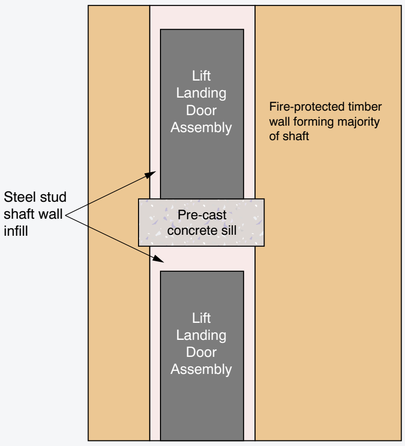
Lift shafts can be constructed in a similar manner to stair shafts as described above. Care is needed to ensure that the lift shaft is compatible with the selected lift system. Compatibility issues should be resolved early in the design process and early liaison with the lift supplier is strongly recommended.

In the short term, most lift landing door assemblies will have been fire tested in masonry/concrete or steel stud shaft wall systems. The following details provide an interface between fire-protected timber and a pre-cast concrete sill and steel shaft wall systems. This can enable lift doors to be installed within sections of the wall of steel stud /plasterboard shaft wall and concrete construction to which existing lift landing door fire-resistance test results can be applied.

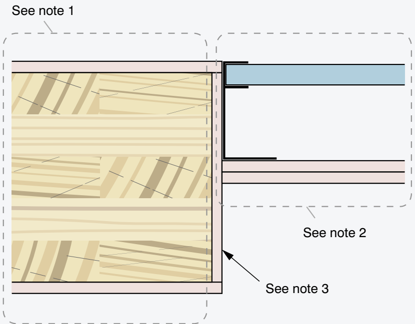
In the longer term, a larger range of lift landing doors is expected to be fire tested in fire-protected timber construction, providing simpler installation details.

The interface details in Figure 7.34 have been assessed by an Accredited Testing Laboratory (refer report RIR 37401400). The applicability of the Evidence of Suitability to an application should be checked with the authority having jurisdiction.

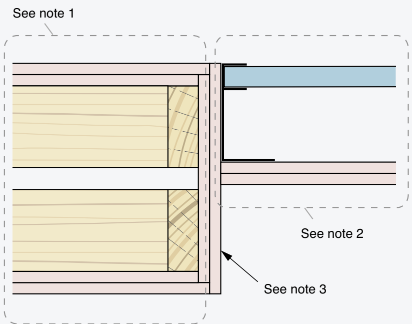
Impact sound from lift use may vibrate the lift shaft walls, creating a pathway for sound transmission. While this can be addressed to some extent using double stud wall assemblies or twin-skin massive timber panel construction utilising two layers of 13 mm plasterboard, there are other options, such as the construction of a framework within the lift shaft that supports the lift assembly independently.



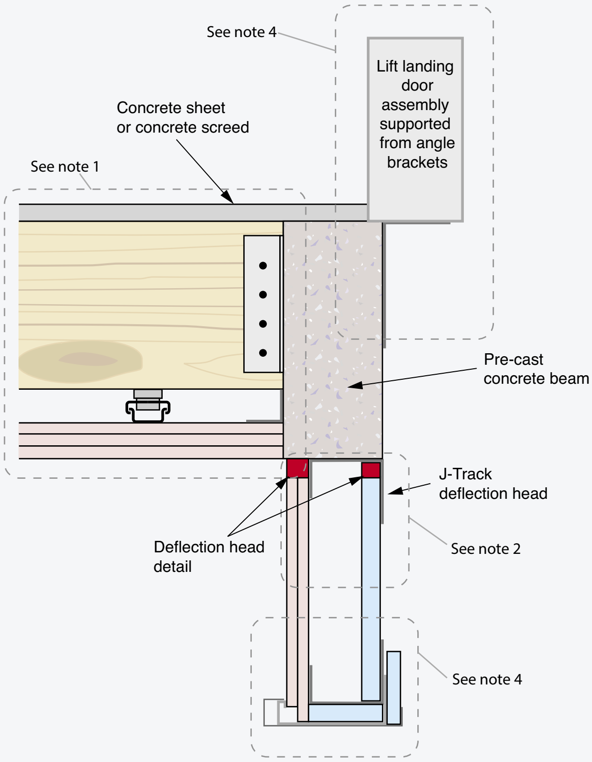
Elevation of lift doors in shaft



Side interface between shaft-wall and double timber stud shaft



Side interface between shaft-wall and massive timber panel



Head and sill detail for interfaces with shaft wall and concrete sill (timber-frame)

Figure 7.34: Typical details for shaft wall conversion for lift-landing door installation.

Note 1: Fire-protected timber element having the required FRL and RISF or MRISF as appropriate. Any cavity insulation must be non-combustible.

Note 2: Shaft wall construction having the required FRL.

Note 3: Interface protected with the same fire protective coverings that are applied to the fire-protected timber element face.

Note 4: Lift landing door assembly having the required FRL installed in accordance with the lift door and shaft wall supplier instructions and evidence of compliance confirming the FRL.

7.12 Cavity Barriers and Junction Details

Cavity barriers are required at the junctions between fire-protected timber floor assemblies and fire-protected timber walls in framed construction. In many instances the Deemed-to-Satisfy solutions permitting the use of solid timber and/or mineral fibre enable integration of cavity barriers with typical wall and floor junction details.

7.12.1 Typical Junction Details at Intersection of Fire-Protected Timber Walls and Floors

Cavity barriers are required at the junctions between fire-protected timber floor assemblies and fire-protected timber walls in framed construction. In many instances the Deemed-to-Satisfy Solutions permitting the use of solid timber and/or mineral fibre enable integration of cavity barriers with typical wall and floor junction details.

The key design parameters are to achieve, as a minimum, the required seal thickness in the direction of potential fire spread through the cavity and ensure the seals are continuous.

Typical details for double stud walls and external walls are shown in Figure 7.35 to Figure 7.38. These details are based on a 'ring beam' design concept which can be useful in the management of the risk of disproportionate collapse. This form of construction is also compatible with the prefabrication of floor cassettes. Prefabrication can provide several advantages including:

- acceleration of the construction program
- improved quality control
- improved safety.

Although the mineral fibre cavity barrier is only required to be 45 mm or 60 mm thick (depending on the required FRL of the elements) in the potential direction of fire spread, where practical, installation of cavity barriers the full floor depth provides a more robust solution since any joins in the ring beam/ blocks will also be backed by the mineral fibre.

For single stud internal walls, the detail is simplified because the top and bottom plates of the wall frame close off the cavities within the wall as shown in Figure 7.38.

Massive timber panel designs are required to avoid cavities and therefore the main consideration with the design of junctions is to maintain continuity of the fire-protective coverings.

Figure 7.35 to Figure 7.38 include typical examples of joint seals to allow for movement and maintain acoustic and fire separations. The joint sealing details may vary, depending on the installation order of wall and ceiling fire-protective grade coverings, among other things. Refer to the plasterboard and/or sealant suppliers for Evidence of Suitability.

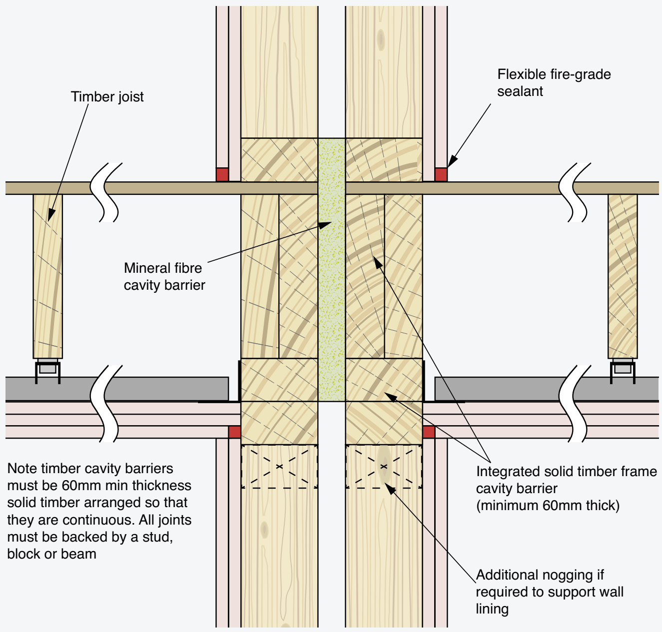


Figure 7.35: FRL 120/120/120 Fire-protected timber frame wall/floor junction with integral cavity barriers – beams parallel to wall

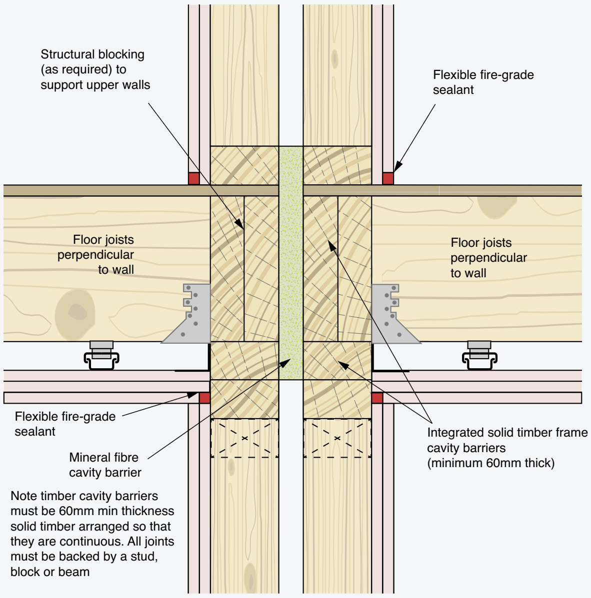
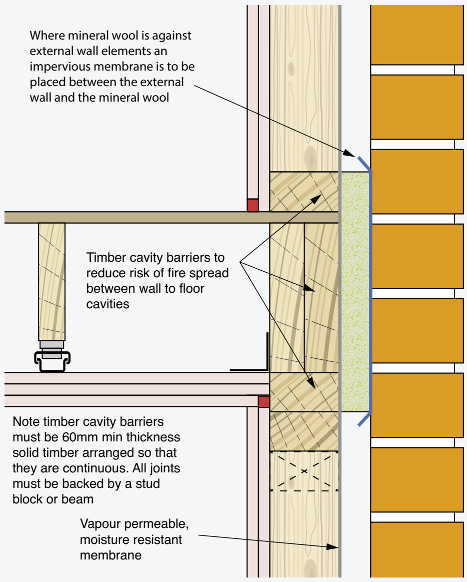


Figure 7.36: FRL 120/120/120 Fire-protected timber frame wall /floor junction with integral cavity barriers – beams perpendicular to wall.



Performance can vary dependant on stud frame depth, installed insulation, cavity insulation and masonry veneer material and thickness. Evidence of suitability must be obtained to demonstrate compliance with the required FRL.

Figure 7.37: FRL 120/120/120 Fire-protected timber frame wall/floor junction with integral cavity barriers – beams parallel to wall.

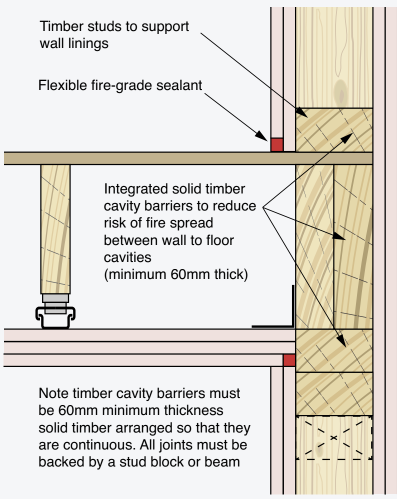


Figure 7.38: FRL 120/120/120 Fire-protected single stud timber frame wall/floor junction with integral cavity barriers – beams parallel to wall.

7.12.2 Vertical Cavity Barriers

Vertical cavity barriers are required at the intersection of walls and at 10 metres maximum horizontal centres. Typical details for double stud walls and external walls are shown in Figure 7.39 to Figure 7.42.

For double stud walls separate cavity barriers can be provided for each skin as shown in Figure 7.40 but in most instances a more practical solution is to fit a wider section spanning the full width of the intersecting wall, as shown in Figure 7.39 and Figure 7.41.

Massive timber designs are required to avoid cavities and therefore the main consideration with the design of junctions is to maintain continuity of the fire-protective coverings.

Where external cladding or veneer systems form part of the fire-protective coverings (e.g. brick veneer) at cavity barrier positions an impervious membrane must be placed between the mineral fibre and cladding or veneer surface to control moisture transfer from the cladding or veneer.

An alternative approach for external walls that may avoid the risk of bridging at cavity barrier positions is to apply the fire-protective coverings to the outer face of the timber elements as well as the inner face and then fit a non-combustible external cladding system that satisfies the NCC DTS requirements.

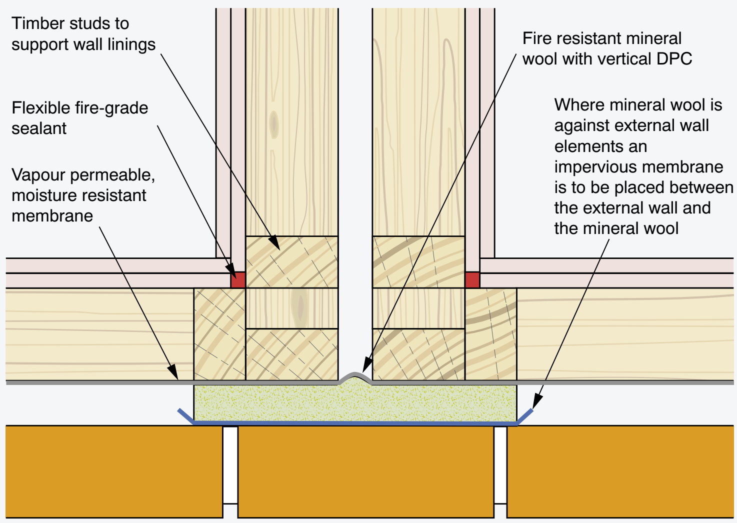


Figure 7.39: Double stud fire-protected timber internal wall intersecting a brick veneer wall.

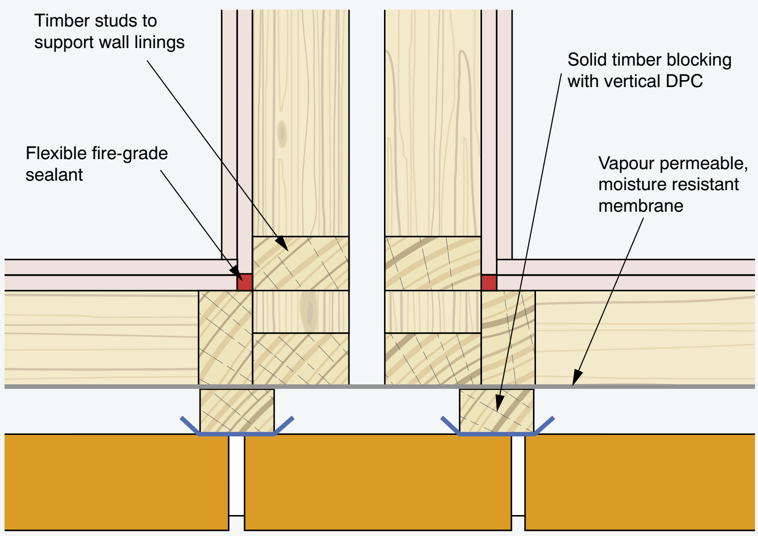


Figure 7.40: Double stud fire-protected timber internal wall intersecting a brick veneer wall with split cavity barrier system.

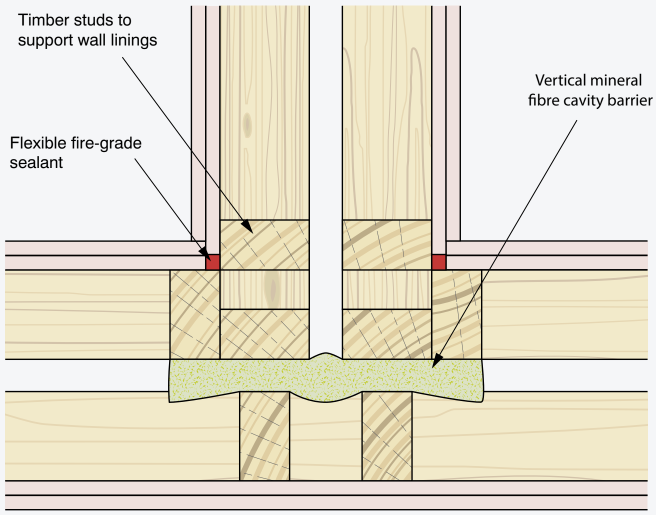


Figure 7.41: Double stud fire-protected timber internal wall intersection.

Provided the timber studs are a minimum of 45 mm thick, intermediate cavity barriers (at maximum 10 metres centres) can be fitted at a stud position as shown in Figure 7.42 if FRLs for the elements no greater than 90/90/90 are required. In elements with higher FRLs (as required for Class 9 buildings) the timber thickness must be increased to a minimum of 60 mm, which can be achieved by nailing 2 to 35 mm studs together (70 mm total thickness)

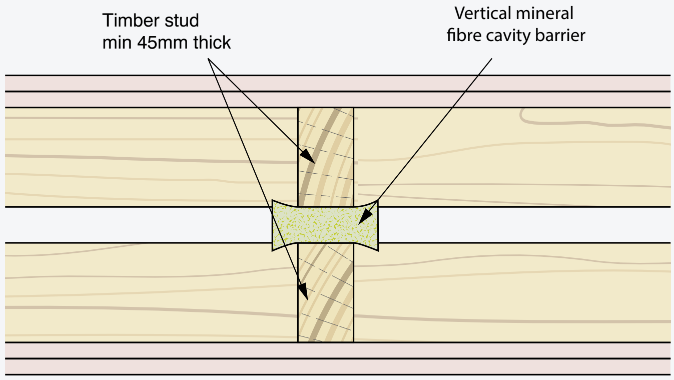


Figure 7.42: Intermediate vertical cavity barrier in double stud wall. Cavity barrier stud thickness needs to be increased to 60 mm if this detail is to be applied for FRLs greater than 90/90/90.

7.12.3 Unprotected Openings in External Walls

Cavity barriers are required around the perimeter of openings, such as unprotected windows in external walls, to prevent premature entry into the fire-protected timber cavities at these positions.

A typical example is shown in Figure 7.43 for an external wall. Timber and mineral fibre thicknesses to be selected based on required FRL as specified in NCC Spec C1.13 Table 1.

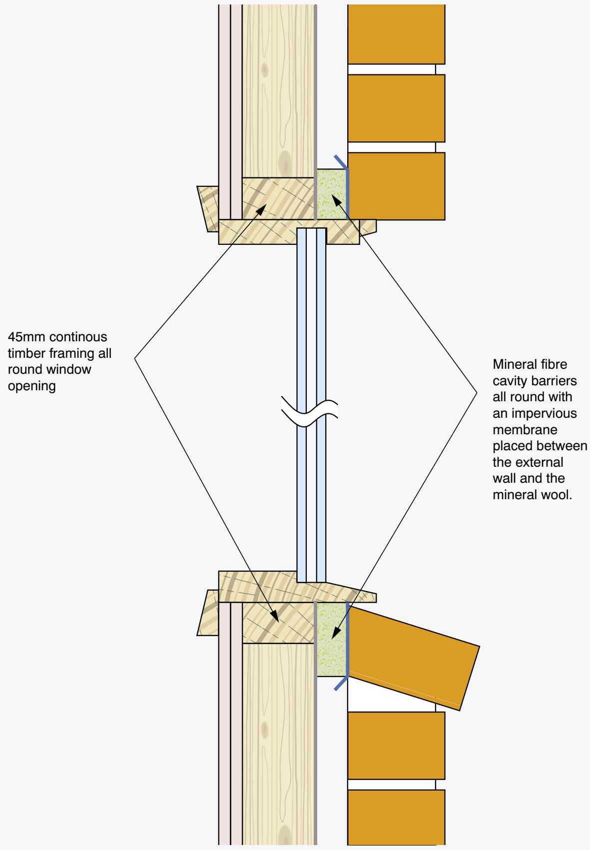


Figure 7.43: Cavity barrier around window in external wall. (Minimum thickness of timber and mineral fibre must be in accordance with NCC Spec C1.13 Table 1).

7.12.4 Intersection of Non-fire-resisting Walls with Fire-protected Timber Elements

Fire-protective coverings of fire-protected timber elements should not be interrupted at the point of intersection with non-fire-resisting walls to ensure the FRLs and RISF or MRISF are not compromised.

Typical examples are shown in Figure 7.44 and Figure 7.45. Where the non-fire-resisting element is fixed to the fire-protected element, additional framing may be required to avoid the risk of failure of the non-fire-resisting element compromising that of the fire-protected element. A typical detail for additional framing is shown in Figure 7.45.

With massive timber, the fixing point is less likely to require additional strengthening.

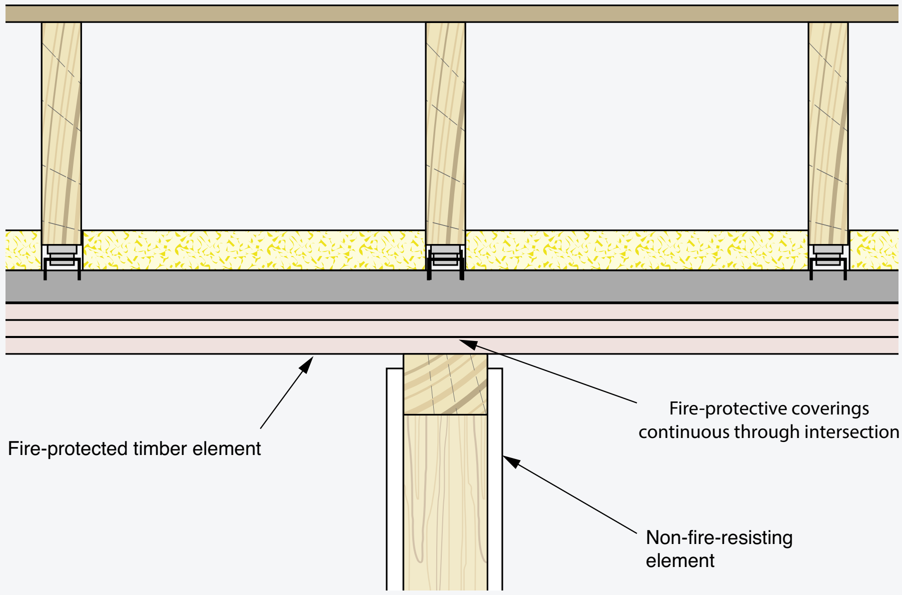


Figure 7.44: Junction of non-fire-resistant wall and fire-protected timber floor

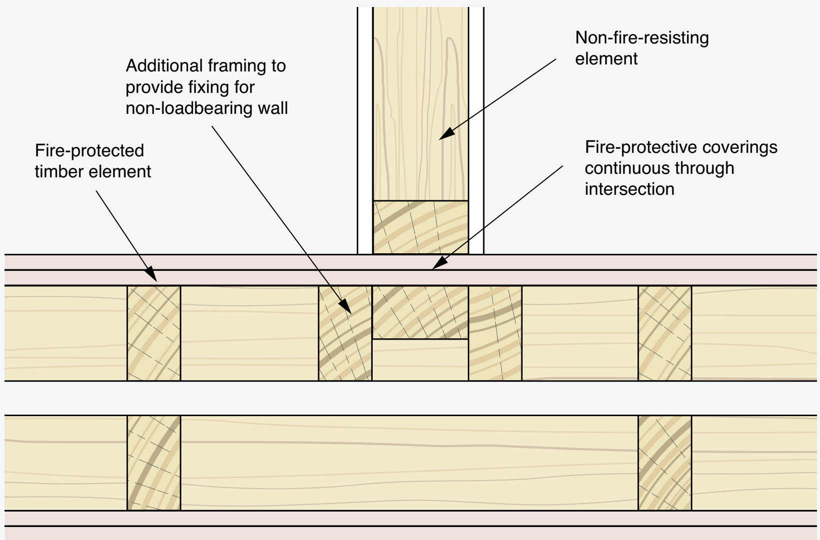


Figure 7.45: Junction of non-fire-resistant wall with fire-protected timber wall including additional framing detail.

7.12.5 Roof Space Cavity Barriers or Fire-protected Timber Wall Extension

Special attention needs to be given to the design of roof spaces to address the risk of uncontrolled fire spread if timber-frame construction is adopted, although for many applications massive timber construction may be preferred. There are generally two approaches that can be adopted for timber-frame construction.

Option 1: Extend fire-resisting timber walls to roof level

This option requires fire-protected timber walls to be continued to roof level (Figure 7.46). This has the advantage that the ceilings to the top floor do not need to be fire-resisting because the wall extension can provide the necessary fire and sound separation.

It is critical that the seal against the underside of the roof can achieve the required FRL, RISF or MRISF and that the fire separation is not interrupted or bypassed at vulnerable positions such as the eaves or where framing members intersect extension of the SOU boundary walls.

If this option is adopted a horizontal cavity barrier should be provided for timber-framed construction at ceiling level as shown in Figure 7.46.

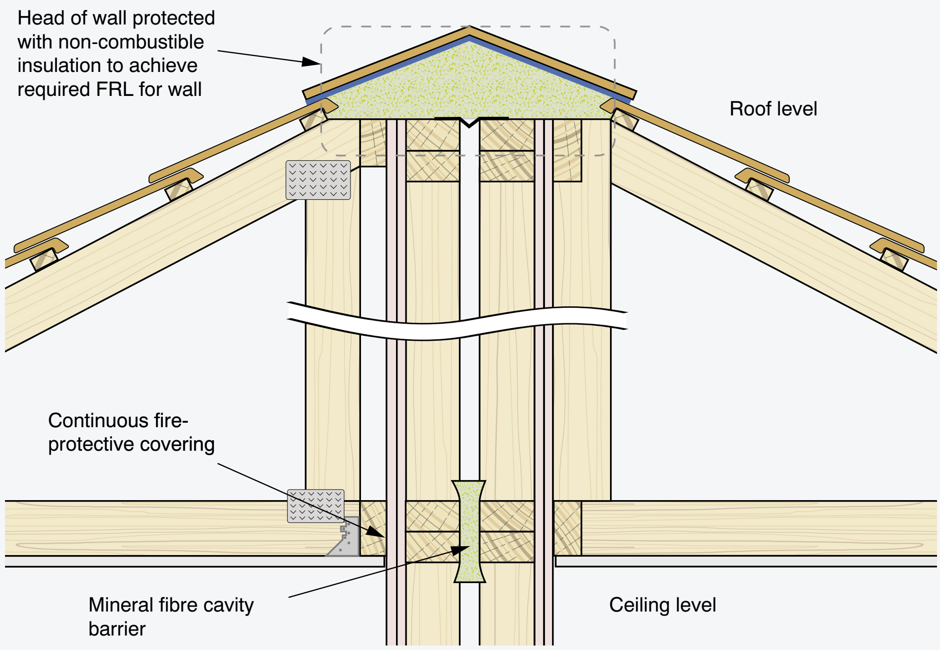


Figure 7.46: Roof space Option 1 extending SOU bounding fire-protected timber walls to roof level.

Option 2: Provide fire-protected timber ceiling and cavity barriers within roof space

If Option 2 is applied to the Class 9 example building, assuming timber-framed construction, the ceiling/roof system would require an FRL of 120/60/30 and a RISF of 45 minutes. The roof spaces would need to be divided by cavity barriers above each wall required to be fire resisting. Where the roof void is relatively deep it may be impractical to apply the Deemed-to-Satisfy Solutions of solid timber or mineral fibre and a plasterboard partition achieving the required FRL of −/60/60 minutes or a proprietary cavity barrier may provide a more practical solution as shown in Figure 7.47.

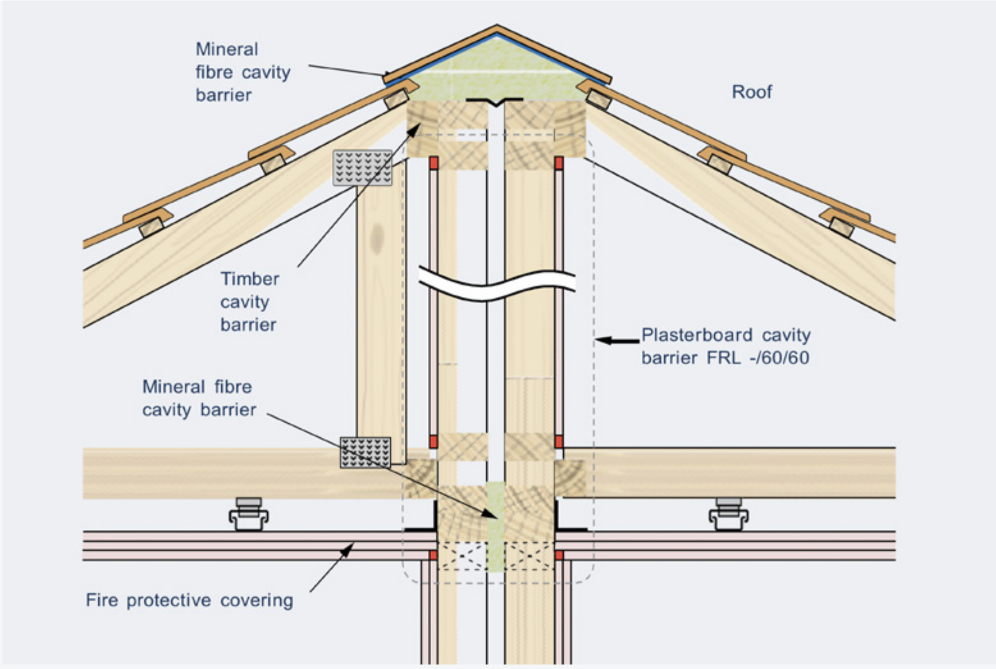


Figure 7.47: Roof space Option 2 fire-protected timber ceiling and cavity barriers within roof space.

If this option is selected it is critical that the seal against the underside of the roof is capable of achieving the required performance and the fire separation provided by the cavity barrier is not interrupted or bypassed at vulnerable positions such as the eaves or where framing members intersect at the extension of the fire-resistant wall.

A horizontal cavity barrier should be provided for timber-framed construction at ceiling level as shown in Figure 7.47. Depending on the roof design the roof cavity height can vary from nominally 150 mm to several metres and careful consideration should be given to detailing and checking installations to ensure the design objectives are achieved.

7.13 Service Penetration Treatments

Careful detailing of services and service penetration systems during the design stages can simplify construction details and streamline the construction process as described in early chapters of this Guide. The general design approach can be expressed as three fundamental principles:

1. Select services, service locations and service runs to avoid, as far as practical, the need for service penetrations through fire-protected timber elements (e.g. the use of false walls and ceilings can substantially reduce the number of penetrations that require protecting).
2. If service penetrations cannot be avoided, where practical they should be grouped and penetrate lined openings or non-combustible shaft walls, which minimises the risk of exposing the cavity during maintenance operations. This approach also simplifies the installation of new services.
3. If service penetrations are required to pass through fire-protected timber elements, ensure the FRL and RISF or MRISF as appropriate at service penetration positions.

The following Sections provide typical generic examples. Over time, it is expected that proprietary systems will become available simplifying the installation process.

7.13.1 Multi-penetration Systems with Lined Openings

Refer report RIR 37401400 available from WoodSolutions website

Typical multi-penetration systems with lined openings are shown in Figure 7.48.

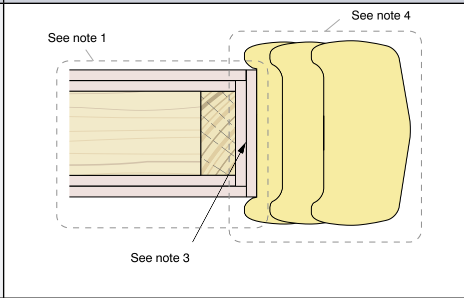
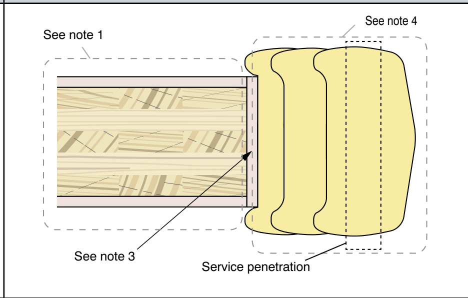
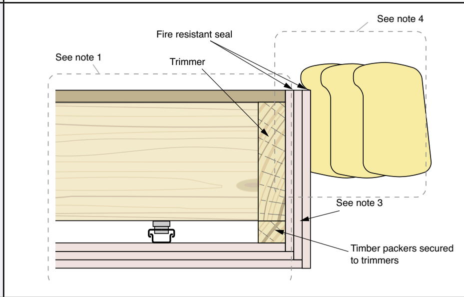
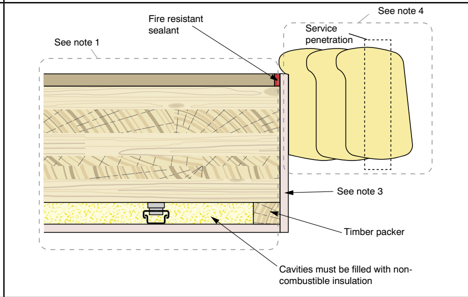
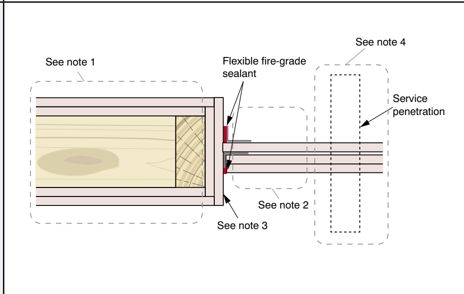
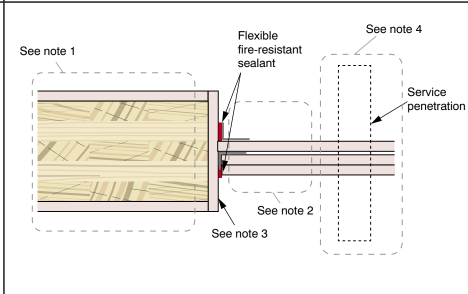
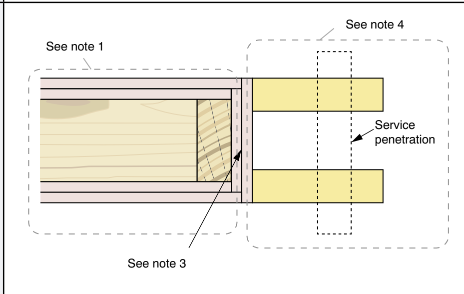
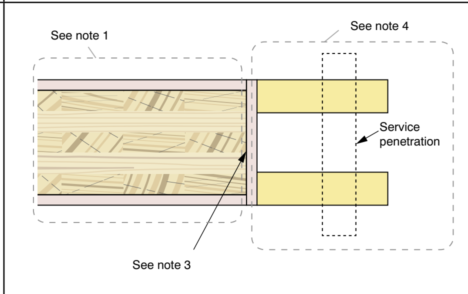
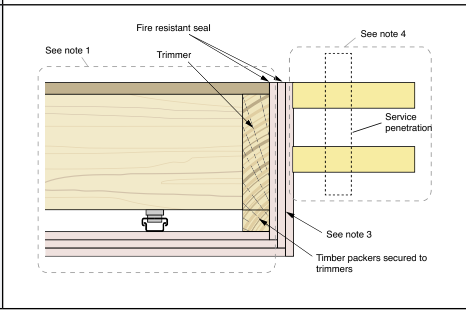
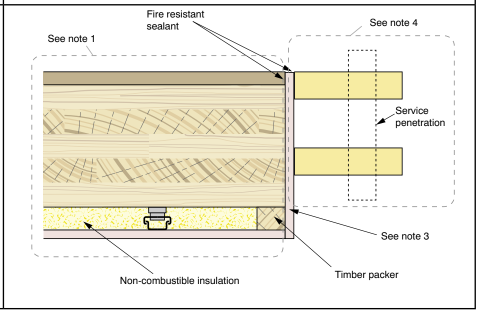
System	Timber Frame	Massive Timber Panel
Pillow in wall opening		
Pillow in floor opening		
Shaft-wall infill in wall opening		
Mineral fibre batt wall opening		
Mineral fibre batt floor opening		

Figure 7.48: Typical multi-penetration systems with lined openings.

Note 1: Fire-protected timber element having the required FRL and RISF or MRISF as appropriate. Any cavity insulation must be non-combustible.

Note 2: Shaft wall construction having the required FRL.

Note 3: Interface protected with the same fire protective coverings that are applied to the fire-protected timber element face.

Note 4: Service penetration protected to achieve the required FRL. Evidence of performance to be in the form of a report from an Accredited Testing Laboratory in accordance with AS 1530.4 and AS 4072.1 as appropriate.

Interface details shown in Figure 7.48 have been assessed by an Accredited Testing Laboratory to determine that the details will not reduce the RISF or MRISF to below 45 minutes for the timber frame systems and 30 minutes for the massive timber panel systems (Refer Report RIR 37401400). Other details may be adopted provided appropriate Evidence of Suitability to demonstrate compliance with the NCC requirements is provided.

Refer report RIR 37401400 available from WoodSolutions website

7.13.2 Fire Damper and Duct Penetrations

The lined opening approach can also be applied to duct and damper penetrations (Figure 7.49).

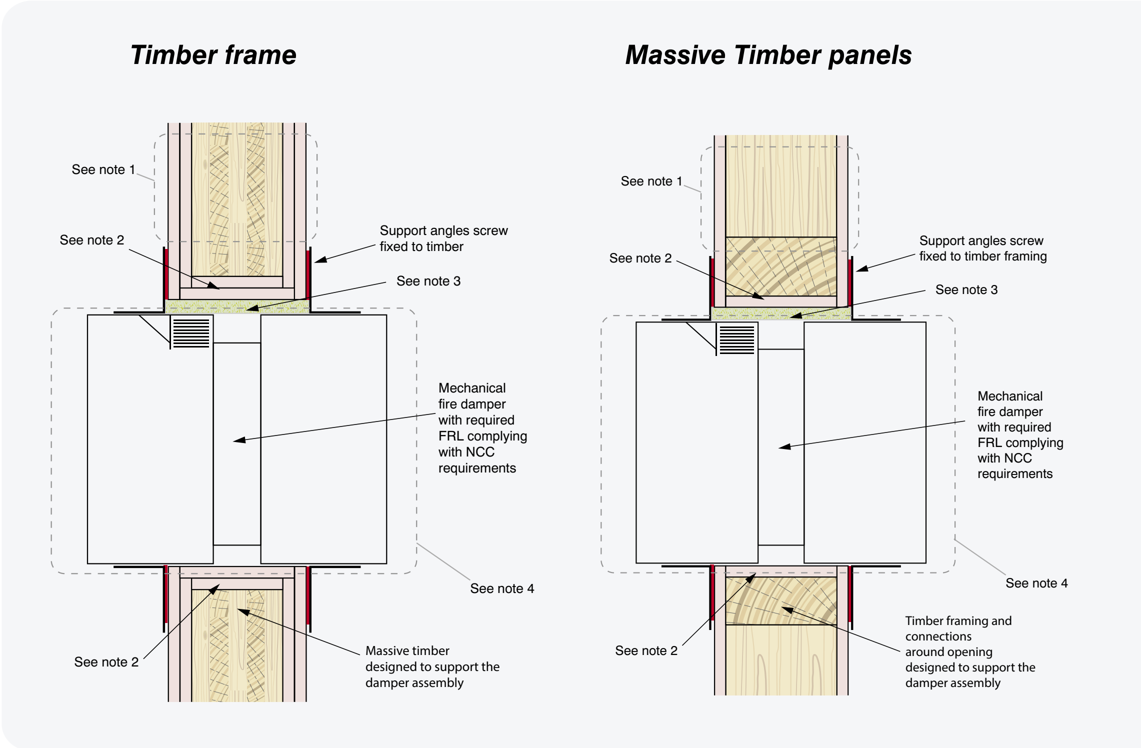


Figure 7.49: Typical details for fire damper and duct penetrations.

Note 1: Fire-protected timber element having the required FRL and RISF or MRISF as appropriate. Any cavity insulation must be non-combustible.

Note 2: Interface protected with the same fire protective coverings that are applied to the fire-protected timber element face.

Note 3: Non-combustible mineral fibre packing may be used for fire damper penetration seal or proprietary fire damper penetration seals that achieve the required FRL with evidence of performance in the form of a report from an Accredited Testing Laboratory to be in accordance with AS 1530.4 and AS 4072.1 as appropriate.

Note 4: Mechanical fire damper having the required FRL when tested in accordance with AS 1530.4 and complying with AS 1682 Parts 1 and 2 as appropriate.

7.13.3 GPO Outlets and Switches

Where practical, the need to protect GPO outlets, switches and similar penetrations should be avoided by mounting them within internal (non-fire-resisting walls) or false (decorative) linings fitted in front of fire-protected timber elements as shown in Figure 7.50.

Methods of attaching non-fire-resisting decorative linings that will not compromise the FRL, RISF or MRISF performance of wall and floor systems, such as shown in Figure 7.50, have been assessed in a report from an Accredited Testing Laboratory (refer RIR 37401400).

If it is impractical to apply an additional lining, a proprietary GPO protection system may be adopted, if it has Evidence of Suitability, demonstrating that the required FRL and RISF or MRISF for the element will not been compromised.

Alternatively, the generic systems shown in Figure 7.51 or Figure 7.52 may be adopted.

New products (e.g. skirting service ducts) also enable services to be run without penetrating fire-protective grade linings.

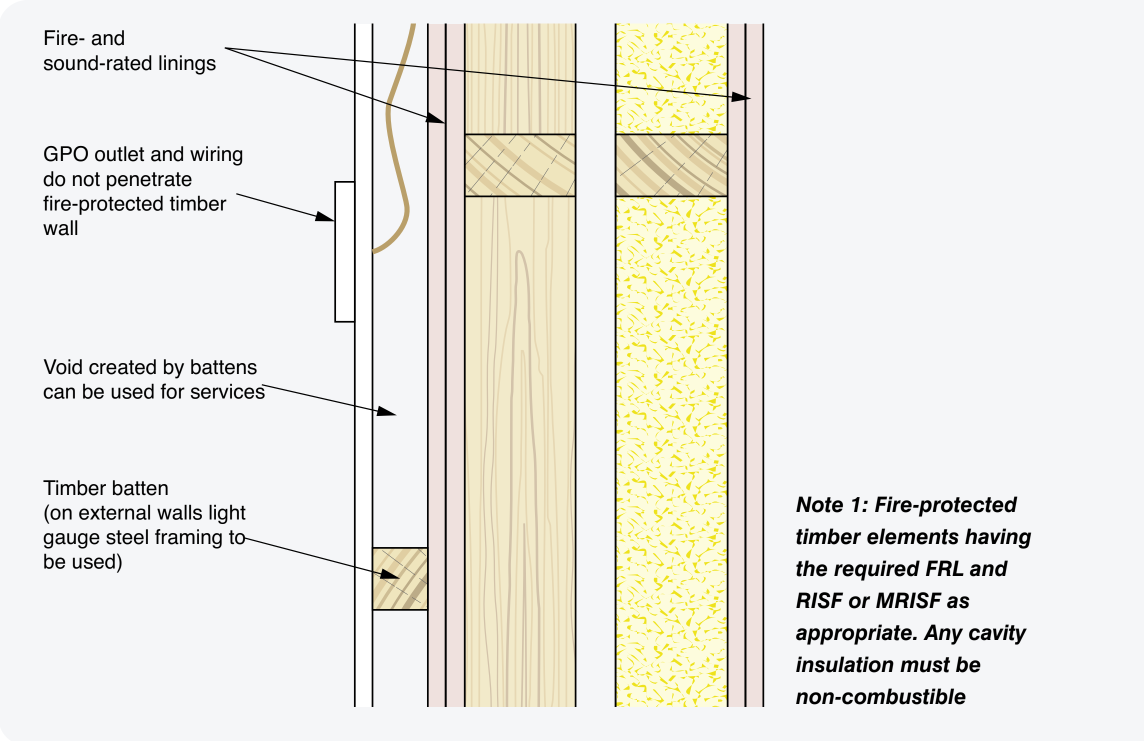


Figure 7.50: False wall system.

Refer report RIR 37401400 available from WoodSolutions website

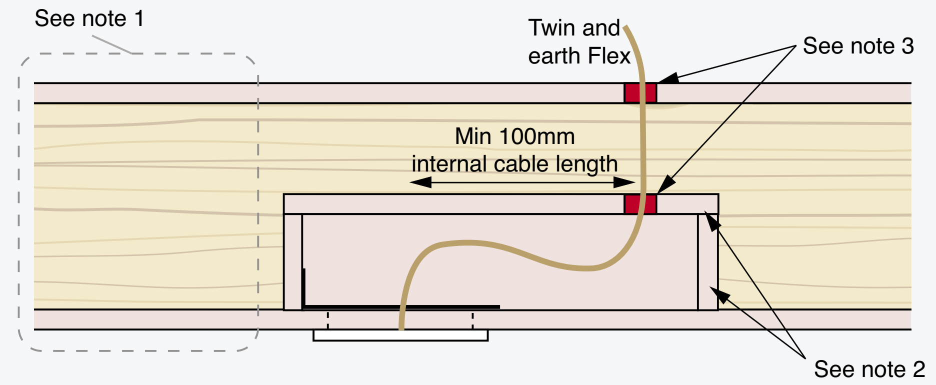


Figure 7.51: Generic GPO protection systems in massive timber construction.

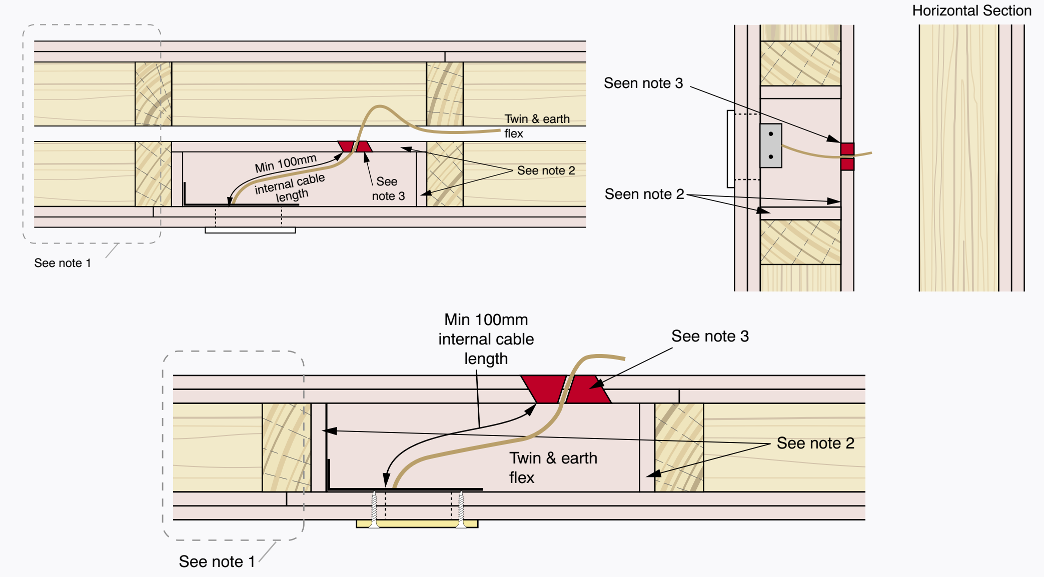
Note 1: Fire-protected timber element having the required FRL and RISF or MRISF as appropriate. Any cavity insulation must be non-combustible.

Note 2: Aperture lined with a minimum of one layer of 16 mm plasterboard. Greater thicknesses/number of layers may be required for the faces of the wall since it forms part of the wall system.

Note 3: Linings must be sealed full depth where penetrated by a service with a 'fire-resistant mastic'. The mastic should have a test report from an Accredited Testing Laboratory demonstrating that when protecting pipe or cable service penetrations through plasterboard elements the system can achieve

Refer report RIR 37401400 available from WoodSolutions website

Plasterboard lined framed out protection.



Mineral fibre protection

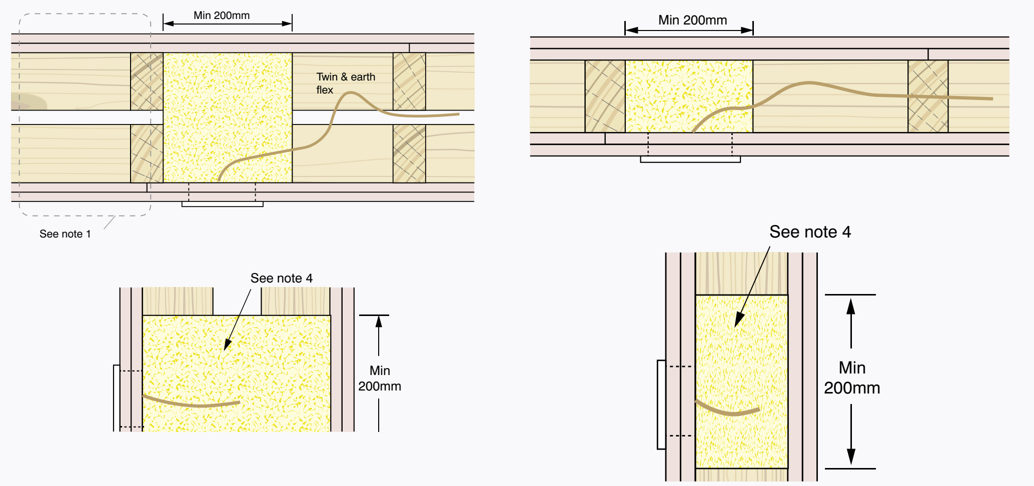


Figure 7.52: Generic GPO protection systems in timber-framed construction.

Note 1: Fire-protected timber element having the required FRL and RISF or MRISF as appropriate. Any cavity Insulation must be non-combustible.

Note 2: Aperture lined with a minimum of one layer of 16 mm plasterboard. Greater thicknesses/number of layers may be required for the faces of the wall since it forms part of the wall system.

Note 3: Linings must be sealed full depth where penetrated by a service with a 'fire-resistant mastic'. The mastic should have evidence of performance in the form of a test report from an Accredited Testing Laboratory demonstrating that when protecting pipe or cable service penetrations through plasterboard elements the system can achieve an FRL of –/60/–.

Note 4: Cavity filled full depth with mineral fibre of minimum density 60 kg/m3 for at least 100 mm to the sides and above and below the centreline of the GPO.

Note: Fire tested proprietary systems in which the RISF or MRISF performance have been determined may provide more practical options; subject to adequate Evidence of Suitability being available.

Refer report RIR 37401400 available from WoodSolutions website

7.13.4 Single Cable and Metal Pipe Penetrations

If it is impractical to apply an additional lining, a proprietary system may be adopted, if it has Evidence of Suitability, demonstrating that the required FRL and RISF or MRISF for the element will not been compromised.

Alternatively, the generic systems shown in Figures 7.53 and 7.55 may be adopted.

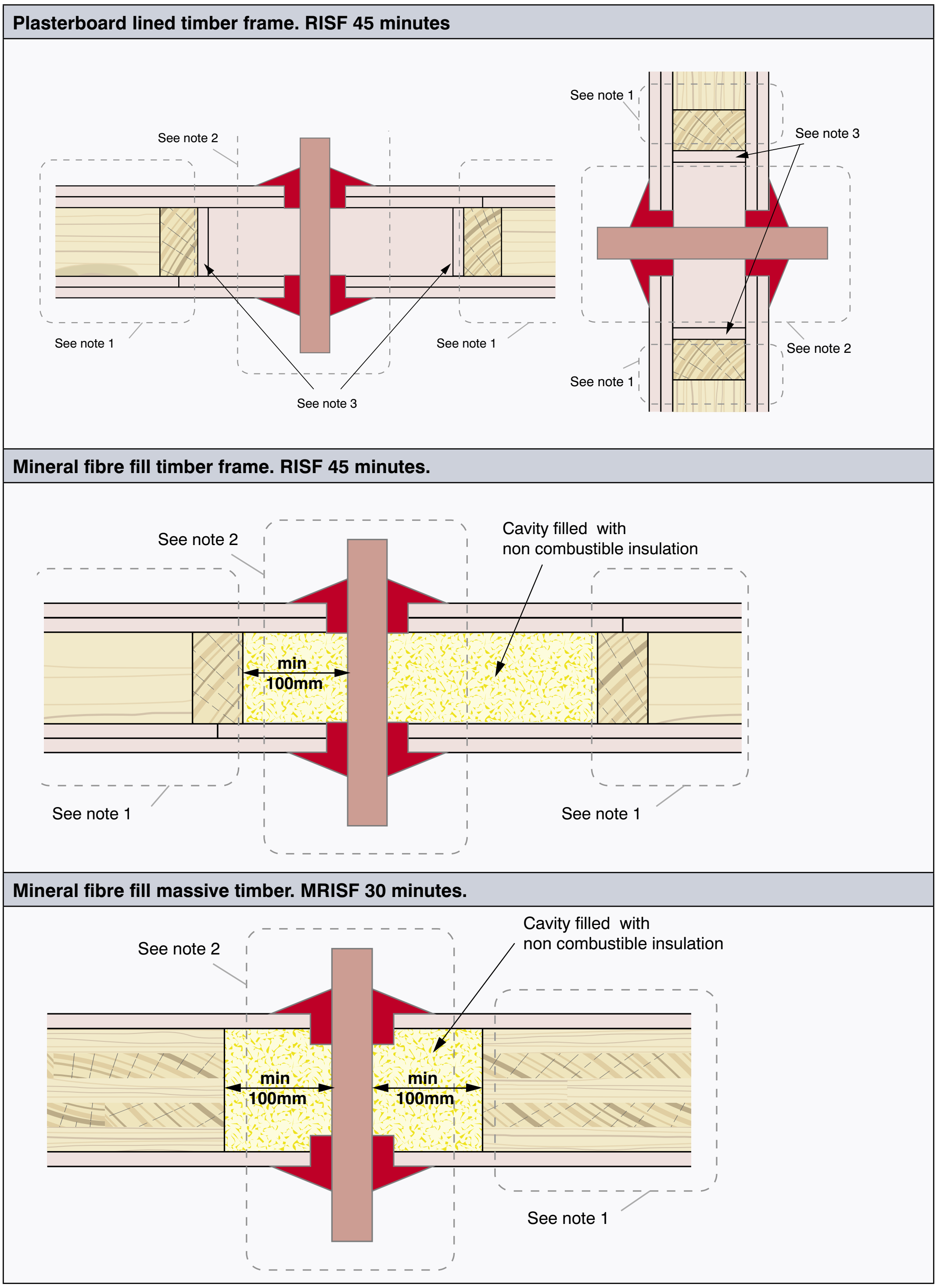


Figure 7.53: Pipe and cable penetrations through fire-protected timber

Note 1: Fire-protected timber element having the required FRL and RISF or MRISF as appropriate. Any cavity Insulation must be non-combustible.

Note 2: Service penetration protected to achieve the required FRL. Evidence of performance to be in the form of a report from an Accredited Testing Laboratory in accordance with AS 1530.4 and AS 4072.1 as appropriate.

Note 3: Aperture lined with a minimum of 1 layer 16 mm plasterboard. Greater thicknesses/number of layers may be required for the faces of the wall since it forms part of the wall system.

Refer report FAS 190034, available from the WoodSolutions website, for assessment of ceiling lining detail.

Refer report RIR 37401400, available from the WoodSolutions website, for assessment of back blocking system

The preferred option for lighting cables, sprinkler pipe penetrations and the like is to run them through the cavity above a false ceiling. A typical false ceiling detail is shown in Figure 7.54. Larger cavities can be provided above false ceilings by using suspended ceiling fixings to accommodate down lights and larger services.

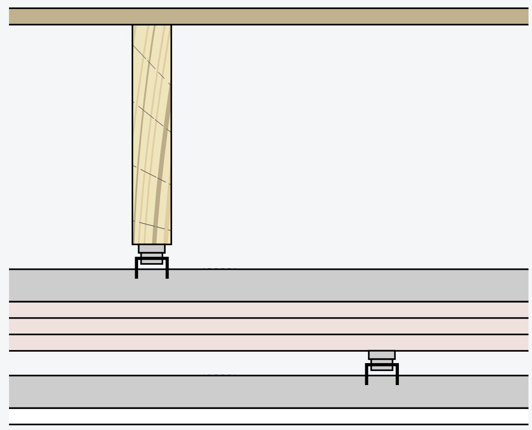


Figure 7.54: False ceiling detail for minimising service penetrations through ceiling systems.

If it is impractical to provide a false ceiling a solution for lighting cable penetrations through fire-protected timber ceilings is to use cover blocks as shown in Figure 7.55. Proprietary systems may be available to protect down-light penetrations and sprinkler pipe penetrations but access for the long-term service and maintenance of these systems and options for reconfiguration would be very limited.

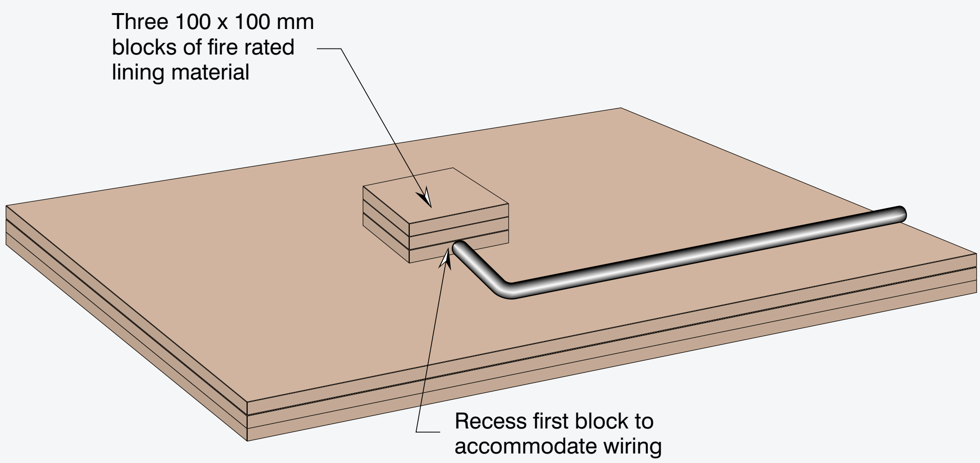


Figure 7.55: Recess block protection system for lighting cables penetrating fire-protected timber floors.

Refer report RIR 37401400, available from the WoodSolutions website, for assessment of rebated ceiling system

7.13.5 Rebated Ceiling Details for Housing Services

Another alternative for ceiling systems is to create a rebate to house services without penetrating a fire-protected element such as a fire-protected timber floor/ceiling system as shown in Figure 7.56. This detail has been assessed by an Accredited Testing Laboratory as achieving an FRL 120/120/120 and a RISF greater than 45 minutes. Care should be taken not to attach the rebate framing members to the floor structure to avoid short-circuiting the sound separation.

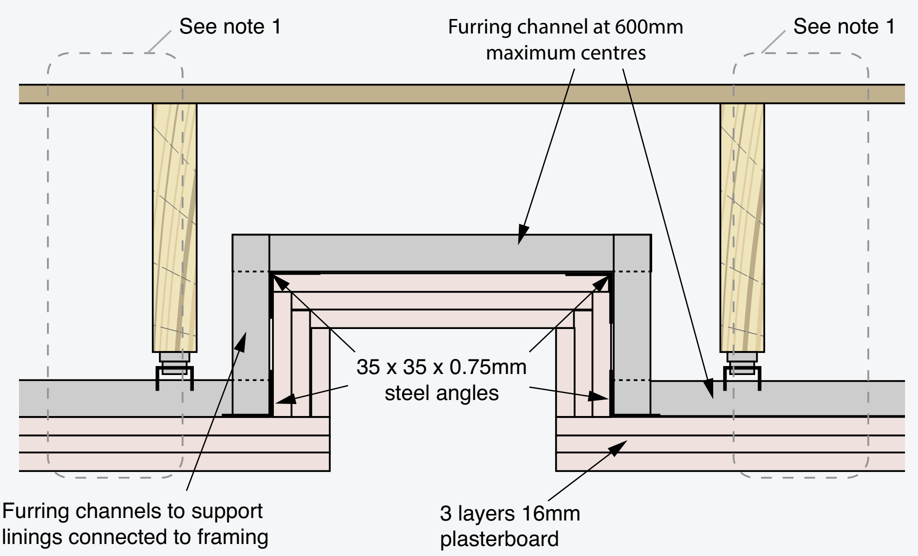


Figure 7.56: Rebated ceiling system.

Note 1: Fire-protected timber element having the required FRL and RISF or MRISF as appropriate. Any cavity Insulation must be non-combustible.

The rebate may be fitted with a grill, a section of false ceiling or may be sized to mount individual items of equipment.

7.13.6 Plastic Pipe Penetrations

Where it is impractical to adopt false wall and ceiling linings or use non-combustible shaft construction or lined opening multi-penetration systems, the following details, shown in Figure 7.57 to Figure 7.59, have been developed to maintain a RISF of 45 minutes or a MRISF of 30 minutes of the wall. The systems must have achieved the required FRL when fitted in plasterboard partitions to protect individual plastic pipe penetrations. The following notes apply:

Note 1: Fire-protected timber element having the required FRL and RISF or MRISF as appropriate. Any cavity Insulation must be non-combustible.

Note 2: Service penetration protected to achieve the required FRL. Evidence of Suitability to be in the form of a report from an Accredited Testing Laboratory in accordance with AS 1530.4 and AS 4072.1 as appropriate.

Note 3: Aperture lined with a minimum of 1 layer 16 mm plasterboard. Greater thicknesses/number of layers may be required for the faces of the wall since it forms part of the wall system.

Refer report RIR 37401400, available from the WoodSolutions website, for assessment of details to maintain the wall RISF or MRISF

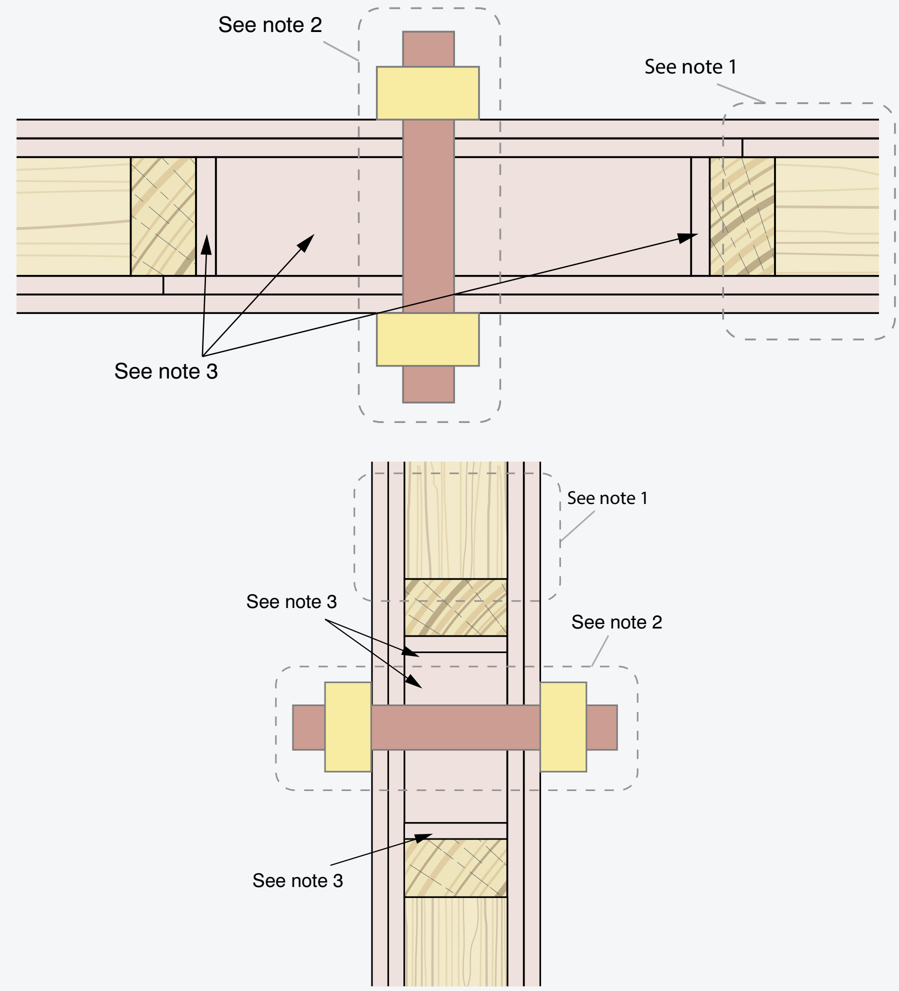


Figure 7.57: Plastic pipe penetration through fire-protected timber-framed walls with internal linings.

Refer report RIR 37401400, available from the WoodSolutions website, for assessment of details to maintain the wall RISF or MRISF

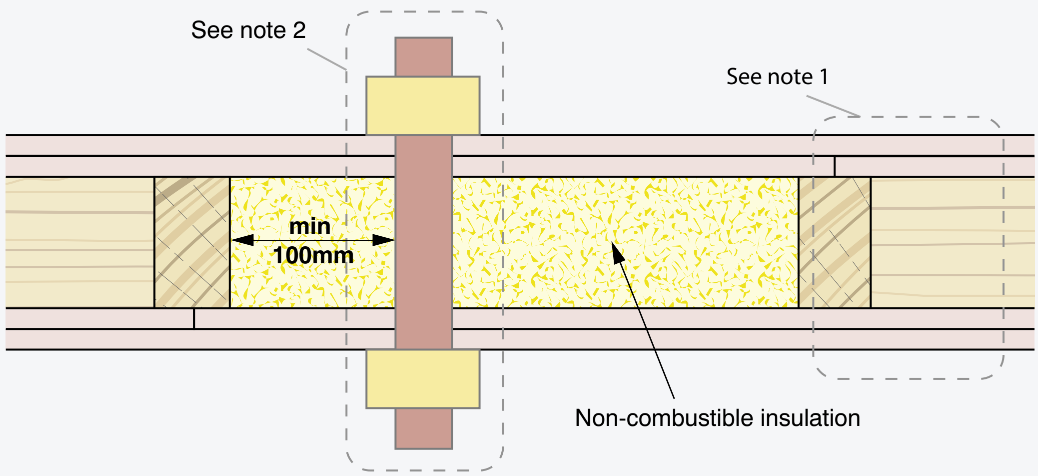


Figure 7.58: Plastic pipe penetration through fire-protected timber-framed walls with non-combustible mineral fibre insulation.

Refer report RIR 37401400, available from the WoodSolutions website, for assessment of details to maintain the wall RISF or MRISF

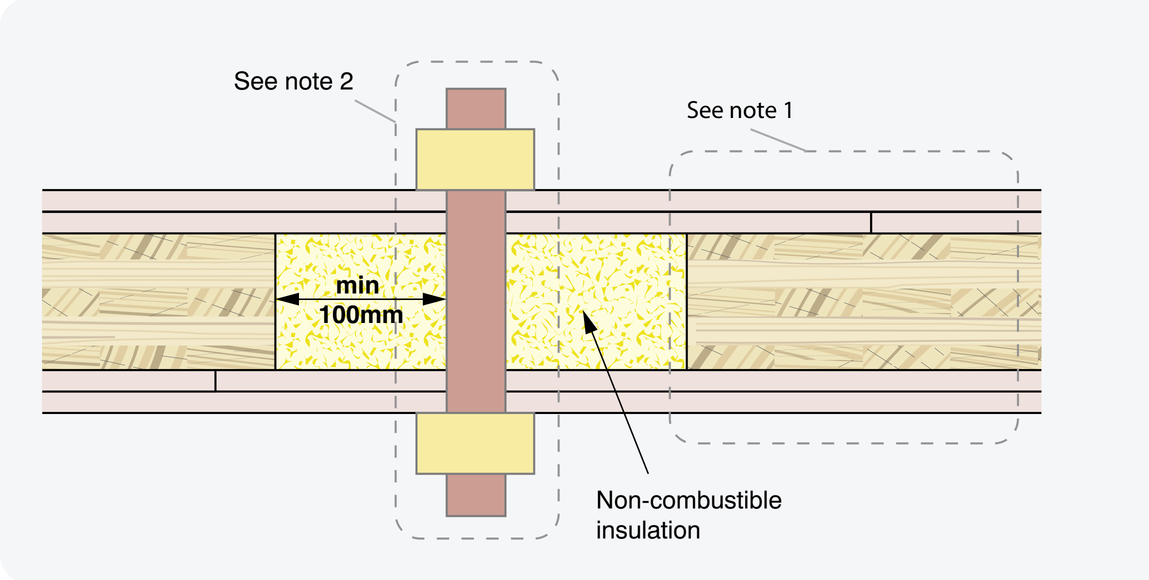


Figure 7.59: Plastic pipe penetration through fire-protected massive timber walls with non-combustible mineral fibre insulation.

Evidence of Suitability required from supplier to confirm required RISF and MRISF performance of penetrated elements is maintained in addition to the FRL for the system

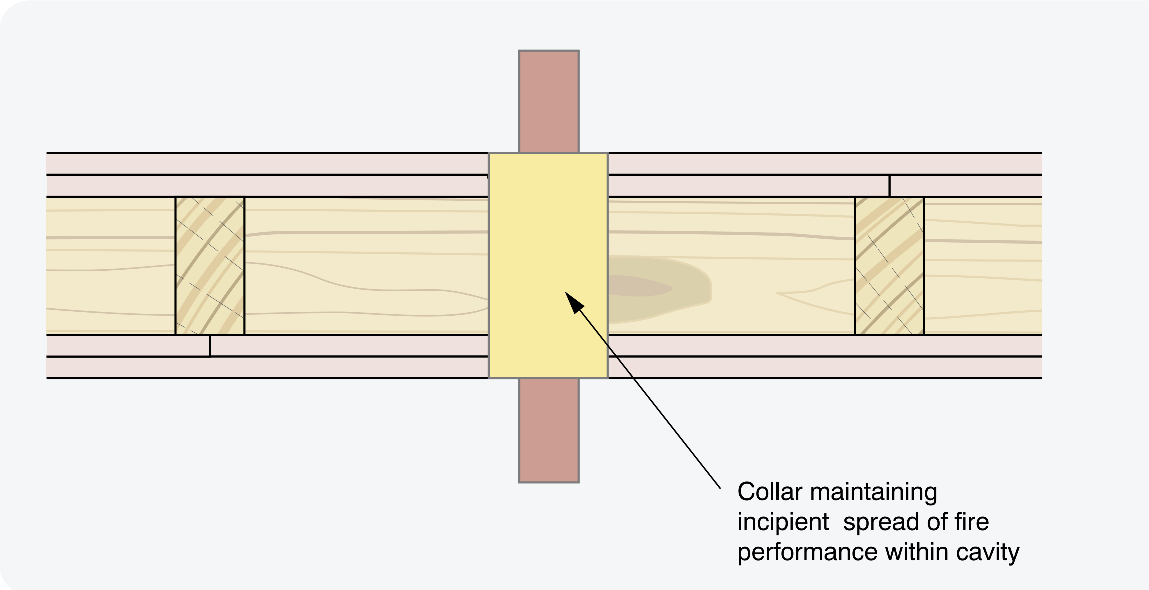


Figure 7.60: Option for a proprietary system with integral insulation protecting a plastic pipe penetration

Refer report RIR 37401400, available from the WoodSolutions website, for assessment of interface details to maintain the RISF and MRISF performance of elements penetrated by access panels as shown in the following figures.

7.13.7 Access Panels

Access panels may be used to protect openings providing access to a floor/ceiling cavity as shown in Figure 7.61 or to shafts through fire-protected timber walls as shown in Figure 7.62 and Figure 7.63.

Providing access panels will tend to compromise the sound separation and therefore they should normally be located in areas that are not sound 'sensitive'.

The following notes apply to the typical details shown in Figure 7.61 through Figure 7.63.

Note 1: Fire-protected timber element having the required FRL and RISF or MRISF as appropriate. Any cavity insulation must be non-combustible.

Note 2: Interface protected with the same fire-protective coverings that are applied to the fire-protected timber element face.

Note 3: Proprietary access panel system with the required FRL. For access panels providing access to ceiling cavities an RISF rating of 45 minutes or a MRISF rating of 30 minutes as appropriate is also required to be satisfied.

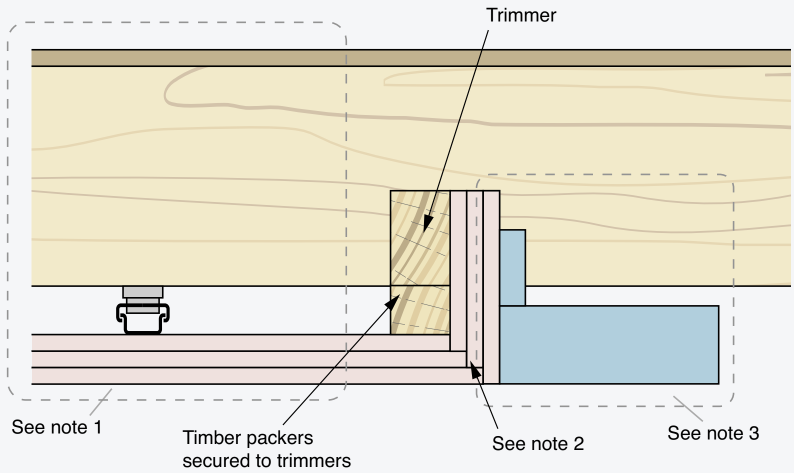


Figure 7.61: Access panel in a fire-protected floor/ceiling system.

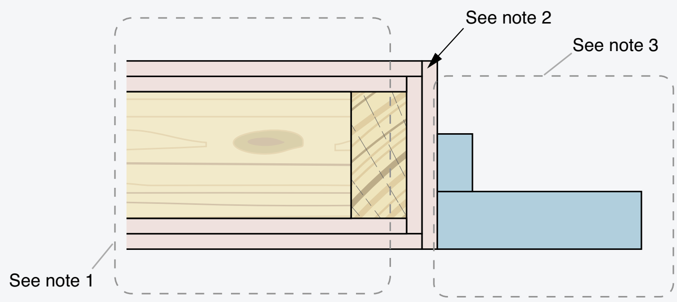


Figure 7.62: Access panel in a fire-protected timber-framed wall.

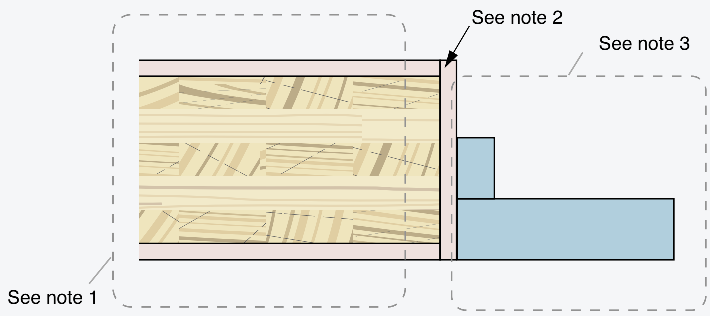


Figure 7.63: Access panel in a fire-protected massive timber wall.

7.14 Automatic Fire Sprinkler Systems

The provision of an automatic fire sprinkler system in accordance with NCC Specification E1.5 (other than a FPAA101D or FPAA101H system) is a mandatory requirement for mid-rise timber buildings if the DTS Solution pathway is adopted.

The automatic fire sprinkler system is a critical component of the fire safety design and must be designed and installed by organisations and/or individuals with appropriate competence. Detailed information about the design of automatic fire sprinkler systems is outside the scope of this Guide; however in common with all services the design needs to be integrated with the architectural, structural and passive fire protection systems. The following sub-sections highlight some key considerations, but it is not an extensive summary.

It is important that the design documentation clearly specifies the requirements for the sprinkler systems such as locations of pipe runs, types of materials and components to be used, treatment of penetrations, types of sprinkler head and positions.

7.14.1 Piping Materials and Connections

Materials for piping and connection details for fire sprinkler systems should be carefully selected to:

- comply with the NCC Specification E1.5 requirements (other than a FPAA101D or FPAA101H system)
- suit the environment
- minimise the time the system is unavailable after maintenance/repair
- minimise hot works on site such as cutting and welding metal pipes
- facilitate the reinstatement of the performance of fire-protected timber at the points of penetration by sprinkler pipes.

While plastic pipes (e.g. CPVC) can largely negate the need for hot works, if alterations are made to plastic pipes the sprinkler system could be unavailable while the adhesive sets. This is an important consideration for buildings that need to remain operational, such as healthcare buildings.

Also, the reinstatement of the performance of fire-protected timber when penetrated by plastic pipes can be more complex than metal pipe penetrations

Metal pipes may be more appropriate for some applications, but they should be pre-prepared so that, as far as practical, all on-site connections can be made without hot works. Fittings can be selected that can be adjusted on site, such as flexible sprinkler fittings minimising the need for hot works.

Once the materials and components have been selected, the pipe runs should be clearly defined to minimise the number of penetrations through fire-protected timber and that, if they cannot be avoided, they occur where the performance of the fire-protected timber can be readily reinstated.

7.14.2 Sprinkler Head Selection

Although not mandatory in AS 2118.1, fast response heads should be used where practicable and appropriate since they respond faster, reducing the risk of occupants and increasing the likelihood that the sprinkler system will suppress the fire.

Sprinkler head options include concealed and semi-recessed. Concealed heads are a common choice in public areas because they can reduce the risk of vandalism and accidental impact. However, the following issues should be considered during the selection process and appropriate mitigation measures adopted:

- Larger cut outs in ceilings are required, which can be addressed by use of a non-rated false ceiling. The false ceiling depth should be designed to allow for the fitting of the concealed heads and related pipework.
- The response time will tend to be slower; this should be checked with the manufacturer.
- Overpainting and use of sealants to retain covers can compromise the performance of a head. This should be addressed through regular inspections.

7.14.3 Monitored Isolation Valves

The reliability of an automatic fire sprinkler system can be enhanced by specifying monitored isolation valves incorporating a check valve and flow switch at each level that is permanently connected to a fire alarm monitoring service provider by a direct data link.

This approach allows the water supply to the sprinkler system on individual floors to be isolated for maintenance or reconfiguration of the system without the need to isolate the whole building. Since the valves are monitored, the risk of the water supply not being reinstated is also significantly reduced.

This arrangement is compatible with the progressive commissioning of automatic fire sprinkler systems during construction, allowing protection of the lower levels while work progresses on the upper levels and individual floors to be easily isolated for adjustments to systems. This may be adopted as part of the fire safety strategy to address fire safety during construction.

7.14.4 Fire-isolated Stairs and Passageways with Timber Stairways

The NCC allows the use of timber stairways in fire-isolated stairs and passageways subject to the automatic fire sprinkler system coverage being extended to cover the fire-isolated stair in addition to other precautions (refer Section 6.10.2 Timber Stairways Concession).

In the absence of other specifications, sprinkler heads should be provided in the following locations:

- at the top of the shaft
- under the landings at each floor level
- under intermediate landings
- providing coverage to other positions where there is a significant risk of accumulation of combustible materials.

7.15 Other NCC Requirements

This is a guide to the use of fire-protected timber for mid-rise timber buildings as a DTS Solution in the NCC. It does not address all NCC requirements that apply to mid-rise buildings nor does it address all NCC fire-related requirements (e.g. fire hazard properties of linings).

Seek advice from appropriately qualified practitioners and relevant regulatory authorities regarding compliance with the NCC for specific projects.

8

Step 6 - Further Design Assistance and Information (Appendices).

9

Appendix A – Determination of Compliance of Fire-protected Timber

Refer NCC A5.4 and Schedule 5 for FRL

Refer NCC A5.6 for RISF

Refer NCC A5.2 for non- combustibility

There are three components to the performance of fire-protected timber that need to be satisfied:

- the protected element must achieve the required Fire Resistance Level (FRL)
- the protected element must achieve the required Resistance to the Incipient Spread of Fire (RISF).
- fire-protective coverings must be non-combustible.

A1 Non-Combustible Fire-Protective Covering

Unless the NCC deems a material or element of construction to be non-combustible, non-combustible means:

- Applied to a material – not deemed combustible as determined by AS 1530.1 – Combustibility Tests for Materials.
- Applied to construction or part of a building – constructed wholly of materials that are not deemed combustible.

If the fire-protective covering is a composite or multi-layer system, each layer must be non-combustible. It is not acceptable to undertake a single combustibility test on the composite or just the facing materials and claim the fire-protective covering is non-combustible.

Typical examples of multi-layer systems are shown in Figure A1.

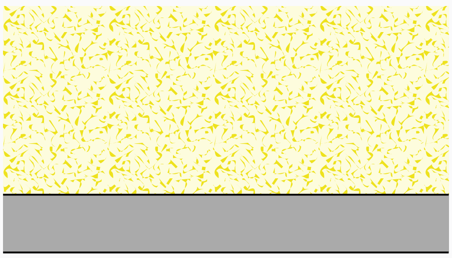
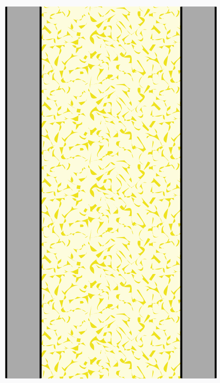
	
Multi-layer system – each layer must be non-combustible	Composite panels – each layer of the composite must be non-combustible
Commonly fire-resistant board supporting non-combustible lightweight insulation used in ceilings protecting floors/beams	Commonly non-combustible lightweight insulating core between non-combustible durable facings used for external claddings

Figure A1: Example of multi-layered fire-protective coverings (all layers).

Clause C1.9(e) of the NCC allows (deems) the following materials, though combustible or containing combustible fibres, to be used wherever a non-combustible material is required:

- plasterboard
- perforated gypsum lath with a normal paper finish
- fibrous-plaster sheet
- fibre-reinforced cement sheeting
- pre-finished metal sheeting having a combustible surface finish not exceeding 1 mm thickness and where the Spread-of-Flame Index of the product is not greater than 0
- sarking-type materials that do not exceed 1 mm in thickness and have a Flammability Index not greater than 5
- bonded laminated materials where:
  - each laminate is non-combustible
  - each adhesive layer does not exceed 1 mm in thickness
  - the total thickness of the adhesive layers does not exceed 2 mm
  - the Spread-of-Flame Index and the Smoke-Developed Index of the laminated material as a whole does not exceed 0 and 3 respectively.

All materials forming the fire-protective covering are either permitted to be used in accordance with NCC Clause C1.9(e) or determined to be non-combustible by testing to AS1530.1.

A2 Fire Resistance Level

A fire-protected timber element must achieve the required FRL specified in the NCC for the particular application. The fire resistance of a fire-protected timber element has to be determined in accordance with Schedule 5.2(b) and (c) of the NCC.

Generally, Schedule A5.2(b) requires a prototype to be submitted to the Standard Fire Test (AS1530.4), or an equivalent or more severe test, and the FRL achieved by the prototype, without the assistance of an active fire suppression system, is confirmed in a report from an Accredited Testing Laboratory which:

- describes the method and conditions of the test and the form of construction of the tested prototype in full
- certifies that the application of restraint to the prototype complied with the Standard Fire Test;

or differs in only a minor degree from a prototype tested under Schedule 5.2(b) and the FRL attributed to the building element is confirmed in a report from an Accredited Testing Laboratory which:

- certifies that the building element is capable of achieving the FRL despite the minor departures from the tested prototype; and
- describes the materials, construction and conditions of restraint which are necessary to achieve the FRL.

The option to use AS 1720.4 char-based calculation methods to determine the fire resistance is not permitted for fire-protected timber. This is because concerns were expressed with respect to the suitability of the AS 1720.4 approach for certain types of adhesives and connections forming parts of engineered timber products. The proprietary nature of massive timber panel products and lack of standardisation of adhesives and other critical materials used in their construction meant that there was insufficient data available at the time to demonstrate the suitability or otherwise of AS 1720.4.

A3 Resistance to the Incipient Spread of Fire

A3.1 Determine Applicable Resistance to the Incipient Spread of Fire Requirements

The Resistance to the Incipient Spread of Fire (RISF) in relation to a fire-protective covering means the ability of the covering to insulate voids and the interfaces with timber elements so as to limit the temperature rise to a level that will not permit ignition of the timber and the rapid and general spread of fire throughout any concealed spaces. The performance is expressed as the period in minutes that the covering will maintain a temperature below the specified limits when subjected to a test in accordance with AS 1530.4.

The general requirement for fire-protected timber is an RISF of 45 minutes.

The NCC permits a relaxation to the RISF requirements for fire-protected timber providing both the following additional criteria are satisfied.

- the minimum timber panel thickness is not less than 75 mm
- there are no cavities between the surface of the timber and the fire protective covering or between timber members.

The 75 mm dimension relates to the inherent fire resistance achieved when using a timber panel member. If the relaxation conditions are satisfied, the Modified Resistance to the Incipient Spread of Fire (MRISF) criteria are applicable. Typical examples of massive timber installations satisfying these conditions are shown in Figure 6.3 in the body of this Guide.

Figure A2 shows the process for determining the applicable Resistance to the Incipient Spread of Fire requirements. The general requirement for fire-protected timber is a RISF of 45 minutes.

The relaxed requirements for massive timber construction without voids and cavities is a MRISF that applies a higher interface temperature limit and the time periods for which the temperature limit applies varies according to the application in accordance with Table A1.

Table A1: Modified Resistance to the Incipient Spread of Fire required performance for applications where criteria are relaxed (massive timber construction without voids and cavities).

Application	Modified Resistance to the Incipient Spread of Fire (MRISF)
Inside a fire-isolated stairway or lift shaft	20 min
External walls within 1 metre of an allotment boundary or 2 metres of a building on the same allotment	45 min
All other applications	30 min

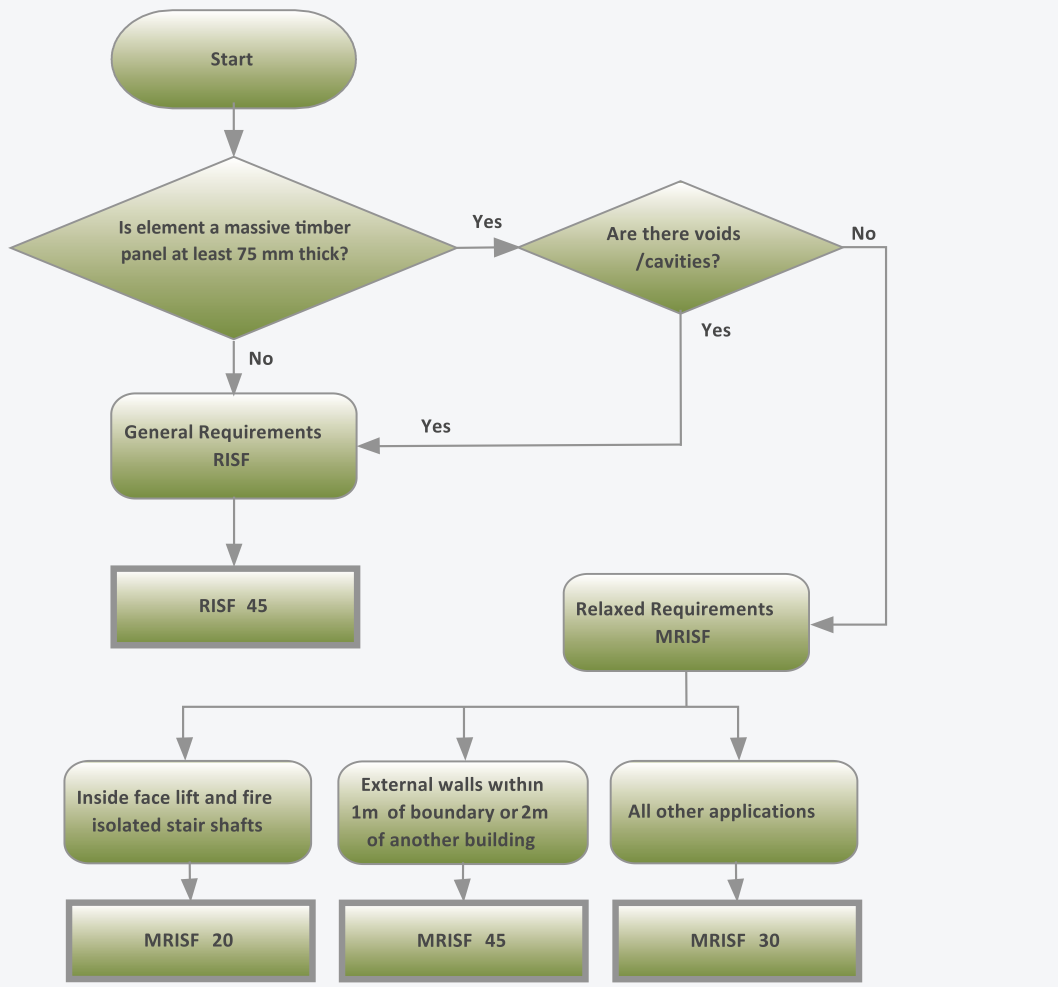


Figure A2: Determination of Resistance to the Incipient Spread of Fire acceptance requirements.

A3.2 Compliance Paths for Resistance to the Incipient Spread of Fire

Three paths are permitted to demonstrate compliance with the RISF requirements;

- simultaneous determination during a full-scale fire resistance test
- smaller-scale fire resistance test (at least 1 metre x 1 metre specimen)
- selection of Deemed-to-Satisfy fire-resisting grade plasterboard coverings.

Simultaneous determination during a full-scale fire resistance test

When a fire resistance test is undertaken to determine the FRL of an element, additional instrumentation can be included in the test to also determine the RISF or MRISF performance, providing a cost-effective approach for new protection systems.

Smaller-scale fire resistance test

There are a large number of systems that have been tested previously to determine their FRLs but in most cases insufficient data will have been recorded to determine the RISF or MRISF performance. Under these circumstances, the use of a smaller specimen (not less than 1 metre x 1 metre) is permitted to obtain supplementary data to determine the RISF or MRISF of the system in a cost effective manner. The fire-protective covering should be fitted in the same manner as that used for the original test that determined the FRL of the system.

Deemed-to-Satisfy Fire-Protective Grade Plasterboard coverings

Specification C1.13 deems fire-protective grade plasterboard facings, if fixed in accordance with the requirements to achieve the required FRL of the element, to also satisfy the requirements for Resistance to the Incipient Spread of Fire (RISF) or Modified Resistance to the Incipient Spread of Fire (MRISF). Table A2 shows the minimum requirements for plasteboard coverings.

Table A2: Fire-protective grade plasterboard coverings Deemed-to-Satisfy RISF requirements.

Requirements	Application	Performance	Minimum Deemed-to-Satisfy fire-protective grade plasterboard
General Requirements	All applications	RISF 45min	2 layers x 13 mm thick
Relaxed requirements for timber panels not less than 75 mm thick without cavities voids or cavities voids filled with non-combustible material	Inside a fire-isolated stairway or lift shaft	MRISF 20 min	1 layer x 13 mm thick
	External walls within 1 metres of an allotment boundary or 2 metres of a building on the same allotment	MRISF 45 min	2 layers x 13 mm thick
	All other applications	MRIFS 30 min	1 layer x 16 mm thick

Table A2 is a derivative of Specification C1.13a of the National Construction Code 2019 Amendment 1 provided by ***https://www.abcb.gov.au/*** *Australian Building Codes Board © 2020.*

A3.3 Resistant to the Incipient Spread of Fire (RISF) Test Procedures

The test procedure for determining the Resistance to the Incipient Spread of Fire (RISF) of horizontal elements during a full-scale fire resistance test is provided in Section 4 of AS 1530.4 . Specification C1.13a of the NCC requires the relevant procedures from AS 1530.4 Section 4 to be applied to other elements.

AS 1530.4 requires walls to be full size or not less than 3 m high x 3 m wide and floor/ceiling systems to be full size or not less than 4 m long x 3 m wide. Floor systems are exposed to furnace heating conditions (Figure A3) from the underside and fire-resisting walls are exposed from one side. Asymmetrical walls generally require two tests to evaluate the response to exposure to fire from either side unless the side exposed to fire is specified.

Smaller-scale specimens (not less than 1 m x 1 m) can be used to retrospectively determine the RISF performance of a floor or wall system that has previously achieved the required FRL in a fire resistance test satisfying the minimum size requirements specified in AS 1530.4.

For universal application of results the minimum cavity depth should be fire tested.

To determine the RISF, five thermocouples with insulating pads as prescribed in AS 1530.4 are fixed to the inner face of the fire-protective covering system. They are placed at approximately the centre and the centre of each quarter section as shown in Figure A4.

When testing corrugated specimens, increase the number of thermocouples to six to provide an equal number of thermocouples at the maximum and minimum specimen thickness.

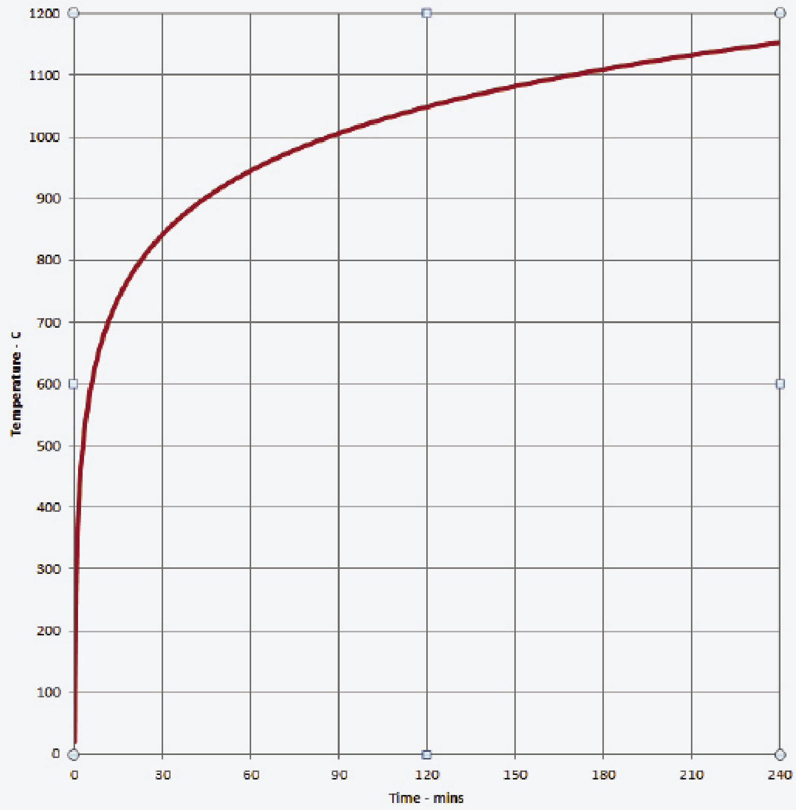


Figure A3: Standard fire resistance test heating regime.

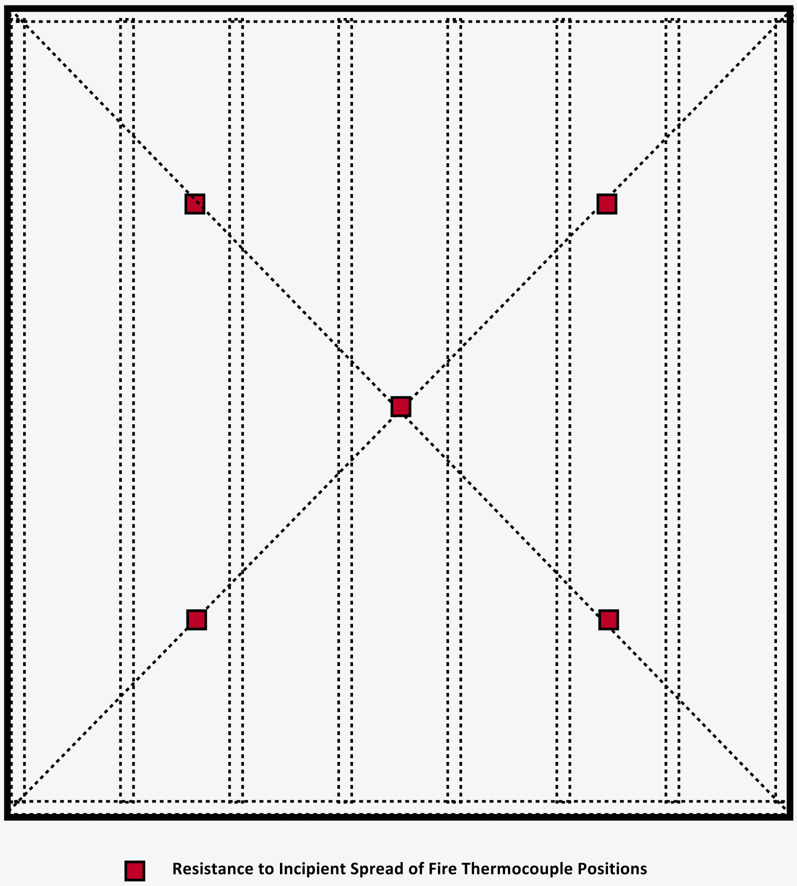


Figure A4: Elevation of a wall showing RISF thermocouple positions.

Sections through typical specimen configurations are shown in Figure A5 to illustrate the correct surfaces to apply thermocouples to determine the RISF. For fire-protected timber, the temperature has to be maintained below the prescribed temperature on the surface of the fire-protective covering facing the void and at the interface with timber elements within the wall or floor. If a wall or ceiling system is protected by a board system, for example, the temperatures are measured on the board surface within the cavity even if non-combustible insulation is applied between the timber studs or beams. However, if the non-combustible insulation forms a continuous layer between the timber elements and the board the thermocouples (t/c) should be applied to the surface of the insulation as shown in Figure A5.

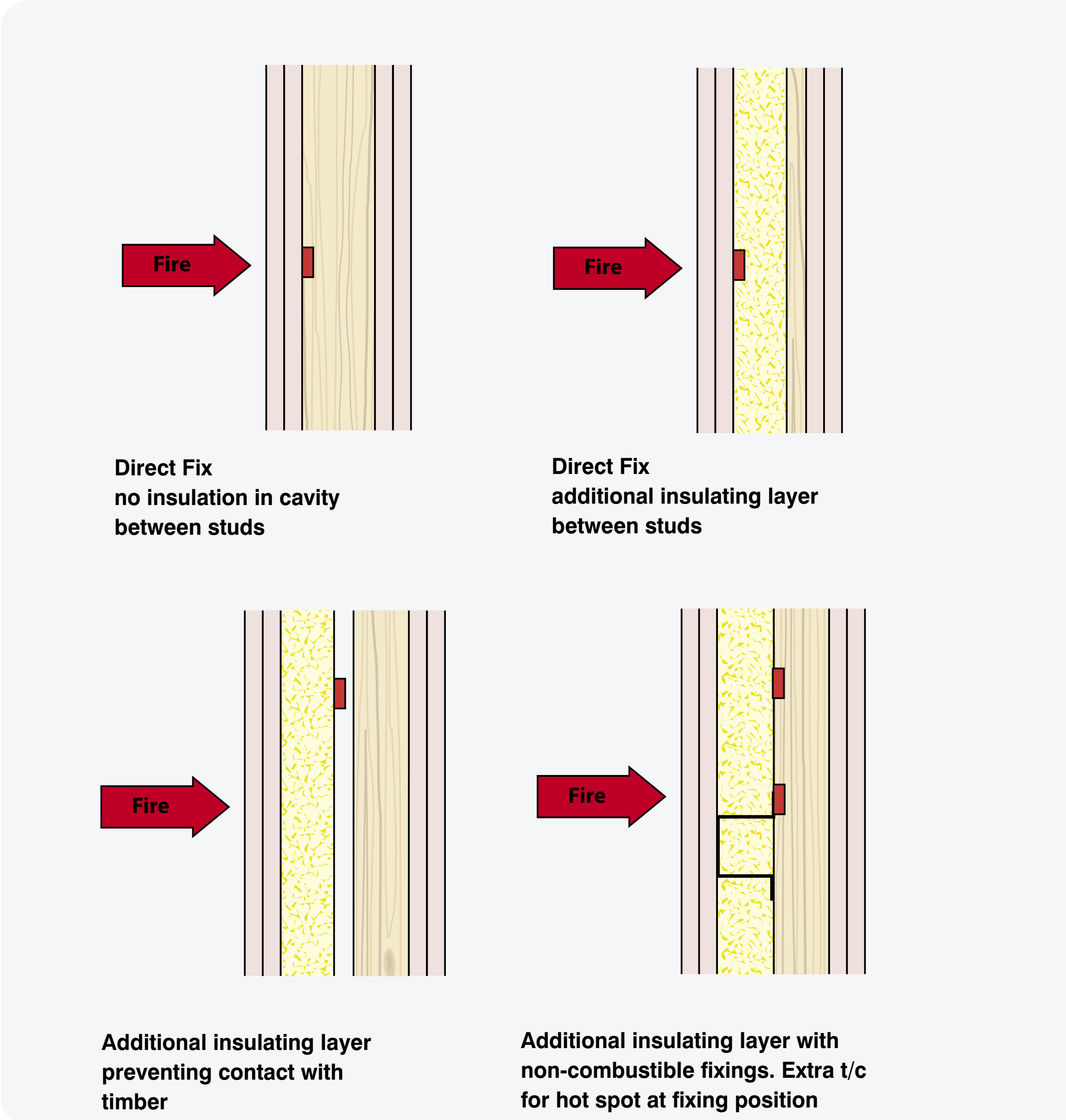
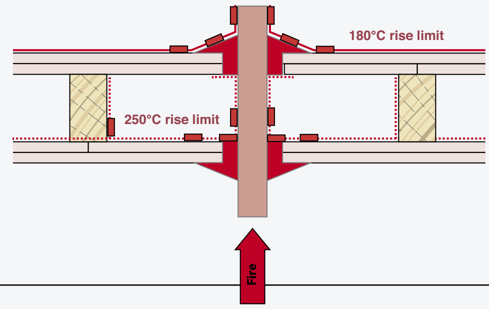


Figure A5: Resistance to the incipient spread of fire thermocouple positions for typical specimen configurations.

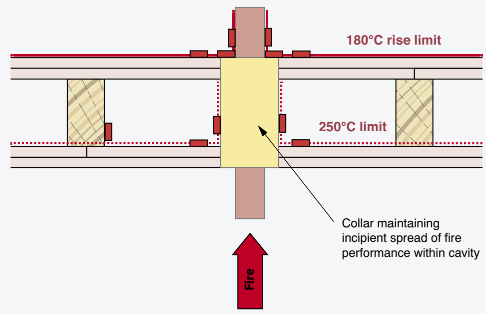
Failure in relation to the RISF is deemed to occur when the maximum temperature of the thermocouples described above exceeds 250°C.

Smaller scale specimens 1 m x 1 m can be used to determine the performance of services penetrations in fire-protected timber. Typical examples of thermocouple configurations for various types of service penetrations are shown in Figure A6. Additional thermocouples are shown to allow the simultaneous determination of the FRL of the service penetration system.

Cable/metal pipe penetration protected with fire-resistant mastic.

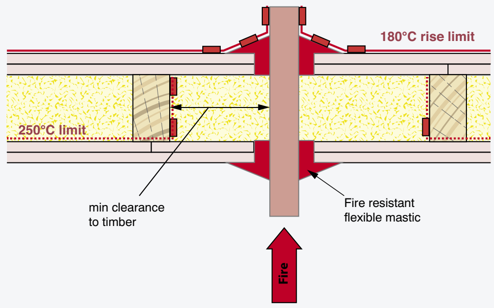


Plastic pipe protected by insulating collar system.



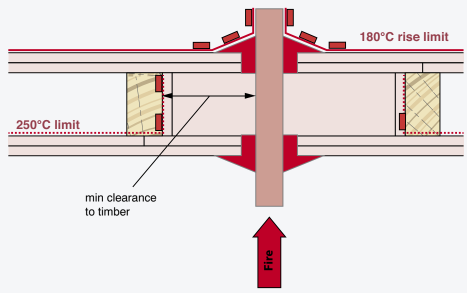
Cable/metal pipe penetration protected with fire resistant mastic and non-combustible cavity infill.

The critical interface for RISF for the service penetration system is the surface of the insulation where it is in contact with timber elements. Note: plasterboard surface is the critical surface for determining the RISF of the wall system



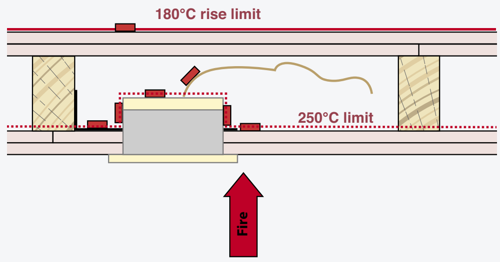
Cable/metal pipe penetration protected with fire-resistant mastic and cavity lined with non-combustible board.

The critical interface for RISF for the service penetration is the surface of the lining board where it is in contact with timber elements.



Proprietary GPO outlet protection system.

Note: Thermocouples applied to cable surface connected to the GPO, on fixing bracket and adjacent element.



GPO outlet with non-combustible cavity infill protection.

The critical interface for RISF is the surface of the insulation where it is in contact with timber elements. Note: plasterboard surface is the critical surface for determining the RISF of the wall system

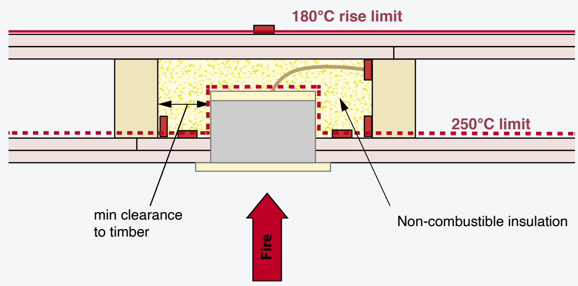


Figure A6: Typical thermocouple positions for determining the RISF of service penetrations.

The thermocouples positions must satisfy the following requirements:

- At not less than two points about 25 mm from the edge of the hole made for the passage of the service.
- Attached to adjacent structural members and those elements that support the penetrating service.
- At points on the surface of the penetrating service or its fire stopping encasement, as follows:
  - at least two thermocouples about 25 mm from the plane of the general surface of the covering and non-combustible insulation
  - where the seal or protection around the service is tapered or stepped, two additional thermocouples beyond the step or the end of any taper if it is expected that the temperatures will be higher at these points.
- Where practicable, at two points on the seal or protection around the service.
- One in the centre of the surface of the penetration nominally parallel to the plane of the fire protective covering if it terminates within the cavity (e.g GPO outlets or down lights).

Failure in relation to the RISF is deemed to occur for the service penetration when the maximum temperature of the thermocouples described above exceeds 250^{0}C.

A3.4 Modified Resistance to the Incipient Spread of fire (MRISF) Test Procedures

The MRISF is applicable to massive timber panels having a thickness not less than 75 mm if there are no voids/cavities through which fire and smoke can spread. The MRISF, amongst other things, relaxes the failure temperature from 250˚C to 300˚C to reflect the reduced risk of fire spread through cavities and higher inherent fire resistance of timber with larger cross-sections. The test procedures are described in Section 3 of Specification C1.13a of the NCC and are summarised below:

- Tests must be carried out in accordance with AS 1530.4, or an equivalent or more severe test, on the timber element with the proposed non-combustible fire protective coverings fixed in a representative manner.
- Smaller scale specimens (not less than 1m x 1m) can be used to retrospectively determine the MRISF performance of a system that has previously achieved the required fire resistance level in a fire resistance test satisfying the minimum size requirements specified in AS 1530.4. If a fire protection system incorporates joints, the test specimens must incorporate representative joints.

To determine the MRISF interface, temperatures must be measured over the following features by a minimum of two thermocouples complying with Appendix C1 and Section 2 of AS 1530.4 as appropriate:

- at joint positions in the protection systems
- at least 200 mm from any joint
- at any other locations where, in the opinion of the Accredited Testing Laboratory, the interface temperature may be higher than the above positions.

Where the fire protective covering is not in contact with the timber (e.g. multi-layer system), the surface of the fire-protective covering is deemed to be the interface.

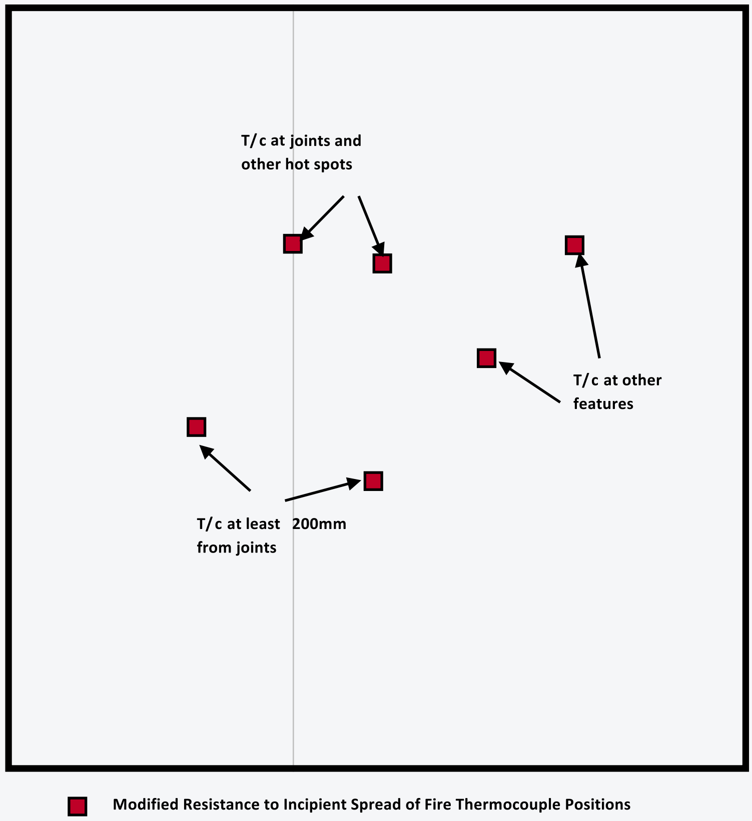


Figure A7: Elevation of a wall showing modified RISF thermocouple positions.

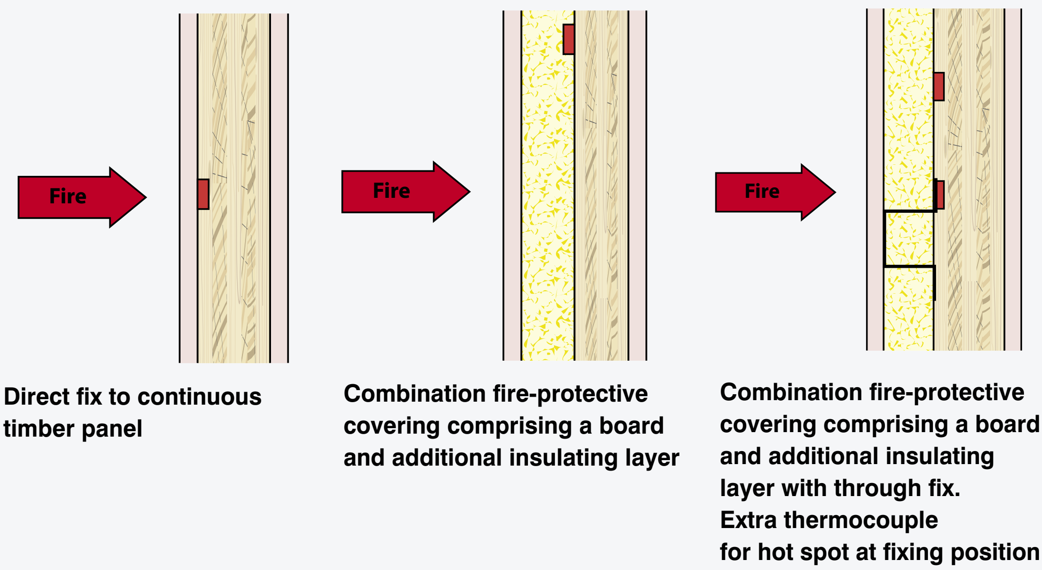


Figure A8: Modified RISF thermocouple positions for typical specimen configurations.

Failure in relation to the MRISF is deemed to occur when the maximum temperature of the thermocouples described above exceeds 300°C.

Smaller scale specimens 1 metre x 1 metre can be used to determine the performance of services penetrations in fire-protected timber. Typical examples of thermocouple configurations for various types of service penetrations to determine both the MRISF and FRLs are shown in Figure A9.

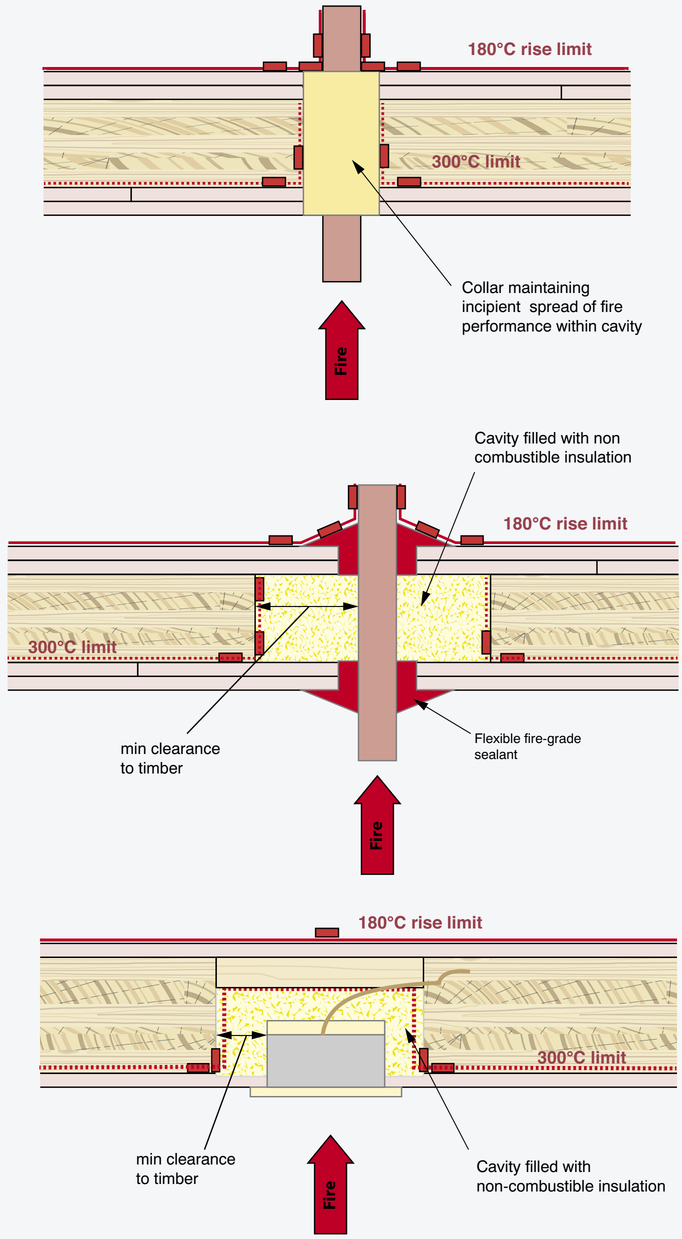


Figure A9: Typical thermocouple positions for determining the MRISF of service penetrations.

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Appendix B – Determination of the Performance of Cavity Barriers in Fire-Protected Timber Construction

Specification C1.13 of the NCC sets out the requirements for cavity barriers in fire-protected timber construction.

The following compliance options are provided for cavity barriers:

- the cavity barrier system must achieve the FRLs specified in Table B1 when mounted in timber elements having the same or a lower density than the timber members in the proposed application or
- comprise timber of minimum thickness as specified in Table B1 or
- comprise polythene-sleeved mineral wool or non-sleeved mineral wool slabs or strips placed under compression and of minimum thickness as specified in Table B1 or
- another option is that, for cavity barriers around doors and windows, steel frames are also Deemed-to-Satisfy the requirements for cavity barriers provided that the steel frames should be tightly fitted to rigid construction and mechanically fixed. It should, however, be noted that if the windows or doors are of fire-resistant construction, the windows or door system needs to be capable of achieving the required fire resistance when mounted in the wall system, notwithstanding the requirements for cavity barriers.

Table B1: Cavity barrier requirements for fire-protected timber.

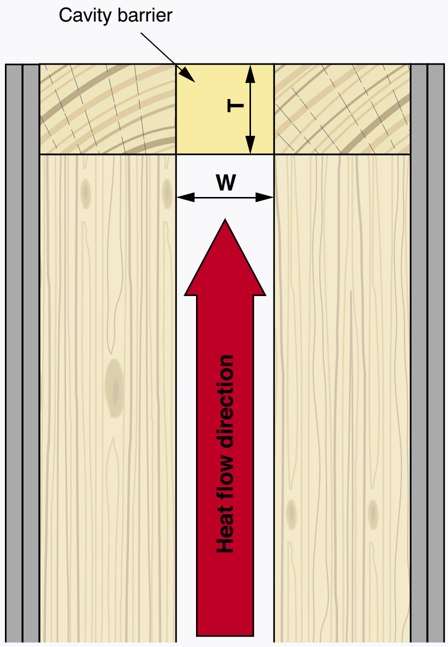
Cavity Barrier Compliance Options	FRL required for element cavity barrier is fitted to (minutes)	
	–/90/90 or less	greater than –/90/90
Cavity Barrier Required FRL – minutes	–/45/45	–/60/60
Timber required minimum thickness	45 mm	60 mm
Mineral wool required minimum thickness	45 mm	60 mm

*Table B1 is a derivative of Specification C1.13 Table 1 of the National Construction Code 2019 Amendment 1 provided by **https://www.abcb.gov.au/** Australian Building Codes Board © 2020.*

The minimum thicknesses of protection are required to be measured in the direction of heat flow. The role of a cavity barrier is normally to prevent a fire spreading from the cavity on one side of the cavity barrier to the other. The top plate of a double stud partition (Detail A of Figure B1) is a typical example of this where the direction of heat flow for the cavity barrier would be from the underside to the upper face of the barrier.

The other role for cavity barriers is to reduce the risk of fire spread to cavities occurring around openings for doors and windows within a fire-resisting wall. This configuration is shown as Detail B in Figure B1. For this scenario, the heat flow is from the occupied area of the building through the framing to the cavity. In the Figure, the thickness dimension is identified as 'T'.

Detail A
Cavity barrier at the head of a double stud partition



Detail B
Cavity barrier around door opening

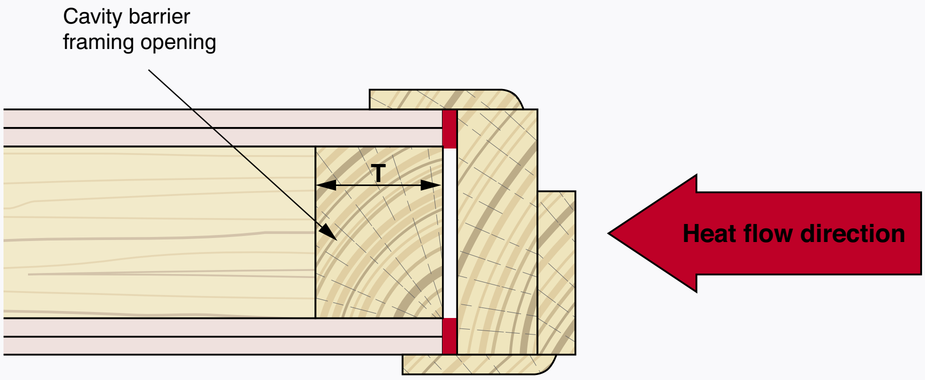


Figure B1: Heat flow direction for cavity barriers.

Proprietary cavity barrier systems may provide more practical options than the Deemed-to-Satisfy solutions for some applications. To encourage the development and use of these systems a compliance path has been provided through the specification of FRLs. For smaller cavity barriers, the performance should be determined by testing the cavity barrier as a control joint system in accordance with Section 10 of AS 1530 using timber members as the separating element. Specification C1.13 permits the results from such a test to be used for applications where the fire-protected timber is constructed from timber with a nominal density at least equal to the tested timber.

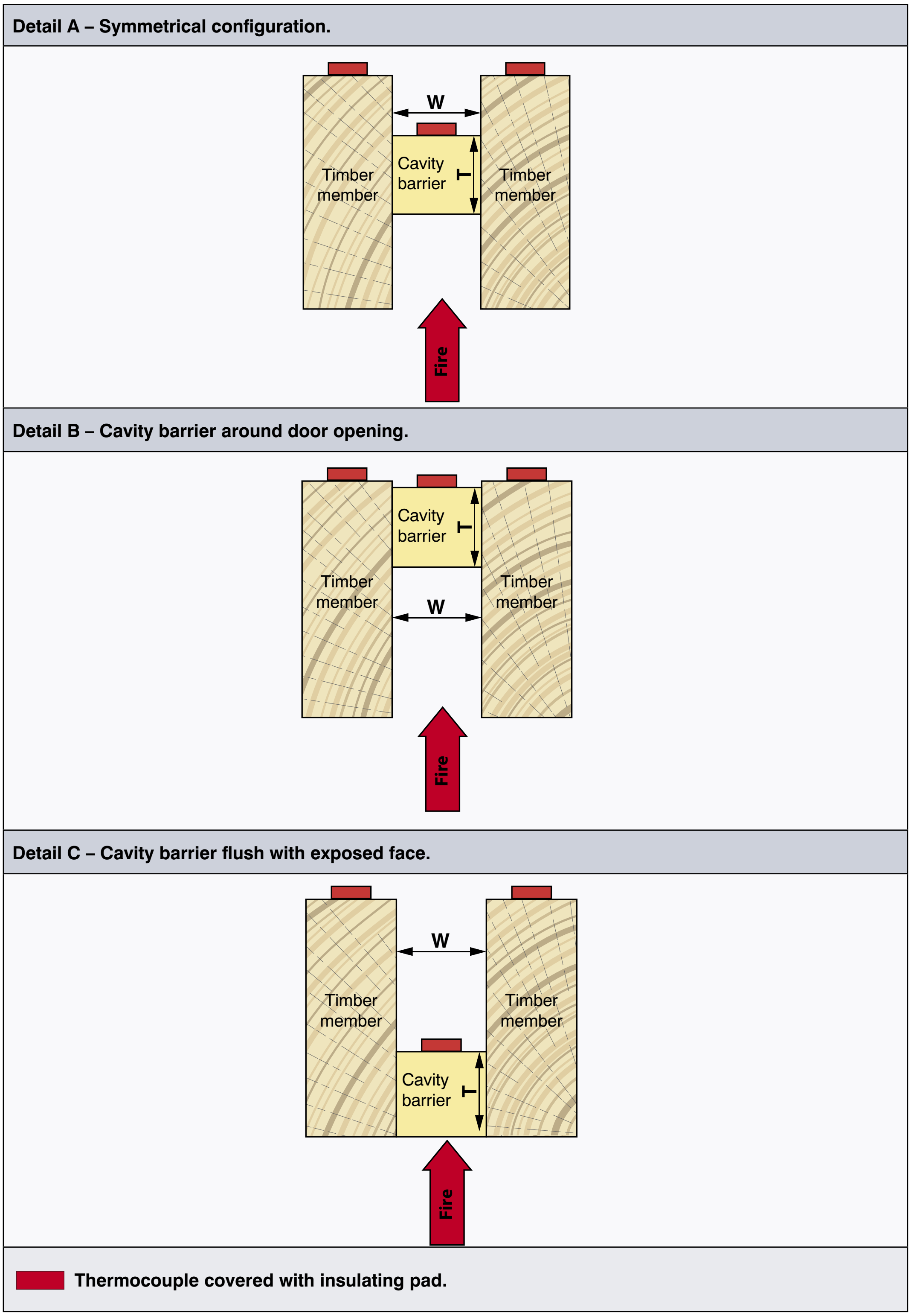


Figure B2: Typical cavity barrier test configurations.

Typical test configurations are shown in Figure B2. The selection of the test configuration(s) depends on how the cavity barrier will be mounted. If it is symmetrical (e.g. fitted at the mid-depth of a timber member), Detail A is appropriate. If the cavity barrier system is not symmetrical both details B and C should be tested unless the most onerous configuration can be determined by the test laboratory or the cavity barrier use is restricted to one configuration. A report from an Accredited Testing Laboratory should state the field of application for the cavity barrier based on the test results.

Cavity barriers can be of combustible construction and therefore a timber framed partition with exposed timber members could be used subject to the wall achieving the required FRL.

In some instances, it may be more practicable to continue the fire-resisting walls up to roof level in lieu of providing a fire-protected timber roof system with cavity barriers. This option is shown in Figure B3.

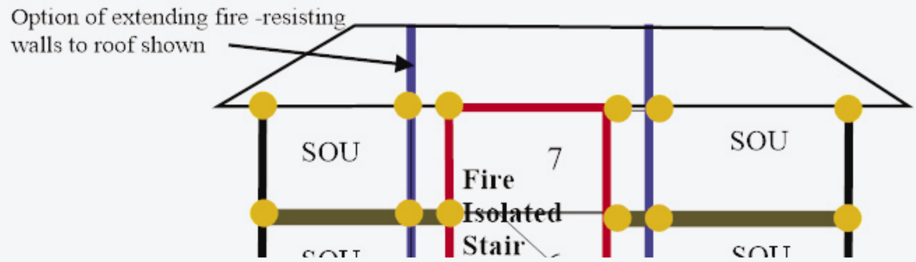


Figure B3: Design option to extend fire walls to roof level in lieu of using large cavity barriers within a fire-protected timber roof system.

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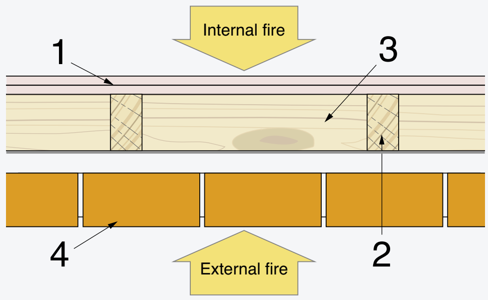
Appendix C – Example Data Sheets for an External Wall System

The following data sheet provides an example of the Evidence of Suitability required by the NCC. A brick veneer external wall system has been used because, in addition to fire and sound requirements, thermal resistance, weatherproofing and structural tests apply.

System External Wall 1

External Brick Veneer Timber framed wall system



1 Fire protective grade plasterboard, 2 x 13 mm thick

2.Timber framing in accordance with Evidence of Suitability

3 Cavity. – Cavity insulation may be required to achieve sound ratings and R –value (insulation must be non-combustible)

4 Outer brick veneer 90 mm thick

Typical Performance

Fire-protected timber	FRL90/90/90: RISF45: NC
Sound transmission and insulation	R_w 50: R_w+C_{tr} 50
Thermal resistance	R Value 3.3 m^2K/W
Damp and weatherproofing	NCC performance requirement FP1.4
Structural tests	NCC specification C1.8 Clause 3.4

Evidence of Suitability

Fire-protected timber:	
Internal Fire Exposure	FRL Test or assessment report from an Accredited Testing Laboratory complying with NCC A5.4 – (e.g.Exova Warringtonfire report 22567A-01) RISF – 45 (NCC Spec C1.13a DTS)
External Fire Exposure	FRL Test or assessment report from an Accredited Testing Laboratory complying with NCC A5.4 or design in accordance with AS 3700 RISF – 45 (AS 3700 design for insulation or test or assessment report from an Accredited Testing Laboratory)
Non-combustibility	Plasterboard NCC C1.9(e)(i) DTS Fire-protected timber NCC C1.13 Concession Cavity Insulation AS 1530.1 test report Brickwork –traditional building material

Obtain Evidence of Suitability from product supplier before specifying or installing any product or system

Sound Transmission and Insulation No NCC requirement for external walls in NCC 2016 but commonly specified for inner city locations. Report from a laboratory or acoustics engineer stating performance achieved.

Thermal Resistance R-Value Report complying with NCC Clause A5.2

Weatherproofing Statement of compliance with relevant requirements of AS 3700 and report confirming applicability of AS 3700 – complying with NCC Clause A5.2.

Structural tests for lightweight construction Report complying with NCC Clause A5.2 expressing results of tests in accordance with NCC specification C1.8.

Notes

Selection of systems that are fit for the purpose and the provision of Evidence of Suitability to the satisfaction of the relevant authority is the responsibility of the designers and product suppliers. Forest and Wood Products Australia Limited (FWPA) and the authors of this Guide make no warranties or assurances with respect to the fitness for purpose of the systems described in this Guide.

Ensure installation is in accordance with Evidence of Suitability, manufacturer's instructions and design drawings.

Primary Distributors

Various plasterboard distributors

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Appendix D – Definitions and Abbreviations

12.1 NCC-related Definitions

Unless otherwise stated, the following NCC-related Definitions are based on the Definitions given in Schedule 3 of the National Construction Code 2019 Amendment 1 provided by *https://www.abcb.gov.au/* Australian Building Codes Board © 2020.

Accredited Testing Laboratory:

- an organisation accredited by the National Association of Testing Authorities (NATA) to undertake the relevant tests; or
- an organisation outside Australia accredited to undertake the relevant tests by an authority recognised by NATA through a mutual recognition agreement; or
- an organisation recognised as being an Accredited Testing Laboratory under legislation at the time the test was undertaken.

Aged care building: A Class 9c building for residential accommodation of aged persons who, due to varying degrees of incapacity, are provided with personal care services and 24-hour staff assistance to evacuate the building during an emergency.

Appropriate Authority (for the purposes of Schedule 7): The authority with the statutory responsibility to determine the particular matter satisfies the relevant Performance Requirement. The Appropriate Authority is typically the building surveyor or building certifier charged with the statutory responsibility to determine building compliance and issue the building permit/approval and occupancy certificate/approval.

Combustible:

- Applied to a material — combustible as determined by AS 1530.1
- Applied to construction or part of a building — constructed wholly or in part of combustible materials.

Cavity barrier: A barrier placed in a concealed space, formed within or around the perimeter of fire-protected timber building elements that complies with Specification C1.13 of the NCC, to limit the spread of fire, smoke and hot gases to other parts of the building.

Deemed-to-Satisfy Provisions: Provisions that are deemed to satisfy the Performance Requirements.

Deemed-to-Satisfy Solution: A method of satisfying the Deemed-to-Satisfy Provisions.

Discontinuous construction: A wall system typically having a minimum of 20 mm cavity between two separate wall frames (leaves) with no mechanical linkage between the frames except at the periphery intended to reduce sound transmission.

Effective height: The vertical distance between the floor of the lowest storey included in the calculation of rise in storeys and the floor of the topmost storey (excluding the topmost storey if it contains only heating, ventilating, lift or other equipment, water tanks or similar service units).

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
- a fire-isolating passageway
- horizontal exit.

External wall: An outer wall of a building that is not a common wall.

Fire-isolated stair or ramp: A stair or ramp construction constructed of materials required by the NCC and located 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 or to open space.

Fire-protected timber: Fire-resisting timber building elements that comply with Volume One Specification C1.13a.

Fire-protective covering:

- 13 mm fire-protective grade plasterboard; or
- 12 mm cellulose cement flat sheeting complying with AS/NZS 2908.2 or ISO 8336; or
- 12 mm fibrous plaster reinforced with 13 mm x 13 mm x 0.7 mm galvanised 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 grade plasterboard, fixed in accordance with the normal trade practice for a fire-protective covering.

Fire-protective grade plasterboard: Plasterboard with glass fibre and mineral additives used to improve strength and control shrinkage under fire conditions. Typically, a lightweight loadbearing timber framed wall protected by one layer of 16 mm fire-protective grade plasterboard applied to each face would be expected to achieve an FRL of at least 60/60/60 and if protected by two layers of 13 mm fire-protective grade plasterboard on each face an FRL of at least 90/90/90.

Fire-resistance level (FRL): The grading periods in minutes determined in accordance with Schedule 5, for the following criteria, expressed in this order:

- structural adequacy
- integrity
- insulation

Note: A dash means that there is no requirement for that criterion. For example, 90/–/– means there is no requirement for an FRL for integrity and insulation, and –/–/– means there is no requirement for an FRL.

Fire-resisting (applied to a building element): Having an FRL appropriate for that element.

Fire-resisting construction: One of the types of construction referred to in the NCC.

Fire-resisting sealant: A fire-grade material used to fill gaps at joints and intersections in fire-protective linings and around service penetrations to maintain Fire Resistance Levels and Resistance to Incipient Spread of Fire performance of elements of construction. Note: The material should also be flexible to allow for movement and where required be waterproof.

Fire-source feature:

- 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 that is not of Class 10.

Fire wall: A wall with an appropriate resistance to the spread of fire that divides a storey or building into fire compartments.

Healthcare building: A building whose occupants or patients undergoing medical treatment generally need physical assistance to evacuate the building during an emergency and includes:

- a public or private hospital
- a nursing home or similar facility for sick or disabled persons needing full-time care
- a clinic, day surgery or procedure unit where the effects of the predominant treatment administered involve patients becoming non-ambulatory and requiring supervised medical care on the premises for some time after the treatment.

Lightweight construction: Construction that incorporates or comprises:

- sheet or board material, plaster, render, sprayed application, or other material similarly susceptible to damage by impact, pressure or abrasion
- concrete and concrete products containing pumice, perlite, vermiculite, or other soft material similarly susceptible to damage by impact, pressure or abrasion
- masonry having a width of less than 70 mm.

Loadbearing: Intended to resist vertical forces additional to those due to its own weight.

Massive timber: An element not less than 75 mm thick as measured in each direction formed from solid and laminated timber.

Non-combustible:

- Applied to a material: not deemed combustible as determined by AS 1530.1 – Combustibility Tests for Materials.
- Applied to construction or part of a building: constructed wholly of materials that are not deemed combustible.

Massive Timber 'Concession': A relaxation allowing the Resistance to Incipient Spread of Fire requirements for fire-protected timber to be modified if both the following conditions are satisfied:

- the timber is at least 75 mm thick
- any cavity between the surface of the timber and the fire-protective covering is filled with non-combustible materials.

Modified Resistance to the Incipient Spread of Fire (MRISF): The MRISF, among other things, relaxes the RISF limiting temperature from 250˚C to 300˚C to reflect the reduced risk of fire spread through cavities and higher inherent fire resistance of timber with larger cross-sections. The test procedures for MRISF are described in Section 3 of Specification C1.13a of the NCC.

Multi-service penetration system: A service penetration system used to protect a group of services penetrating a single opening in a fire-resisting element such that the FRL, RISF or MRISF of the element is not reduced. Note: Fire protective coverings or other means may be required to be fitted around the opening to ensure that the RISF or MRISF are not reduced.

Patient care area: A part of a healthcare building normally used for the treatment, care, accommodation, recreation, dining and holding of patients including a ward area and treatment area.

Performance-based design brief (PBDB), for the purposes of Schedule 7: Means the process and the associated report that defines the scope of work for the performance-based fire safety engineering analysis and the technical basis for analysis as agreed by stakeholders.

Performance Requirement: A requirement that states the level of performance that a Performance Solution or Deemed-to-Satisfy Solution must meet.

Performance Solution: A method of complying with the Performance Requirements other than by a Deemed-to-Satisfy Solution.

Product Technical Statement: A form of documentary evidence stating that the properties and performance of a building material, product or form of construction fulfil specific requirements of the NCC, and describes:

- the application and intended use of the building material, product or form of construction
- how the use of the building material, product or form of construction complies with the requirements of the NCC
- any limitations and conditions of the use of the building material, product or form of construction relevant to (b).

Residential aged care building: A Class 3 or 9a building whose residents, due to their incapacity, are provided with physical assistance in conducting their daily activities and to evacuate the building during an emergency.

Residential care building: A Class 3, 9a or 9c building that is a place of residence where 10% or more of persons who reside there need physical assistance in conducting their daily activities and to evacuate the building during an emergency (including any aged care building or residential aged care building) but does not include a hospital.

Resident use area: Part of a Class 9c building normally used by residents, and

- includes sole-occupancy units, lounges, dining areas, activity rooms and the like
- excludes offices, storage areas, commercial kitchens, commercial laundries and other spaces not for the use of residents.

Resistance to the incipient spread of fire (RISF), in relation to a ceiling membrane: The ability of the membrane to insulate the space between the ceiling and roof, or ceiling and floor above, so as to limit the temperature rise of materials in this space to a level that will not permit the rapid and general spread of fire throughout the space.

Rise in storeys: The greatest number of storeys calculated in accordance with C1.2 of NCC.

Separating element: A barrier that exhibits fire integrity, structural adequacy, insulation or a combination of these for a period of time under specified conditions (often in accordance with AS 1530.4).

Shaft: The walls and other parts of a building bounding:

- a well, other than an atrium well
- a vertical chute, duct or similar passage, but not a chimney or flue.

Standard Fire Test: The Fire-resistance Tests of Elements of Building Construction as described in AS 1530.4.

Storey: A space within a building which is situated between one floor level and the floor level next above, or if there is no floor above, the ceiling or roof above, but not:

- a space that contains only—
  - a lift shaft, stairway or meter room
  - a bathroom, shower room, laundry, water closet, or other sanitary compartment
  - accommodation intended for not more than 3 vehicles
  - a combination of the above
  - a mezzanine.

Structural adequacy, in relation to an FRL: The ability to maintain stability and adequate loadbearing capacity as determined by AS 1530.4.

Structural member: A component or part of an assembly that provides vertical or lateral support to a building or structure.

Treatment area: An area within a patient care area, such as an operating theatre and rooms used for recovery, minor procedures, resuscitation, intensive care and coronary care from which a patient may not be readily moved.

Verification Method: A test, inspection, calculation or other method that determines whether a Performance Solution complies with the relevant Performance Requirements.

Ward area: That part of a patient care area for resident patients and may contain areas for accommodation, sleeping, associated living and nursing facilities.

12.2 General Definitions

For general terminology used to describe the typical forms of timber construction that can be adopted for mid-rise buildings refer to the Timber Construction Options for Mid-rise Buildings (Page 10)

High-rise buildings: Buildings with an effective height greater than 25 m.

Low-rise buildings: Buildings of Type B or C construction as required by the NCC. For healthcare Class 9a and Class 9c buildings low-rise buildings are typically 1-2 storeys high but may typically extend up to 3 storeys for other classes.

Mid-rise buildings: Buildings that are not low-rise and have an effective height not more than 25 m. Typically they are 3-8 storeys high. The maximum number of storeys depends on the specific site conditions and building design.

12.3 Abbreviations

CLT	Cross-laminated Timber
DTS	Deemed-to Satisfy
LVL	Laminated Veneer Lumber
MRISF	Modified Resistance to the Incipient Spread of Fire
NCC	The National Construction Code Volume One, Building Code of Australia 2019 Amdt. No. 1
RISF	Resistance to the Incipient Spread of Fire

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Appendix E - References

13.1 WoodSolutions Technical Design Guides

#1 Timber-framed Construction for Townhouse Buildings Class 1a

#2 Timber-framed Construction for Multi-residential Buildings Class 2 and 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

#16 Massive Timber Construction Systems: Cross-laminated Timber (CLT)

#20 Fire Precautions during Construction of Large 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 (incl.Class 4 parts)

#38 Fire Safety Engineering Design of Mid-Rise Buildings

#39 Robustness in Structures

#42 Building Code of Australia DTS Solutions for Timber Aged Care Buildings (Class 9c)

#44 CLT Acoustic Performance

13.2 Australian Standards

AS 2118.1 Automatic fire sprinkler systems – General requirements

AS 2118.4 Automatic fire sprinkler systems – Sprinkler protection for accommodation buildings not exceeding four storeys in height

AS 2118.6 Automatic fire sprinkler systems – Combined sprinkler and hydrant systems in multi-storey buildings

AS 1170 series – Structural design actions

AS 1720.1 Timber structures – Design methods

AS 1720.4 Timber structures – Fire resistance for structural adequacy of timber members

AS 5113 Amd 1 Classification of external walls of buildings based on reaction to fire performance

AS 1905.1 Components for the protection of openings in fire-resistant walls – Fire-resistant doorsets

AS 1530.1 Methods for fire tests on building materials, components and structures – Combustibility test for materials

AS 1530.4 Methods for fire tests on building materials, components and structures – Fire-resistance tests for elements of construction

AS 1530.7-2007 Methods for fire tests on building materials, components and structures Part 7: Smoke control assemblies—Ambient and medium temperature leakage test procedure. 2007, Standards Australia: Sydney.

AS 4072.1 Components for the protection of openings in fire-resistant separating elements – Service penetrations and control joints

AS 2444 Portable fire extinguishers and fire blankets – Selection and location

AS 1682.1 Fire, smoke and air dampers – Specification

AS 1682.2 Fire, smoke and air dampers – Installation

AS 1668.1 The use of ventilation and air conditioning in buildings – Part 1 Fire and smoke control in buildings. 2015

AS 6905-2007 Smoke Doors. 2007

AS 2896-2011 Medical gas systems – installation and testing of non-flammable medical gas pipeline systems. 2011

13.3 Accredited Test Laboratory Reports

RIR 22567A-04 – The fire resistance performance of timber-framed walls lined with plasterboard if tested in accordance with AS1530.4-2005

RIR 37600400 – The Fire Resistance Level (FRL) of timber-framed floor/ceiling systems incorporating timber and metal web floor trusses or various engineered joists when tested in accordance with AS 1530.1-2014

RIR 37401400 – The Fire Resistance Level (FRL), Resistance to the Incipient Spread of Fire (RISF) and Modified Resistance to the Incipient Spread of Fire (MRISF) performance of various timber-framed and massive timber panel systems

RIR 55945800.1B – The fire-resistance performance of timber-framed walls lined with 3 layers of 16mm fire protective grade plasterboard if tested in accordance with AS 1530.4-2014 for 180 minutes

WF report FAS190034-RIR 1.0 – Timber-framed floor/ceiling systems incorporating various timber and metal web floor trusses or engineered joists with an FRL of 120/120/120

13.4 ABCB references

National Construction Code 2019 Amendment 1 Australian Building Codes Board https://www.abcb.gov.au/ Australian Building Codes Board © 2020."

Other References

National Construction Code Volume One: Building Code of Australia 2019 Amendment 1 – Australian Building Codes Board, Canberra ACT – © Commonwealth of Australia and the States and Territories 2019

International Fire Engineering Guidelines (2005) – Australian Government, Sate and Territories of Australia

Safe Design of Structures – Safe Work Australia

Exova Warringtonfire Australia Pty Ltd (EWFA) Regulatory Information Reports (RIR) issued to Forest & Wood Products Australia:

RIR 22567A-04 – The fire resistance performance of timber-framed walls lined with plasterboard if tested in accordance with AS1530.4-2005

RIR 37600400 – The fire resistance level (FRL) of timber-framed floor/ceiling systems incorporating timber and metal web floor trusses or various engineered joists when tested in accordance with AS 1530.1-2014

RIR 37401400 – The fire resistance level (FRL), Resistance to the Incipient Spread of Fire (RISF) and Modified Resistance to the Incipient Spread of Fire (MRISF) performance of various timber-framed and massive timber panel systems

Bennetts, ID *et al* Fire Safety of Hospitals - A guide for designers. 2018: Melbourne.