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Timber Fire Design Compliance for Low-rise Office (Class 5) and School (Class 9b) buildings



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Researcher:

Timber Development Association (NSW)
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Introduction

This Guide covers NCC Class 5 and 9b buildings.

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

This Guide is aimed at designers, specifiers, builders, code officials and certifying authorities who want to use or interpret fire-resisting timber construction that is Deemed-to-Satisfy with the National Construction Code's (NCC) – Building Code of Australia, Volume One (BCA)¹ for low-rise Office (Class 5) and School (Class 9b) buildings. The Deemed-to-Satisfy compliance pathway discussed in this Guide is another option other than the recently adopted mid-rise timber buildings concession called fire-protected timber. This particular compliance pathway allows the use of fire-rated exposed mass timber or timber protected by fire-protective coverings.

The Guide is set out according to a simple step-by-step process shown in Figure 1. The steps are used as the basis for headings throughout the rest of the document.

Scope

This Guide demonstrates the achievement of targeted fire Performance Requirements in the Building Code of Australia (BCA) for Office (Class 5) and school (Class 9b) buildings for timber construction. It focuses specifically on fire-resisting construction of beams, columns, wall, floor and ceiling elements. In this context, the Guide provides details that utilise the NCC's Deemed-to-Satisfy Provisions, allowing exposed mass timber or fire-protective covering timber construction.

This Guide does not deal with all aspects of NCC's fire safety performance. For further details, refer to Section 4.

Evidence of Suitability

The NCC requires every part of a building to be constructed in an appropriate manner to achieve the requirements of the BCA. This Guide has been prepared from several sources; however, it is up to the design proponent to ensure appropriate evidence is provided.

Where available, the Guide directs users to sources of relevant evidence, such as other WoodSolutions Guides, industry-based test reports or assessments or NCC-referenced Standards. Other information sources that support this Guide are referenced in Step 4.

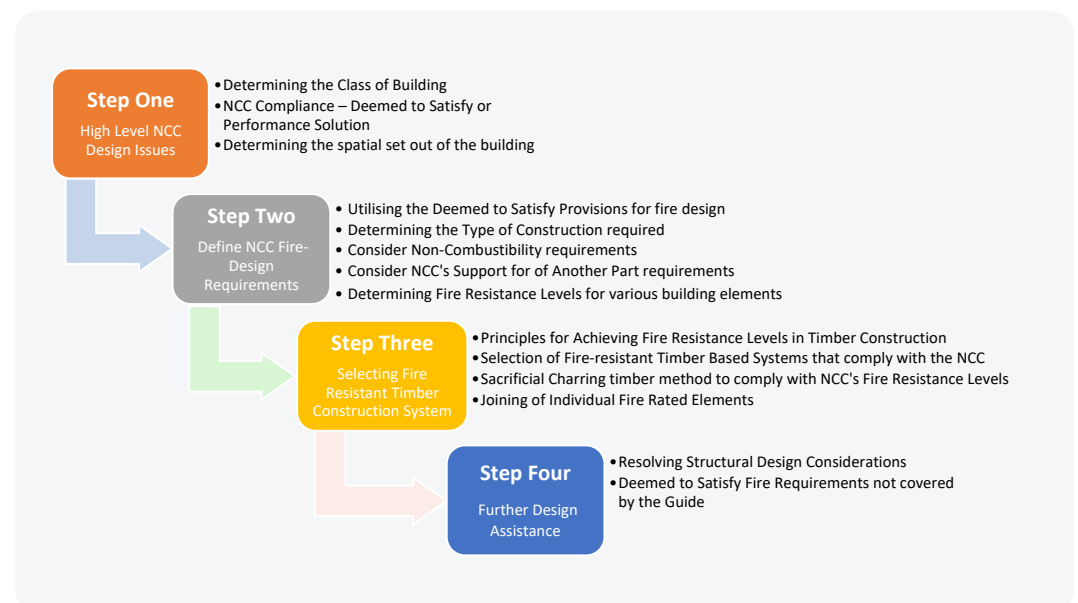


Figure 1: Design approach for fire-resisting timber construction.

1

Step 1 – High-Level BCA Design Issues

The NCC is the regulatory framework for determining minimum construction requirements for all types of buildings in Australia. It contains different levels of detail that subsequently cause different decisions to be made on a building project. The regulations are contained in the volumes of the NCC titled Building Code of Australia¹. A selection of high-level design issues relating to fire-resisting construction is addressed in this Section of the Guide.

1.1 Determining the Class of Building

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

- **Class 5 buildings** – office buildings used for professional or commercial purposes, excluding Class 6, 7, 8 or 9. Refer to Figure 2.
- **Class 9b buildings (only)** – a building of a public nature including an assembly building including a trade workshop, laboratory or the like in a primary or secondary school, but excluding any other parts of the building that are of another Class. Refer to Figure 3.

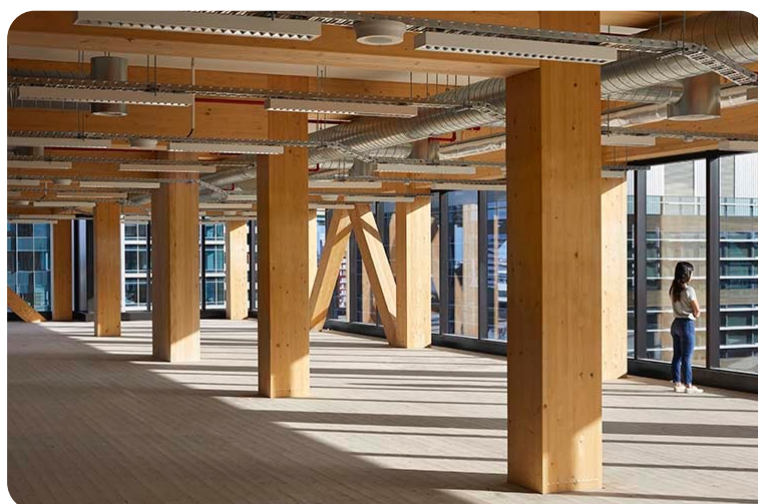


Figure 2: Examples of timber office buildings – 25 King Street. (Image credit: Tom Roe)



Figure 3: Examples of timber school buildings – Our Lady of the Assumption Catholic Primary School. (Image credit: Brett Boardman / Michael Nicholson/ Stefan Hefe)

Building Class determines construction type, which impacts a timber-framed system choice.

1.1.1 Other Building Classification

Supplementary WoodSolutions Technical Design Guides deal with other building classes or building heights. The following contains a list of the building classification and the relevant WoodSolutions Guide that addresses their fire-resisting construction system. Note that the Guides referenced are generally separated by the height of the building, with low-level buildings (up to three storeys) termed low-rise and medium height buildings (4 to 8 storeys) termed mid-rise. Depending on the height of the building, different NCC-compliant fire-resisting design solutions are available.

- Class 1a: WoodSolutions Technical Design Guide #1. Timber-Framed Construction for Townhouse Buildings Class 1a².
- Class 2 and 3:
 - Low-rise Buildings – WoodSolutions Technical Design Guide #2: Timber-Framed Construction for Multi-Residential Buildings Class 2 & 3³
 - Mid-rise Buildings – WoodSolutions Technical Design Guide #37R: Mid-rise Timber Buildings Multi-residential Class 2 and 3⁴.
- Class 9a and 9c:
 - Low-rise Buildings – WoodSolutions Technical Design Guide #46. Building Code of Australia Deemed-to-Satisfy Solutions for Timber Aged Care Buildings (Class 9c)⁵
 - Mid-rise Buildings – WoodSolutions Technical Design Guide #37H: Mid-rise Timber Buildings Healthcare Class 9a and 9c⁶.
- Class 5, 6, 7, 8 and 9b:
 - Mid-rise Buildings – WoodSolutions Technical Design Guide #37C: Mid-rise Timber Buildings Commercial and Education Class 5, 6, 7, 8 and 9b (including Class 4 parts)⁷

All these building classifications are dealt with within Volume One of the NCC, so all future references are to this volume. Users must choose which building Class applies to their building project. This decision influences the timber construction system that can be utilised for the project, including if the fire-resisting elements can be left exposed and still achieve Deemed-to-Satisfy compliance.

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

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

- **Deemed-to-Satisfy Provisions** – a specific Type of Construction with prescriptive design solutions that are acknowledged to comply with the NCC's Performance Requirements.
- **Performance Solution** – a solution not dealt with under the Deemed-to-Satisfy Provisions and must be proven to satisfy the NCC Performance Requirements. Suitable assessment methods are identified in the BCA.

The construction systems and details in this Guide comply with the Deemed-to-Satisfy Provisions. For instance, these provisions direct the level of fire-resisting construction that elements must achieve in order to meet minimum NCC requirements. Where available, accepted NCC assessment methods are then used to ensure that the timber construction systems are shown in this Guide comply with the levels required.

Where a design cannot meet the Deemed-to-Satisfy Provisions, a Performance Solution is required. This Guide does not address Performance Solutions and recommends referral to WoodSolutions Technical Design Guides No. 17⁸, 18⁹ or 19¹⁰.

1.3 Determining the Spatial Set Out of the Building

Spatial issues influence the fire separation and compartmentalisation requirements of Class 5 and 9b buildings. For instance, a fire compartment's floor area or volume must not exceed the stated maximum floor area or volume provided in the NCC Provision C2.2. Related conditions are also provided in Provisions C2.3 and C2.4 of the NCC. Determining spatial requirements is essential because it influences the category of fire-resisting construction that must be used in the building (as dealt with in more detail under Step 2 of this Guide).

Another issue is the need to define individual fire compartments within the Class 5 and 9b buildings. Fire compartments are a part of a building separated from the remainder by walls and/or floors where each element has a level of fire resistance. The fire compartment provides a box that contains the fire in a fire event so that occupants can escape, emergency personnel can gain access, or the fire is prevented from spreading to other parts of the building or neighbouring buildings. In residential construction, they are often referred to as Sole Occupancy Units (SOUs).

For most Class 5 and 9b buildings that don't contain other building classifications, the fire compartment is often the storey of the building itself. However, where relevant, the wall, floor and ceiling elements that bound the fire compartment are central in achieving NCC's fire Performance Requirements. Here, specific requirements vary depending on whether the fire compartments are:

- side by side
- stacked on top of each other (as well as side by side) or
- adjoining a different type of use (such as a building classification).

Note: Though bounding wall and floor elements of a fire compartment are generally identified as the main fire-rated elements, it is also likely that certain internal walls and floors will also need to be fire-rated, particularly where supporting fire-rated construction above or in some cases horizontally. This concept is explained further in Section 2.4.

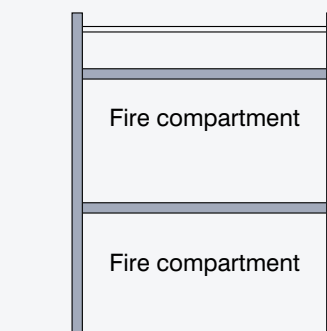


Figure 2: Example of Sole Occupancy Units (SOU).

2

Step 2 – Define NCC Fire-Design Requirements

Designing fire-resistant construction involves a process of understanding how the NCC's Performance Requirements translate into the more objective and measurable Deemed-to-Satisfy (DTS) Provisions and then selecting timber construction systems that suits these requirements. Details about DTS design requirements are discussed in this Step.

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

Part C of the NCC's Building Code of Australia's Performance Requirements is concerned with safeguarding people when a fire occurs in a building. Specific attention is given to the evacuation of occupants, facilitating the activities of emergency services personnel, avoiding the spread of fire between buildings and protecting other property from physical damage caused by structural failure of the building as a result of a fire.

Deemed-to-Satisfy Provisions that meet the above Performance Requirements are detailed in the NCC under:

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

These parts deal with a wide range of issues, but only the fire resistance of specific building elements, e.g. beam, column, wall, floor and ceiling elements, are dealt with in this Guide, as these elements can be made using timber construction. To this end, only relevant clauses from Parts C1, C2 and C3 are discussed in more detail below. To help Guide users understand the full range of issues contained in these parts, a checklist is provided in Section 4 of this Guide.

2.2 Determining the Type of Construction Required

The main issue of interest to timber construction relates to determining the Type of Construction, as defined in the NCC, required to resist fire for a given building type:

- Calculate the 'rise in storeys' of the building. This term is defined in the NCC and is relevant for fire-resistance design, representing the number of storeys above the finished ground. Refer to NCC DTS Provision C1.2 for a precise definition, as there are exceptions to what is considered a storey within a building. For example, the storey below the ground is not considered in the rise of storey count.
- Determine if the construction is Type A, B or C construction; refer to NCC DTS Provision C1.1. This determination is done in conjunction with compartmentalisation limits for floor area/building volume; refer to NCC DTS Provision 2.2. The three types of construction are:
 - **Type A** provides the highest level of passive protection; theoretically, the structural elements must withstand the consumption of the building's movable contents.
 - **Type B** provides lower passive protection, e.g. less of the structure must be able to withstand the consumption of the contents, generally only the external walls.
 - **Type C** provides the lowest passive fire resistance, e.g. only some elements have specified fire resistance intended to restrict the horizontal spread of fire to adjoining buildings.
- Take into account any adjustments arising due to multiple building classifications, NCC Provision C1.3, and 'mixed types of construction', NCC Provision C1.4, and then the Type of Construction can be finalised. Further explanation on how Multiple Building Classification and Mixed Types of Construction are discussed in Appendix A of this Guide.

Tables like the one overleaf will help you choose the right path.

A chart for assisting the selection of the appropriate Type of construction is shown in Table 1. It also allows users to determine if an **all-timber** building solution is possible under the Deemed-to-Satisfy Provisions (no green shading) or if a Performance Solution (green shaded region) is necessary. However, different applications, i.e. beams, columns, walls, floors and roofs, have different DTS limits, and where a Performance Solution is indicated, it is generally inferred to be required for fire-resisting and external walls only. In all Types of Construction, some timber construction is allowed; this is explained in detail in the following Section.

Table 1: Determining the Type of construction, rise in storey and spatial limits under NCC's Deemed-to-Satisfy Provisions.

Rise in Storey	Type of Construction			
	Class 5 Office	Maximum Floor Area or Volume	Class 9b schools, theatres, sports halls, etc	Maximum Floor Area (m ²) or Volume (m ³)
25 m +	A	Floor area – 5,000 Volume – 30,000	A	Floor area – 8,000 Volume – 48,000
8 or less than 25 m	A	Floor area – 5,000 Volume – 30,000	A	Floor area – 8,000 Volume – 48,000
7	A	Floor area – 5,000 Volume – 30,000	A	Floor area – 8,000 Volume – 48,000
6	A	Floor area – 5,000 Volume – 30,000	A	Floor area – 8,000 Volume – 48,000
5	A	Floor area – 5,000 Volume – 30,000	A	Floor area – 8,000 Volume – 48,000
4	A	Floor area – 5,000 Volume – 30,000	A	Floor area – 8,000 Volume – 48,000
3	B	Floor area – 3,500 Volume – 21,000	A	Floor area – 8,000 Volume – 48,000
2	C	Floor area – 2,000 Volume – 12,000	B	Floor area – 5,500 Volume – 33,000
1	C	Floor area – 2,000 Volume – 12,000	C	Floor area – 3,000 Volume – 18,000

Note: The NCC contains concessions and methods to overcome floor area and volume limits, such as firewall separation, sprinkler systems and perimeter vehicular access.

2.3 NCC's Non-Combustibility Requirements

Once the building's Type of Construction is determined, it is recommended to identify what building elements are required to be non-combustible. This determines which elements can be exposed timber or are required to utilise the fire-protected timber concession for non-combustible construction.

Timber elements that are not required to be non-combustible can either be exposed or protected by fire-protective coverings. The exception is generally load-bearing walls in Type A and B construction, which have no non-combustible requirements but must be built from concrete, masonry or fire-protected timber.

Generally, lightweight timber-framing is protected by fire-protective coverings, while mass timber has the option of being left exposed or protected by fire-protective coverings. Where the element is required to be non-combustible, this does not prohibit timber, just limits the option to the concession for fire-protected timber, discussed in more detail below, to a Class 5 building. The associated Fire Resistance Level for each construction type must be applied to the respective parts.

2.3.1 Applicable Type of Construction

The NCC has a specific section on non-combustible construction, NCC Provision C1.9 Non-combustible building elements, that details the elements that are required to be non-combustible. This first point is that only Type A and B construction have non-combustible building elements; Type C is not applicable to this NCC Provision.

Walls (Type A and B Only)

External walls, common walls and non-loadbearing internal walls, where required to be fire-resisting, must be non-combustible. All parts of the wall, including coverings, structure and insulation, must also be non-combustible. This non-combustible requirement does not apply to loadbearing internal walls, loadbearing firewalls and loadbearing shafts. These wall types must be built with either concrete, masonry or fire-protected timber.

Floors (Type A and B Only)

For floor construction, only the flooring and floor framing of lift pits are required to be non-combustible. The NCC has no other direct requirement, necessitating floors to be non-combustible. However, floors in some circumstances may inherit non-combustible requirements due to “support of another part” discussed in Section 2.4 of this Guide.

Products exempt from being required to be Non-Combustible

The NCC list several building components that the non-combustible requirements don't apply to. These components are:

- gaskets and caulking
- sealants
- termite management systems
- glass, including laminated glass and thermal breaks used in glazing systems
- damp-proof courses.

Furthermore, the NCC deems certain materials to be acceptable when they are used in elements required to be non-combustible. These materials are:

- Plasterboard
- Perforated gypsum lath
- Fibrous plaster sheets
- Fibre-reinforced cement sheet
- Prefinished metal sheeting with combustible surfaces
- Sarking-type materials
- Bonded laminated materials with non-combustible lamina and restricted adhesive volume.

Can Timber Still be used if the Building elements is required to be non-combustible?

Although no chemical treatments can make timber non-combustible, the NCC does contain a concession that allows non-combustible building elements to utilise timber-based systems. The NCC Provision C1.13 Fire-Protected Timber: Concession allows fire-protected timber systems to be used when the element is required to be non-combustible. Although fire-protected timber elements can be used for all building classifications, they have additional requirements and limits:

- The effective height (topmost floor height above the finished ground level) is not greater than 25 m.
- Contain complete sprinkler system, excludes FPAA101D¹¹ and FPAA101H¹² systems.
- The insulation used in cavities is to be non-combustible.
- Cavity barriers are installed in accordance with the NCC's Specification C1.13.

Loadbearing Internal Walls, Firewalls and Shafts for Type A and B Construction (NCC Specification C1.1. Clause 3.1 (d) and Clause 4.1 (e))

Loadbearing Internal Walls, Firewalls and Shafts for Type A and B Construction have no non-combustibility requirement and instead are required to be made from concrete, masonry or fire-protected timber.

Summary of NCC Non-Combustible Building Elements Requirements

The NCC Provision C1.9 lists all the elements that have a direct mandatory to be non-combustible. These elements are:

- external walls
- common walls
- non-loadbearing internal walls, where required to be fire-resisting
- flooring and floor framing of lift pits.

All other building elements have no direct non-combustible requirements; however, there are exceptions to the rule, for example (but not limited to):

- support columns to balconies and verandahs in Type A construction
- enclosure to shafts
- smoke-proof walls
- fire-isolated stairs and ramps
- various concessions that lower the fire resistance construction requires the inclusion of non-combustible elements.

Where building elements are required to be non-combustible, they can still be made from timber through the NCC concession, Fire-protected Timber NCC Provision C1.13.

2.4 Non-Combustibility and Support of Another Part

The NCC Specification C1.1 Fire Resisting Construction Clause 2.2 Fire Protection for support of another part may cause a building element with no direct non-combustibility requirements to inherit this requirement. The NCC requires building elements that directly support, either vertically or laterally, another building element with a fire-resistance rating. They must adopt the fire-resistance rating of the element it supports if it is for a more extended period. Furthermore, if the element with a fire-resisting rating is also required to be non-combustible, the supporting element must also be non-combustible. This requirement is logical as the supporting structure cannot be less fire-resistant than the element it supports. However, the requirement is only evoked if the element being supported has a fire-resistance rating. If the element just has a non-combustible requirement without a fire-resistance rating, the non-combustibility is not transferred to the supporting structure.

An example of this requirement transferring non-combustibility onto another element is where a floor directly supports an external wall, common wall or non-loadbearing internal walls, required to be fire-resisting. In this case, the floor itself must adopt the fire resistance level of an element it supports, if it is higher, as well as the non-combustible requirement. This situation often occurs in residential building types, where there are many small fire compartments within the one storey, i.e. Sole Occupancy Units. For Class 5 and 9b buildings, this is not often the case as the fire compartment is frequently the entire floor.

2.4.1 Concession to Support of Another Part

A part of the NCC Specification C1.1 Fire Resisting Construction Clause 2.2 Fire Protection for support of another part describes building elements that need not comply.

Exempt building elements that provide lateral support to external walls:

Elements such as floors or internal walls that the external wall relies on for lateral support are exempt for the transfer of the non-combustible requirements when the construction classification is Type C or the external walls that meet Specification C1.11. Specification C1.11 is limited to concrete external walls panels that are not more than two storeys high.

Furthermore, for external walls with no fire-resistance rating (refer to Table 2 for conditions when this occurs), the NCC provision Fire Protection Support of Another Part is not applicable.

Table 2: Situations where external walls have no fire-resistance rating.

NCC Building Type	Loadbearing External Wall	Non-loadbearing External Wall
	Distance to Fire Source Feature	
Type A	N/A	3 m or more
Type B	18 m or more	3 m or more

Curtin and panel external walls concession

The NCC definition of a panel wall is a non-loadbearing external wall, framed or similar construction wholly supported at each storey. The NCC definition of a curtain wall is a non-loadbearing external wall that is not a panel wall. Therefore, any non-loadbearing external wall meets the NCC definition of either panel or curtain wall.

Where this is the case, the NCC Specification C1.1, Clause 2.5 (d) removes the need for curtain and panel walls to be fire-resisting, as long as the wall is non-combustible and protected by automatic wall-wetting sprinklers. Where this occurs, the NCC Provision Fire Protection for Support of Another Part is again not applicable. Timber based external wall systems can be used in this instance; as seen from above, any non-combustible construction can be substituted with fire-protected timber construction, as long as it meets the fire-protected timber conditions. Therefore, including automatic wall-wetting sprinklers can remove the transfer of non-combustible construction requirements onto other building elements.

Roofs providing lateral support

Building elements such as external walls or non-loadbearing internal fire-resisting rated walls often require lateral support from roof elements. However, they are exempt if the various roof fire resistance concession removes their fire-resistance rating, summarised below.

Type A Construction – complies with one of the following

- sprinkler system other than FPA101D¹¹ or FPAA101H¹² system, or
- the rise in storeys of 3 or less, or
- Class 2 or 3; or
- has an effective height of 25 m or less and the ceiling immediately below has a resistance to the incipient spread of fire of 60 minutes.

Type B and C Construction – not applicable as there are no fire resistance requirements for Type B and C roofs.

Column providing lateral support to a wall

This concession is limited to a single storey building that is generally Type C construction and is not applicable in the first instance.

Building element providing lateral support to firewall or fire-resisting wall

Where a fire-resisting wall is supported on both sides, lateral support is maintained, as long as the failure on one side does not affect the fire performance of the wall itself. Often non-loadbearing fire-resisting walls require support at the base and top of the wall. This concession removes the need for the supporting structure to be non-combustible; for example, the floor needs to be non-combustible due to the lateral support it gives.

2.5 Determining Fire Resistance Levels for Building Elements

Having determined the correct Type of Construction for the building, it is now possible to determine the Fire Resistance Levels required for various beams, columns, walls, floors, ceilings and other building elements through NCC Specification C1.1. Fire Resistance Levels. A Fire Resistance Level (FRL) expresses the minimum amount of time (in minutes) that a building element must resist fire as defined by three separate elements:

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

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

FRLs vary for each Type of Construction and critical building elements have different fire resistance periods for each Type of Construction. In addition, the NCC has many concessions that can be employed to reduce or remove FRLs. The following describes the FRLs required for each Type of Construction.

2.4.1 Type A Construction

Table 3: Summary of the Fire Resistance Level requirements for Type A Construction.

	Class 5 and 9b Building	
		Minimum Fire Resistance Level Required
EXTERNAL WALLS		
Loadbearing	less than 1.5 m	120/120/120
	1.5 m to less than 3 m	120/90/90
	3.0 m or more	120/60/30
Non-loadbearing	less than 1.5 m	– /120/120
	1.5 m to less than 3 m	– /90/90
	3.0 m or more	– / – / –
EXTERNAL COLUMNS (not incorporated with the external wall)		
Loadbearing		120/ – / –
Non-loadbearing		– / – / –
INTERNAL COLUMNS		
Loadbearing		120/ – / –
Non-loadbearing		– / – / –
INTERNAL BEAMS OR TRUSSES		
Loadbearing		120/ – / –
Non-loadbearing		– / – / –
INTERNAL WALLS		
Fire-resisting lift and stair shafts		
Loadbearing		120/120/120
Non-loadbearing		– /120/120
Bounding public corridors, lobbies		
Loadbearing		120/ – / –
Non-loadbearing		– / – / –
Between or bounding sole-occupancy units		
Loadbearing		120/ – / –
Non-loadbearing		– / – / –
Shafts for ventilation, pipe, garbage and the like		– / – / –
Loadbearing		120/90/90
Non-loadbearing		– /90/90
Other load-bearing internal walls		
Loadbearing		120/ – / –
FLOORS		
Loadbearing		120/120/120
ROOFS		
Loadbearing		120/60/30

Concessions for Floors – Type A (NCC Specification C1.1 Clause 3.2)

The FRL is not necessary when a floor is:

- laid directly on the ground
- in Class 5 and 9 buildings, the space below the floor is not considered a storey, is not used as a garage, storage or work area or for other ancillary purposes
- timber staging over a floor with the required fire resistance level
- open-access floor used for electrical and electronic services over a floor with the required fire resistance level.

For floors in Class 5 and 9b buildings, NCC Specification C1.1 Clause 3.3, with a live load not greater than 3.0 kPa, the floor above it, including beams used to support the floor, may have the FRL reduced to 90/90/90.

Concessions for roofs – Type A (NCC Specification C1.1 Clause 3.5)

A roof FRL can be removed if the roof covering is non-combustible and the building complies with one or more of the following

- sprinkler system other than FPA101D¹¹ or FPAA101H¹² system, or
- rise in storeys of 3 or less, or
- Class 2 or 3
- has an effective height of 25 m or less and the ceiling immediately below has a resistance to the incipient spread of fire of 60 minutes.

Internal column and walls Immediate below the roof – Type A (NCC Specification C1.1 Clause 3.7)

For a building with an effective height of not more than 25 m and a roof without a fire-resistance level, for the storey immediately below the roof, the following building elements may have a reduced fire resistance level.

Internal columns, other than internal columns within 1.5 m of a window that is exposed to a fire source feature, NCC Specification C1.1. 3.1 (f) and internal walls, other than firewalls and shaft wall, for Class 5 and 9b buildings:

- with a rise in storey exceeding 3: FRL 60/-/-
- with a rise in storey not exceeding 3: no FRL.

2.4.2 Type B Construction

Table 4: Summary of the Fire Resistance Level requirements for Type B Construction.

	Class 5 and 9b Building	
		Minimum Fire Resistance Level Required
EXTERNAL WALLS		
Loadbearing	less than 1.5 m	120/120/120
	1.5 m to less than 3 m	120/90/90
	3.0 m or more	120/60/30
Non-loadbearing	less than 1.5 m	– /120/120
	1.5 m to less than 3 m	– /90/90
	3.0 m or more	– / – / –
EXTERNAL COLUMNS (not incorporated with the external wall)		
Loadbearing	less than 18 m	120/ – / –
	18.0 m or more	– / – / –
Non-loadbearing		– / – / –
INTERNAL COLUMNS		
Loadbearing		120/ – / –
Non-loadbearing		– / – / –
INTERNAL BEAMS OR TRUSSES		
Loadbearing		– / – / –
Non-loadbearing		– / – / –
INTERNAL WALLS		
Fire-resisting lift and stair shafts		120/120/120
Loadbearing		120/120/120
Fire-resisting stair shafts		120/120/120
Non-loadbearing		– /120/120
Bounding public corridors, lobbies		120/120/120
Loadbearing		120/ – / –
Non-loadbearing		– / – / –
Between or bounding sole-occupancy units		120/90/90
Loadbearing		120/ – / –
Non-loadbearing		– / – / –
Other loadbearing internal walls		120/120/120
Loadbearing		120/ – / –
FLOORS		
Loadbearing		– / – / –
ROOFS		
Loadbearing		– / – / –

Internal Column and Walls Immediate below the Roof – Type B (NCC Specification C1.1 Clause 4.1 (g))

For Class 5 and 9b buildings, the storey immediately below the roof, internal columns and internal walls, other than firewalls and shaft walls, need no fire resistance level.

2.4.3 Type C Construction

Table 5: Summary of the Fire Resistance Level requirements for Type C Construction

	Class 5 and 9b Building	
		Minimum Fire Resistance Level Required
EXTERNAL WALLS		
Loadbearing	less than 1.5 m	90/90/90
	1.5 m to less than 3 m	60/60/60
	3.0 m or more	– / – / –
Non-loadbearing	less than 1.5 m	90/90/90
	1.5 m to less than 3 m	60/60/60
	3.0 m or more	– / – / –
EXTERNAL COLUMNS (not incorporated with the external wall)		
Loadbearing	less than 1.5 m	90/ – / –
	1.5 m to less than 3 m	60 / – / –
	3.0 m or more	– / – / –
Non-loadbearing		– / – / –
INTERNAL COLUMNS		
Loadbearing		120/ – / –
Non-loadbearing		– / – / –
INTERNAL BEAMS OR TRUSSES		
Loadbearing		– / – / –
Non-loadbearing		– / – / –
INTERNAL WALLS		
Bounding public corridors, lobbies		
Loadbearing		– / – / –
Non-loadbearing		– / – / –
Between or bounding sole-occupancy units		
Loadbearing		– / – / –
Non-loadbearing		– / – / –
Bounding a stair if required to be rated		
Loadbearing		60/60/60
FLOORS		
Loadbearing		– / – / –
ROOFS		
Loadbearing		– / – / –

External Walls – Type C (NCC Specification C1.1 Clause 5.1 (b))

External walls required to have a Fire-Resistance Level need only to achieve the FRL from the outside.

3

‘Sacrificial charring’ is a fire-resistant trait that may surprise newcomers to timber.

Step 3 – Selecting Fire-Rated Timber Construction Systems

This Step focuses on matching Deemed-to-Satisfy Fire Resistance Levels (FRLs) and related requirements with appropriate timber construction systems. The Step focuses on low-rise construction; other WoodSolutions Technical Design Guides cover mid-rise construction. Low-rise construction more readily allows the use of exposed mass timber, complementing timber construction that includes fire protective coverings.

The commentary begins by explaining fundamental principles used in timber construction to address fire needs. These principles are presented in the form of integrated systems, e.g. timber-framed wall, floor and ceiling systems and the equivalent in mass timber. Importantly, construction details concepts are provided for each system in terms of fire-rated junctions between elements, penetrations in elements, stair construction details and similar situations.

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

In the classes of buildings dealt with in this Guide, there are two principal ways for dealing with fire resistance of the primary structural elements. The first is by using fire-protective linings. The second is by using sacrificial charring of timber. In many cases, the building may employ a combination of these. The principle of how they work is explained in the following.

3.1.1 Fire-Protective Linings Provide the Primary Source of Protection to Timber Elements

Fire-protective linings provide the primary source of fire resistance to timber framing (refer to Figure 5) and individual timber elements, such as beams and columns (refer to Figure 6), or where the NCC’s fire-protective timber concession is utilised. Generally, the greater the number of layers, the higher the resistance to fire.

As handled in the following paragraphs, additional measures are required at weak spots or breaks in the fire-protective linings that occur at intersections between wall, floor and ceiling elements. Corner laps and exposed edges in fire-protective lining sheets present another area of concern. Extra attention is also needed at penetrations, openings and protrusions.

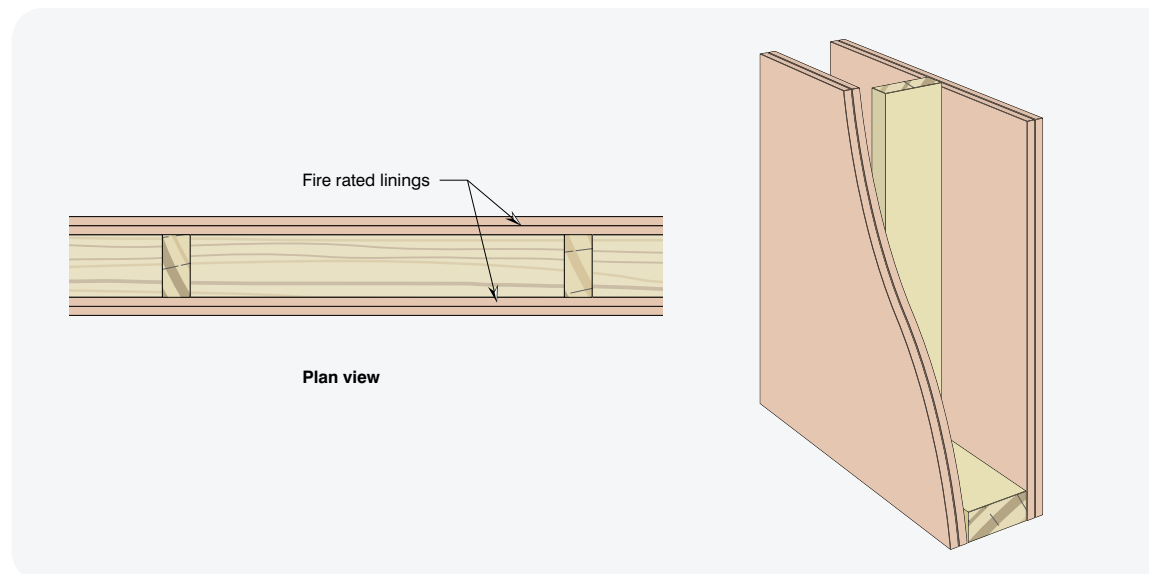


Figure 5: Fire protective covering protecting timber framing.

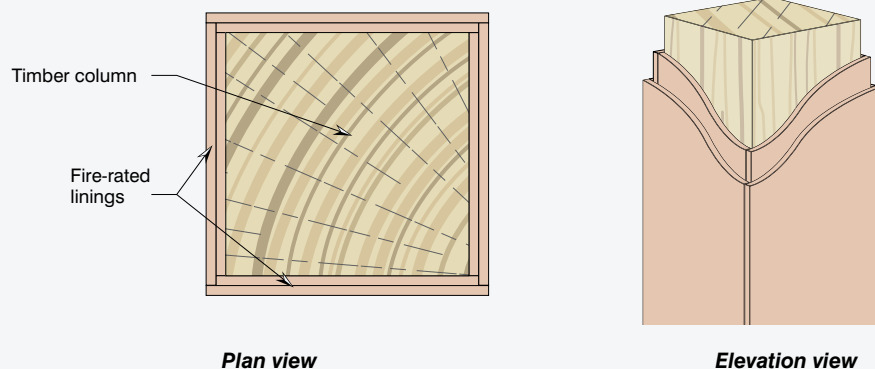


Figure 6: Fire protective covering protecting timber framing.

3.1.2 Sacrificial Charring Timber

In this case, the timber itself is used as the protecting element. When exposed to high temperatures, wood will decompose to provide an insulating layer of char that retards further degradation of the wood.

Initially, charring is rapid, but as the char depth increases, the char rate slows (refer to Figure 7). Charring rates are dependent on the timber density and moisture content and are well known and predictable. As the moisture content of timber within a building is relatively stable, the timber density is used to predict the fire resistance of large timber elements. The Australian Standard AS1720.4 Timber Structures – Fire-resistance of Structural Timber Members¹³, a primary reference document in the NCC, provides a method to calculate the fire-resistant level of solid timber. This concept is explained further in Section 3.4.

The high predictability of charring is surprising.

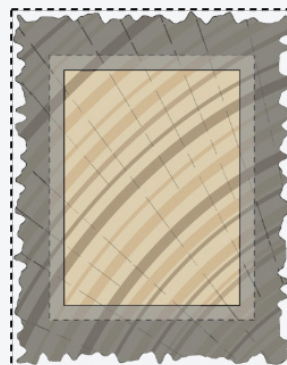


Figure 7: Illustration of charred timber after exposure to fire (dotted line indicates original size).

3.2 Selection of Fire-resistant Timber-based Systems that comply with the NCC

This Guide focuses on Deemed-to-Satisfy solutions. Consequently, to comply with the NCC fire-resistant design, a building system requires an FRL that meets Schedule 5 of the NCC in either Volume One or Two, whichever is applicable. The process is the same in each Volume of the NCC. Schedule 5 of the NCC sets out procedures for determining the Fire Resistance Level of building elements. There are six methods in Schedule 5; however, only a few apply to timber construction. The following discusses the applicability of each. The methods apply to timber elements protected by fire-protective linings or exposed mass timber.

3.2.1 Method 1 (NCC Schedule 5 Clause 2 a)

The NCC contains a table that assigns FRLs for certain Deemed-to-Satisfy building elements and their construction. However, there is no timber-based system contained in the table. Consequently, this method is not appropriate for timber systems.

3.2.2 Method 2: Standard Fire Test (NCC Schedule 5 Clause 2 b)

In this method, a prototype is exposed to a Standard Fire Test and confirmed in an Accredited Testing Laboratory report. The NCC describes the Standard Fire Test as a test carried out in accordance with the Australian Standards AS 1530.4¹⁴. This test is conducted in a furnace where the element is exposed to a never-ending time-temperature curve and the deflection, temperature rise on the cold side of the specimen and integrity are observed (refer to Figure 8). If one of these criteria fails, the exposure period is recorded. The exposure period for the criteria is rounded down to the nearest 15 or 30-minute interval to align with the NCC's Fire Resistance Levels. It is possible to have a system with different failure times for the structural, integrity and insulation criteria.

This method of demonstrating compliance is often used for unique applications; however, conducting fire tests for every variation of a product's span or spacing is generally too costly for a project. Furthermore, although international fire test procedures are very similar to the Australian Standard fire test method, they don't directly comply with the Australian Standard AS 1530.4¹⁴ and therefore are not considered Deemed-to-Satisfy. Fire tests can be conducted overseas, but to be Deemed-to-Satisfy, they must be carried out in accordance with AS 1530.4¹⁴.



Figure 8: Timber element exposed to a Standard Fire Test.

3.2.3 Method 3: Minor Departures from Standard Fire Test (NCC Schedule 5 Clause 2 c)

This method is similar to Method 2, where a Standard Fire Test is carried out on a prototype specimen. This method's difference is that an Accredited Testing Laboratory can modify the report to account for minor departures, such as increased dimensions or grade of the timber or reduced span or height.

An Accredited Testing Laboratory is an organisation accredited to the National Association of Testing Authorities (NATA). The organisation will generally have experience in fire testing. Overseas organisations can be used as long as they are recognised under NATA or have mutual recognition, e.g. BRANZ in New Zealand.

This method is often used for timber-based systems.

3.2.4 Method 4: Referenced Standards (NCC Schedule 5 Clause 2 d):

This method recognises NCC referenced standards for various materials. For timber, the referenced Standard is AS/NZS 1720.4¹³. This Standard forms a Deemed-to-Satisfy procedure for calculating the fire resistance of exposed mass timber elements utilising a sacrificial char layer, based on the timber density at 12% moisture content (refer to Figure 9). The Standard gives a calculation procedure for determining the structural and insulation number for timber elements but requires the integrity performance to be determined by Standard Fire Test. The Standard also includes design procedures for the protection of metal connectors.

The scope of the Standard contains a description of the timber products that can use this method. Timber products within the scope of the Standard are sawn timber, structural plywood, structural Laminated Veneer Lumber, Glue Laminated Timber and round timber that meet their corresponding Australian product Standard. In addition, where adhesives are used to manufacture the timber product, they must be resorcinol based, i.e. dark line adhesives. Finally, the timber element itself must have a minimum width or thickness of 75 mm.

Unfortunately, the current Standard does not cater for cross-laminated timber or timber manufactured to other national Standard or use non-resorcinol based adhesive. These products would require a Standard Fire Test to demonstrate compliance, discussed under Methods 2 and 3.

Typical timber building elements that may use this method of compliance would be columns or beams. Floor, walls and roof systems could also be calculated, except the integrity value is required to be established by the Standard Fire Test. Section 3.3 of this Guide discusses the use of AS/NZS 1720.4¹³ in more detail.

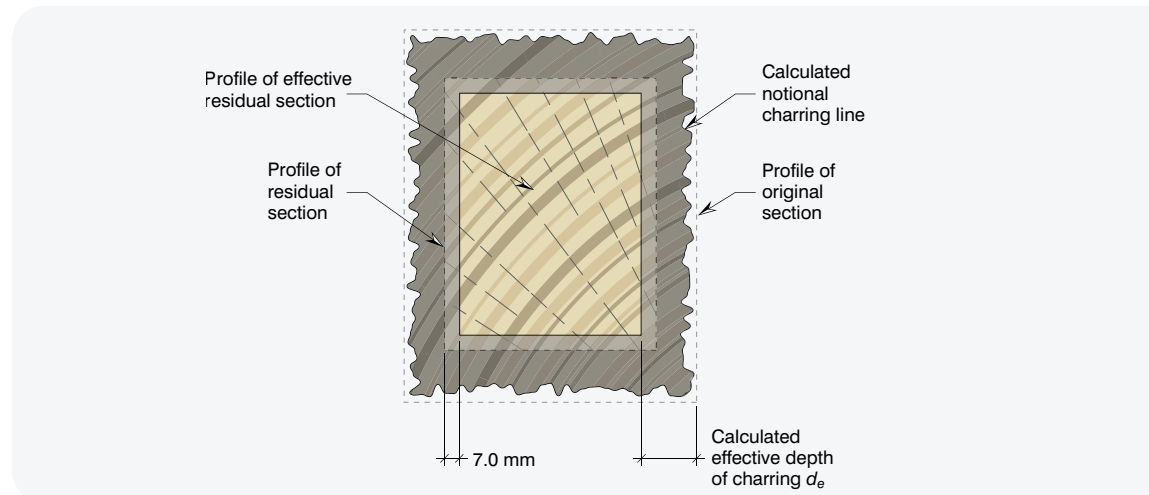


Figure 9: Sacrificial char layer protection method.

3.2.5 Method 5 Calculations based on a Standard Fire Test (NCC Schedule 5 Clause 2 e and Clause 3)

This method allows appropriately experienced professionals to calculate the FRL based on a Standard Fire Test. Variation to the tested prototype generally includes length and height of the wall, height of columns, a span in floors or beams and support conditions, as well as cross-section changes and component use to a minor degree.

This method is commonly used for timber-based products to cater to the various applications in which timber may be used, such as grades, configuration, cross-section size, span and height. Although not required by the NCC, Accredited Testing Laboratories experienced in fire testing often provide this service, as they have knowledge of the performance of building elements under fire conditions.

3.2.6 Method 6: Fire-Protected Timber (NCC Schedule 5 Clause 2 f)

This method is applicable to fire-protected timber only; however, it does not contain an actual method to determine the FRL. It just points users to where fire-protected timber can be used. Therefore, this method circles back to the approaches described above.

3.2.7 Limitations of the Standard Fire Test – AS 1530.4

The referenced NCC Standard Fire Test is AS 1530.4¹⁴. It is often expected that this Standard contains fire test procedures for all building element applications; unfortunately, there are limitations to AS 1530.4¹⁴. This Standard caters for walls, floors, roofs, ceilings, columns beams, trusses, door sets, shutter, glazing, air ducts, service penetrations and fire damper. Applications like connections, the interaction between different fire resisting systems, etc, do not have a direct test and rely on expert opinion.

3.2.8 Sources of NCC Compliant Timber Based Systems

It is not expected that a fire test is carried out every time an element is proposed for use in a new building. Often suppliers of critical fire resistance elements used in the system have information to support the NCC compliance. For example, timber-framed walls and floor systems rely heavily on the fire-protective linings for fire resistance and the framing system is often of a generic product like sawn timber. For these systems, the fire-protective lining supplier often has a range of compliant systems that can be used.

For timber-based systems such as cross-laminated timber, their manufacture is unique to each supplier; therefore, the supplier of these products would be the source of evidence for compliance.

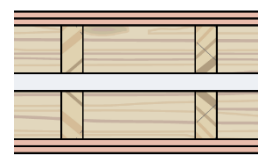
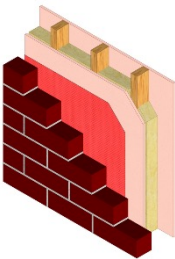
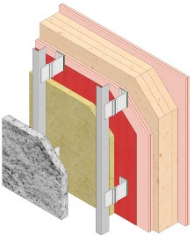
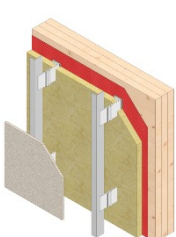
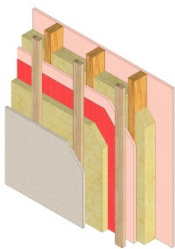
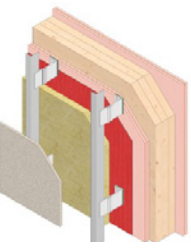
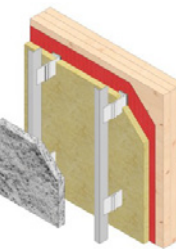
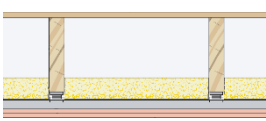
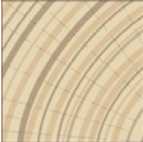
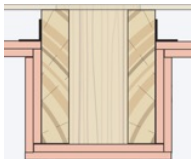
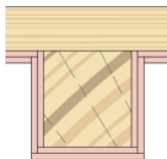
Building elements that require fire resistance are well known, such as walls, floors, columns, beams and their connection. In addition, secondary fire resistance of penetrations for cables, pipes, ducts, construction joints, seals or fire and lift doors are also required. Before specifying a particular supplier's product, investigations are suggested to determine if there is the appropriate support evidence for NCC compliance is available. Any lack of evidence will generally require an assessment or test conducted that adds considerable expense to a project. Often this supporting information is not requested until well into or at the end of the project, resulting in insufficient time to organise before practical completion.

Fire-resistant construction

There are many solutions that are applicable to fire-rated wall construction; the following Table 6 provides some suggested systems based on fire protected linings for timber-framed and mass timber and exposed mass timber.

Encasing timber adds to the natural protective effect of charring.

Table 6: Typical fire-rated timber based wall and floor systems.

	Timber framed with fire protective linings	Mass timber with fire protective linings	Mass timber – exposed
Walls			
Interior – fire-rated only			
Interior – fire and sound rated			
Exterior wall	Masonry clad 	Masonry clad 	Lightweight clad 
	Lightweight clad 	Lightweight clad 	Masonry clad 
Floors			
Interior – fire-rated only			
Interior – fire and sound rated			
Columns			
Fire-rated only			
Beams			
Fire-rated only			

3.3 Sacrificial Charring Timber Method to Determine NCC's Fire Resistance Levels

The NCC primary referenced Standard AS/NZS 1720.4¹³ provides a method to calculate Fire Resistance levels for timber product systems complying with Schedule 5 of the NCC. The Standard offers a method for determining the fire resistance for structural adequacy and insulation of solid-sawn timber, round or pole timber, plywood, laminated veneer lumber, glue-laminated timber. The Standard also provides methods to fire rate metal connectors. However, the Standard does not provide any calculation method for the determination of the integrity, relying on solutions based on the Standard Fire test.

Also, the Standard does not cover all timber products, being only applicable to timber products that are manufactured to their appropriate Australian product Standard, as follows:

- Sawn solid timber – AS 2082¹⁵, AS 2858¹⁶, AS/NZS 1748.1¹⁷, or AS 3519¹⁸
- Plywood – AS/NZS 2267.0¹⁹
- Laminated veneer lumber – AS/NZS 4357.0²⁰
- Glue laminated timber – AS/NZS 1328.1²¹
- Round timber – AS 3818.3²² or AS 3818.11²³.

Other timber products or grades may be used as long as their characteristic properties are established consistent with AS/NZS 4063²⁴ and the duration of load effect for strength and stiffness is established. Additionally, plywood, laminated veneer lumber and glue-laminated timber must use thermosetting adhesives such as phenol, phenol-resorcinol or poly-phenolic adhesives. Other adhesives are outside the scope of the Standard. Finally, the minimum dimension of the timber element must be at least 75 mm.

3.3.1 Timber Products outside the scope of the Standard

Cross-laminated timber or other timber products manufactured based on another national Standard or don't use phenol, phenol-resorcinol, or poly-phenolic adhesives require their fire resistance to be established by the Standard Fire test.

3.3.2 Structural Adequacy

The structural adequacy is determined by calculation based on the notional charring rate and exposure period, plus a zero strength layer. AS/NZS 1720.413¹³ provides three methods to determine the notional charring rate, they are discussed below.

Prescriptive Notional Charring Rate for Common Timber Species

AS/NZS 1720.413¹³ provides a table of common timber species, repeated in Table 7.

Table 7: Notional charring rates of common timber species.

Timber species	Notional charring rate (mm/minute)
Blackbutt	0.50
Cypress	0.56
Douglas Fir	0.65
European Spruce	0.65
Grey Ironbark	0.46
Jarra	0.52
Merbau (Kwila)	0.51
Radiata Pine	0.65
Red Ironbark	0.47
Spotted Gum	0.46
Victorian Ash and Tasmanian Oak	0.59

Calculated notional charring rate

AS/NZS 1720.4¹³ provides a calculation method based on the timber species density at 12% moisture content. For timber products that use adhesive, the density is based on the primary timber species, ignoring and contribution of the adhesive to the density.

Notional Charring rate

$$c = 0.4 + \left(\frac{280}{\delta} \right)^2$$

c = notional charring rate in millimetres per minute

δ = timber density at 12% moisture content

Of importance is the use of the term notional charring rate. Notional means 'theoretical' not 'actual'. Table 8 and Figure 10 compare the notional char rate of timber species and their Density and experimental charring rate. As shown in Table 8, the actual charring rate varies considerably, often because the tested specimen's density is not the average density published.

Table 8: Various timber species and experimental char rates.

Timber Species	AS/NZS 1720.4 Notional charring rate		Charring rate from Standard Fire Test	
	Published average density at 12% MC	Notional charring rate	Sample density (kg/m ³)	Experimental charring rate (mm/min)
European Silver Fir#	420~	0.84	421	0.71
Red Baltic#	500+	0.65	478	0.60
Meranti#	650*	0.58	522	0.54
Radiata Pine ^	550*	0.65	526	0.7
English Oak#	675+	0.57	557	0.59
Victorian Ash ^	650	0.59	659	0.6
Cypress ^	700*	0.56	666	0.6
Bilinga#	770~	0.53	692	0.58
Merbau#	850*	0.51	779	0.50
Brush Box ^	900*	0.50	819	0.5
Jarraah ^	800*	0.52	848	0.5
Afzelia#	800~	0.52	860	0.42
Spotted Gum ^	1,000*	0.46	901	0.5
Blackbutt ^	900*	0.50	939	0.5
Wenge#	870~	0.50	923	0.4
Balau#	900 to 1,100+	0.48	961	0.40
Blue Gum (Southern) ^	950*	0.49	968	0.5
Azobe#	1050~	0.47	1,037	0.42

Notes:

Njankouo et al.,²⁵

^ Gardner et al.,²⁶

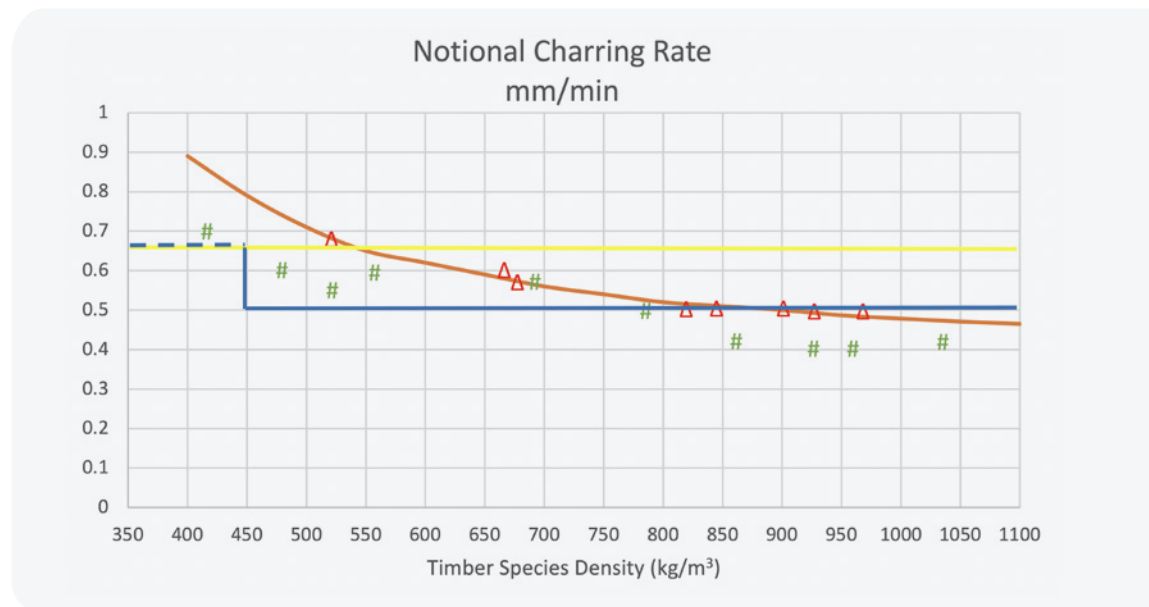
* AS 1720.2²⁷

+ Wood in Australia: Types, Properties and Uses, Bootle²⁸

~ The Wood Data Base²⁹

Figure 10 compares AS/NZS 1720.4¹³ notional char rate against the Eurocode EC5³⁰ charring rate. It illustrates that AS/NZS 1720.4 notional charring rate works well for mid to high-density timber species but is conservative for low-density timber species.

For Eurocode EC5³⁰, the notional charring rate is not conservative for low-density timber species but conservative for high-density hardwood timber species. Interestingly, the often used notional charring rate of timber of 0.65 mm/min is the point that the AS/NZS 1720.4¹³ and Eurocode EC5³⁰ methods intersect.



— AS/NZS 1720.4¹³ Notional Charring Rate

— Hardwood – Eurocode 5³⁰ – without corner rounding – density greater than 290 kg/m³ and less than 450 kg/m³ charring rate 0.65 mm/min. Density greater than 450 kg/m³ charring rate is 0.5 mm/min

— Softwood – Eurocode 5³⁰ – without corner rounding – density greater than 290 kg/m³ charring rate 0.65 mm/min

Njankouo et al.²⁵

Δ Gardner et al.²⁶

Figure 10: Comparison of notional charring rate and experiment charring rate of common timber species

Notional charring rate by test

AS/NZS 1720.4¹³ allows the establishment of the notional charring rate by test. Appendix A of the Standard details a procedure to determine the notional charring rate by Standard Fire test.

Effective depth of charring

The affected depth of charring is the theoretical depth of char for an exposure time period relating to the FRL period. The effective depth of charring is the notional charring rate multiplied by the exposure time period and the addition of 7.0 mm, termed the zero strength layer. This 7.0 mm accounts for an uncharred timber interface where it is assumed the timber has no strength or stiffness. It also accounts for corner rounding and other phenomena that occur in timber charring (refer to Figure 11).

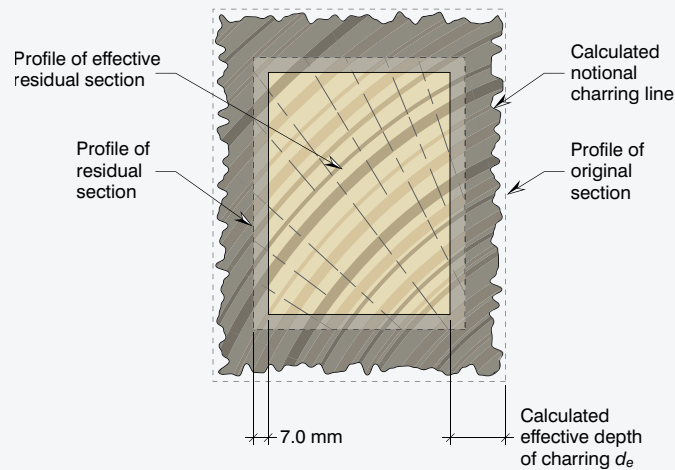


Figure 11: Illustration of the effective depth of charring

Effective depth of charring

$$d_c = c t + 7.0 \text{ mm}$$

d_c = calculated effected depth of charring (mm)

c = notional charring rate (mm/min)

t = period of time (min)

Structural design

The structural capacity of the timber element can be assessed by utilising the residual section size and calculation through AS 1720.1 Timber Engineering Standard³¹. The structural load case for consideration from the action of fire load is found in AS 1170.1³². This load case requires considering a reduced load being an unmodified permanent load (dead load) plus long-term factored imposed load (live load). The Standards also requires the consideration of thermal effects, which for timber is low. Furthermore, the load of duration applicable for fire-action is five hours, contrary to the informal guidance provided in AS 1720.1³¹.

3.3.3 Insulation Criterion

AS/NZS 1720.4¹³ has two methods of determining the insulation depth required for the timber element. The first is by calculation, where 23 mm is added to the effective depth of charring for the nominated fire resistance period. The value is a conservative depth estimated from empirical data found from the investigation of the affected heat regions below the char layer. The alternative method is by Standard Fire test.

3.3.4 Integrity Criterion

AS/NZS 1720.4¹³ contains no calculation method for determining the integrity criterion. The only method available is by Standard Fire Test.

However, Forest and Wood Products Australia has conducted a series of tests on laminated veneer lumber (LVL) panels in respect to the joining method and fire resistance. Accompanying the test work is an assessment for 60 and 90 minutes, discussed below.

LVL panel fire resistance joints

This Section provides information to maintain the fire resistance of a joint in massive timber elements used in a vertical or horizontal direction. The Section is based on a series of fire tests and an assessment report EWFA Warringtonfire Report Number 30073900.2, 2017, Fire resistance of various joints in LVL walls, roofs and floors in accordance with AS 1530.4-2014³³, available from WoodSolutions website.

The massive timber elements that can be used are limited to LVL that has been manufactured with phenol, resorcinol, phenol-resorcinol or poly-phenolic glues and in accordance with AS/NZS 4357.0²⁰.

Joint types

There are several methods to join massive timber elements together, and the details vary depending on the fire resistance period required the thickness of LVL. Tables 9 and 10 summarise the joining method available and the FRL achievable for various thicknesses of LVL. Further information on specific configurations is contained in the detail section of this Guide.

Table 9: Summary of joint type and fire resistance period for vertical elements – walls.

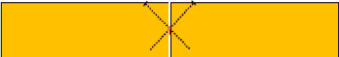
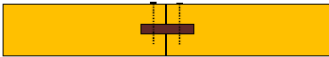
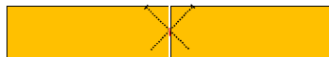
Joint Type		Fire Resistance	
		-/60/60	-/90/90
Thickness		90 mm	135 mm
Central spline		Yes	Yes
Intumescent Seal		Yes	Yes
Half – lap		Yes	Yes

Table 10: Summary of joint type and fire resistance period for horizontal elements – floors and roofs.

Joint Type		Fire Resistance	
		-/60/60	-/90/90
Thickness		90 mm	135 mm
Central spline		Yes	Yes
Intumescent Seal		Yes	Yes
Cover board (surface spline)		Yes	Yes
Half – lap		Yes	Yes

Variations allowed

The following joints have been tested and assessed by a registered testing authority. The following variations are allowed.

- Increase density of LVL, i.e. greater than 500 kg/m³
- Decrease char rate
- Increase the thickness of LVL
- Increase in joint fixing, i.e. reduction in spacing or fixing size or length
- Increase in the dimension of the overlap detailed joint.

Central Spline – Floor and Roof Joint

LVL Minimum Thickness

-/60/60 – 90 mm - /90/90 – 135 mm

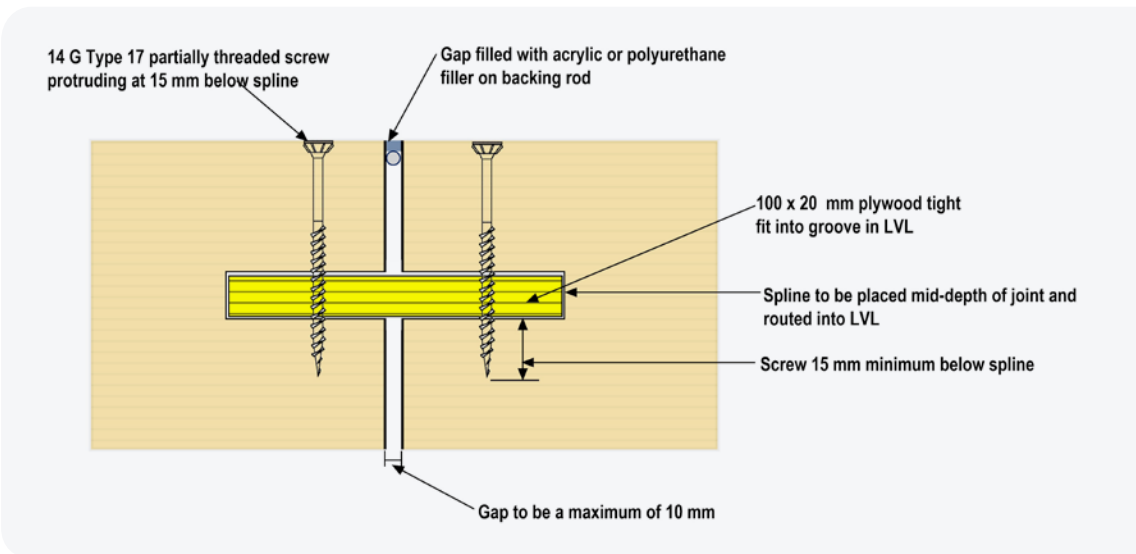


Figure 12: Centre spline – floor and roof joint (cross-section view).

Centre Spline – Wall Joint

LVL Minimum Thickness

-/60/60 – 90 mm - /90/90 – 135 mm

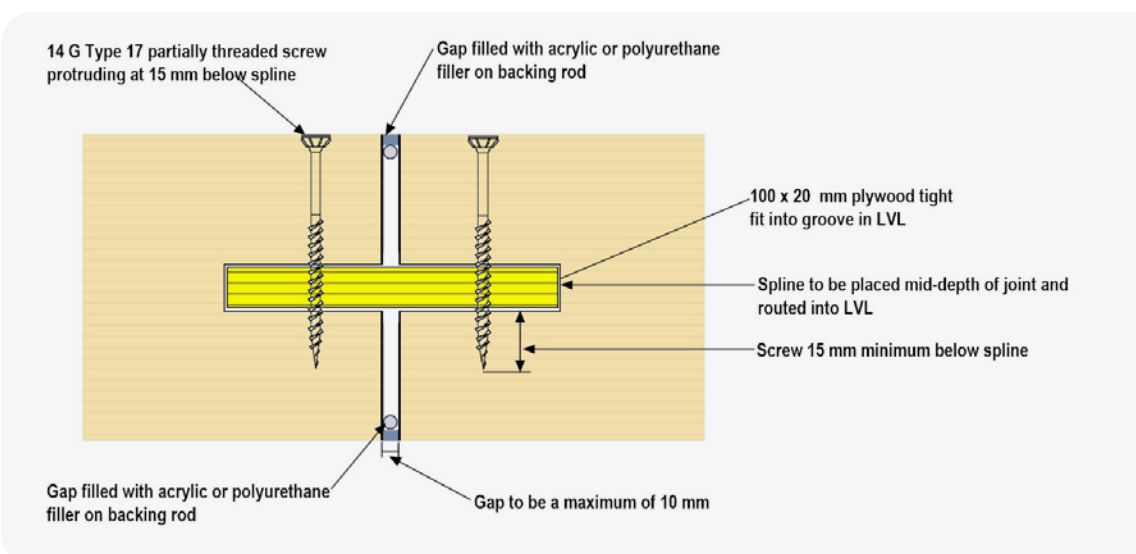


Figure 13: Centre spline – wall joint (cross-section plan view).

Intumescent seal – floor, roof and wall

The intumescent seal must be a Lorient LG3604 36 mm wide by 4.3 mm thick. Its placement is to be mid-depth of the joint and fixed to timber. The intumescent seal may be milled into the LVL.

LVL Minimum Thickness

-/60/60 – 90 mm

- /90/90 – 135 mm

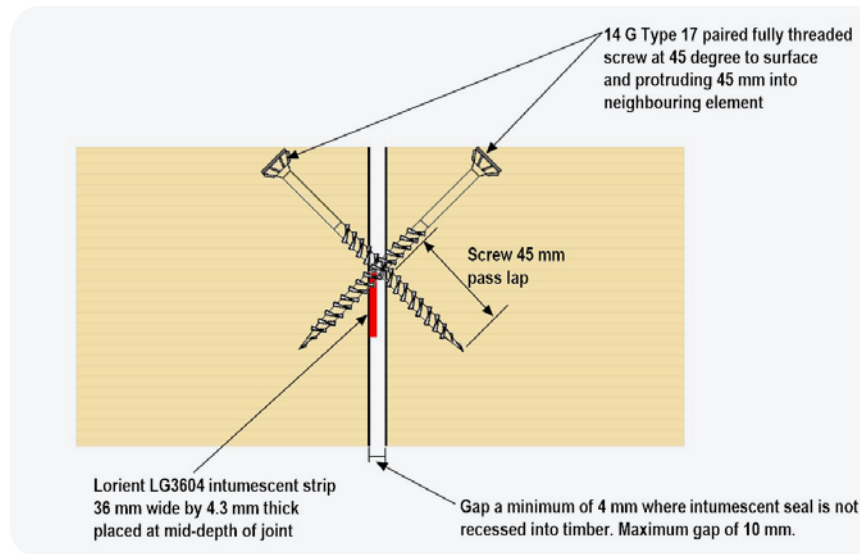


Figure 14: Intumescent Seal – Floor, Roof and Wall (Cross-section view).

Cover board – floor and roof only – /60/60

LVL minimum thickness

-/60/60 – 90 mm

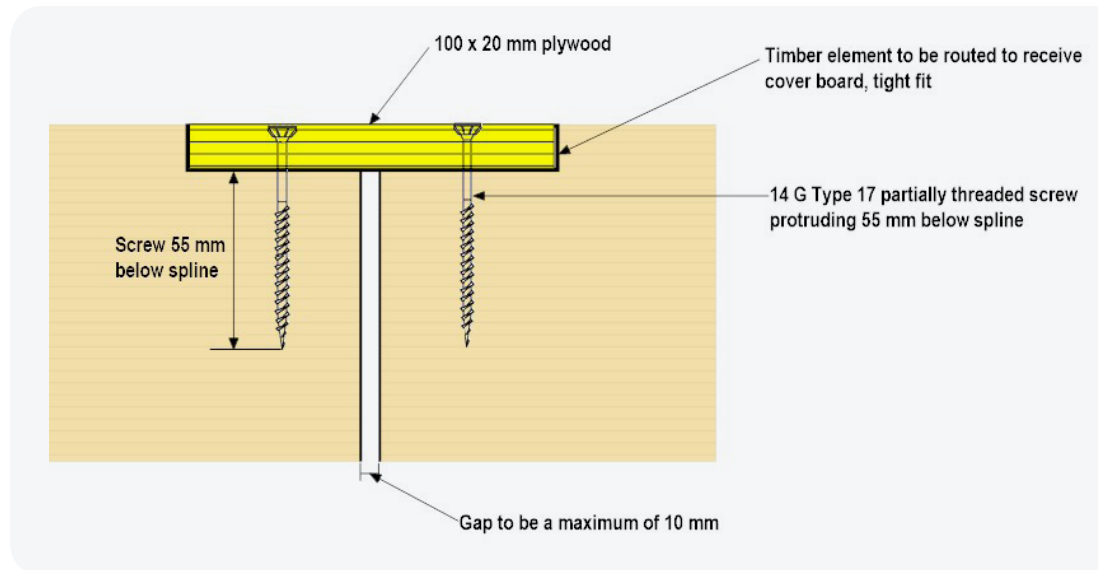


Figure 15: Cover board – floor and roof only – /60/60 (cross-section view).

Cover board – floor and roof only – /90/90

LVL Minimum Thickness

-/90/90 – 135 mm

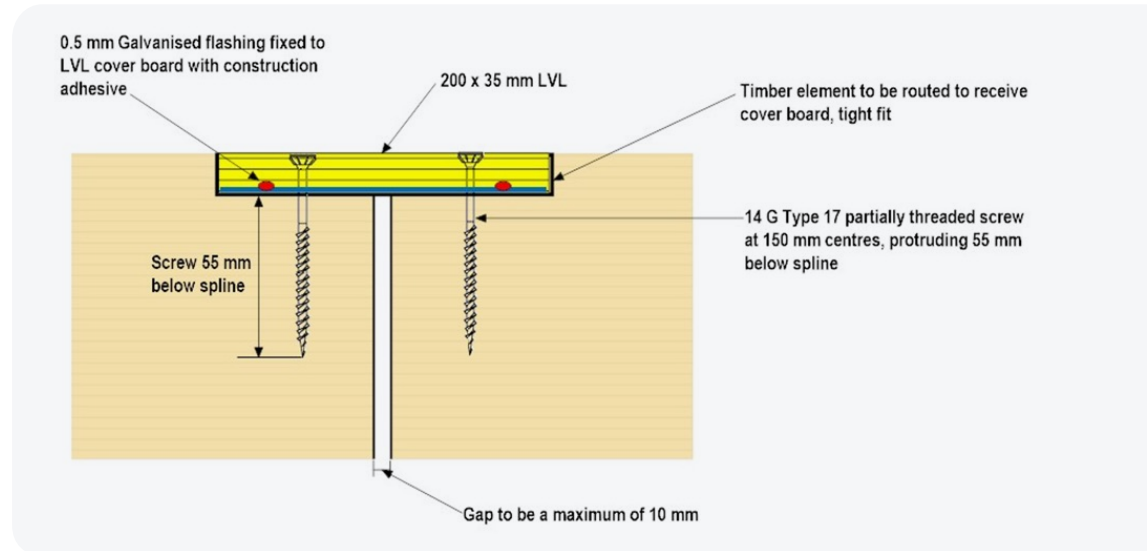


Figure 16: Cover board – floor and roof only – /90/90 (cross-section view).

Half Lap – floor, roof and wall – /60/60

LVL minimum thickness

-/60/60 – 90 mm

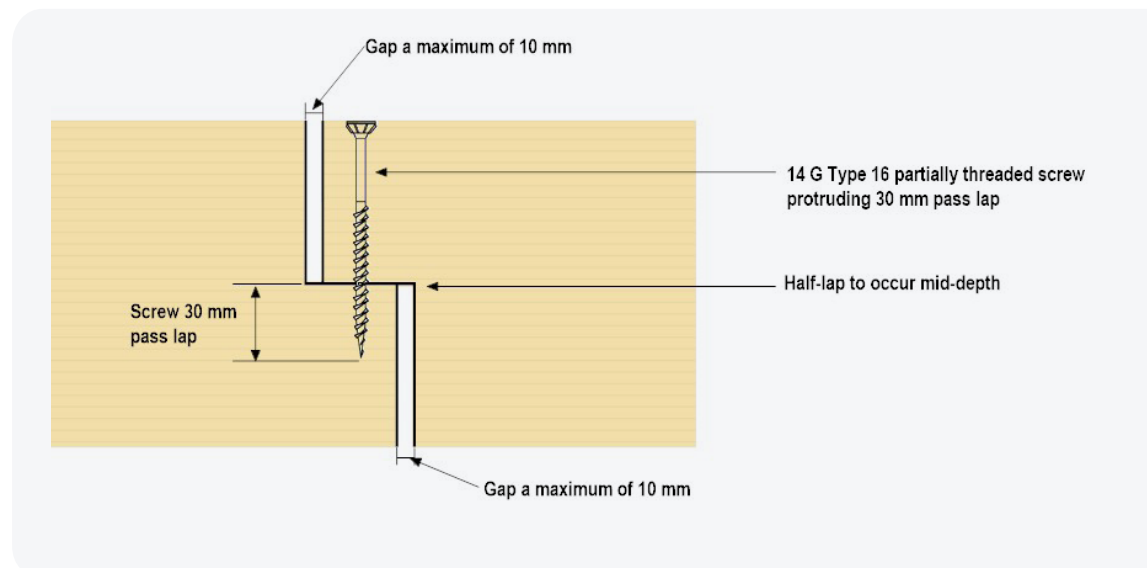


Figure 17: Half lap – floor, roof and wall – /60/60 (cross-section view).

Half lap – floor, roof and wall – /90/90

LVL minimum thickness

-/90/90 – 135 mm

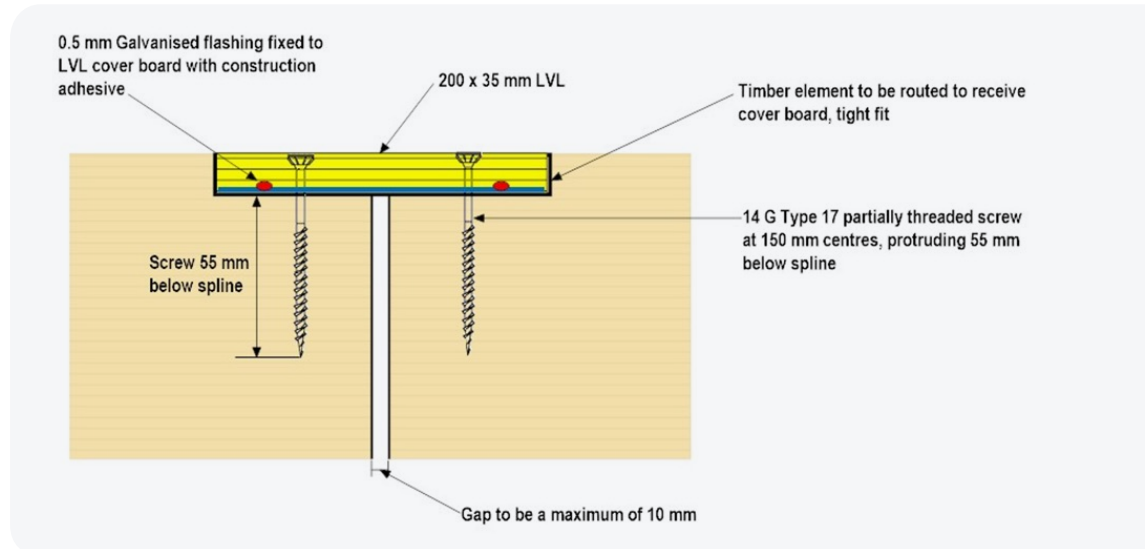


Figure 18: Half lap – floor, roof and wall – /90/90 (cross-section view).

3.4 Joining of Individual Fire-rated Elements

One of the fundamental principles of fire resistance is the creation of fire compartments (boxes) that contain the fire so that occupants can escape or emergency personnel can extinguish the fire. Therefore, fire-rated elements (beam, column, floor, wall, etc) abut each other or require support. Possible weakness in the fire resistance may occur at these junctions. Many solutions are available, each dependent on the kind of fire-rated elements abutting each other or the required fire resistance level. The following discusses various scenarios and solutions available.

3.4.1 Timber-Framed

A critical part of successful timber frame construction is to ensure that the installations occur logically and are not reliant on the installation of products that are out of sequence or affect other building issues such as acoustic separation or durability. This issue mainly occurs in regards to fire resistance construction and placement of the fire resistance linings.

For timber-frame construction, there is a long history of solutions that are mindful of these issues, and they are illustrated in Figures 19, 20 and 21. There are several solutions available in these situations: fire-resisting mineral wool, solid-timber blocks, and fire-resisting sealants. WoodSolutions Technical Design Guide No 6³⁴ details systems that have either 60 or 90 minutes FRL that is also supported by an assessment by Warringtonfire Australia, The Fire Resistance Performance of Various MRTFC Roof and Wall Junctions in Fire Resistant Wall Construction if Tested in Accordance with AS1530.4-2014³⁵.

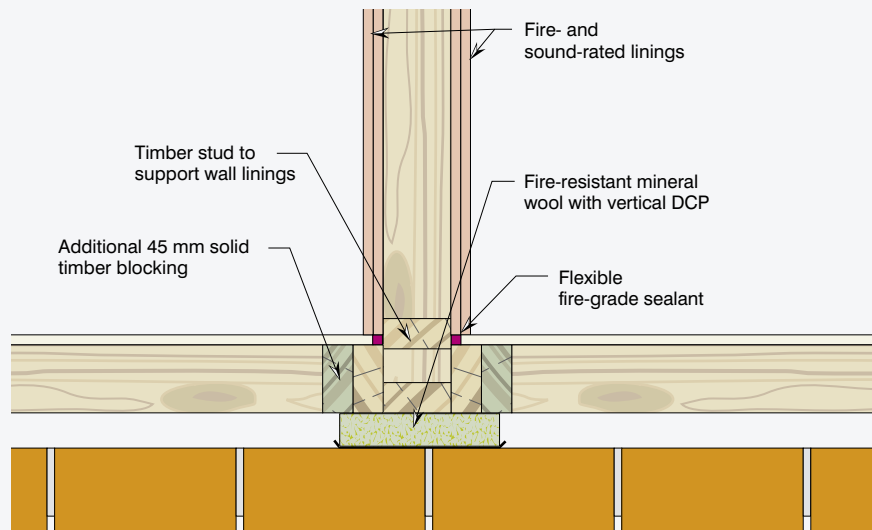


Figure 19: Fire-resisting mineral wool used to close the gap in the exterior brick veneer wall.

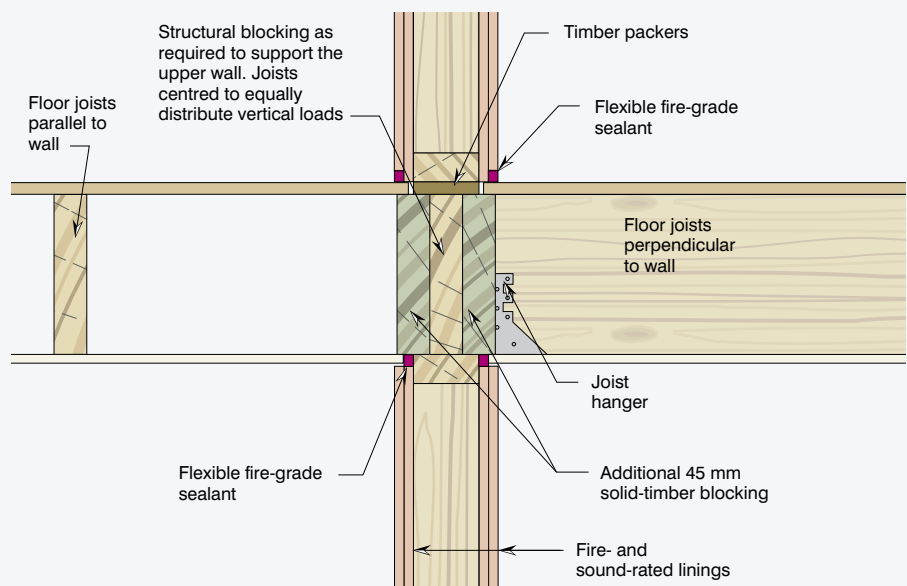


Figure 20: Non-fire-resisting floor to a wall junction – FRL 60 minutes – elevation view.

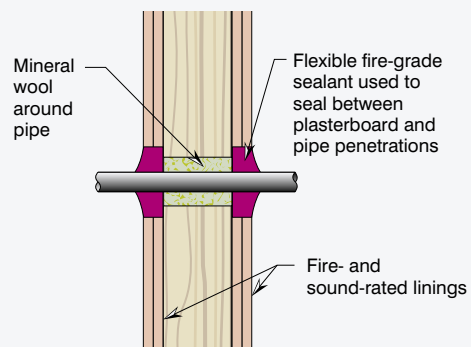


Figure 21: Fire-resistant sealant used to close a gap around a pipe – elevation view.

It is also essential to ensure the sequence of trades occurs, such that systems are not reliant on fire-protective plasterboard being installed during the framing stage of the construction. In this case, gaps in fire resistance may occur and utilise the principles discussed above to maintain the system's fire resistance. An example where this may occur is a non-fire resisting wall abutting a fire-resisting wall, Figures 22 and 23.

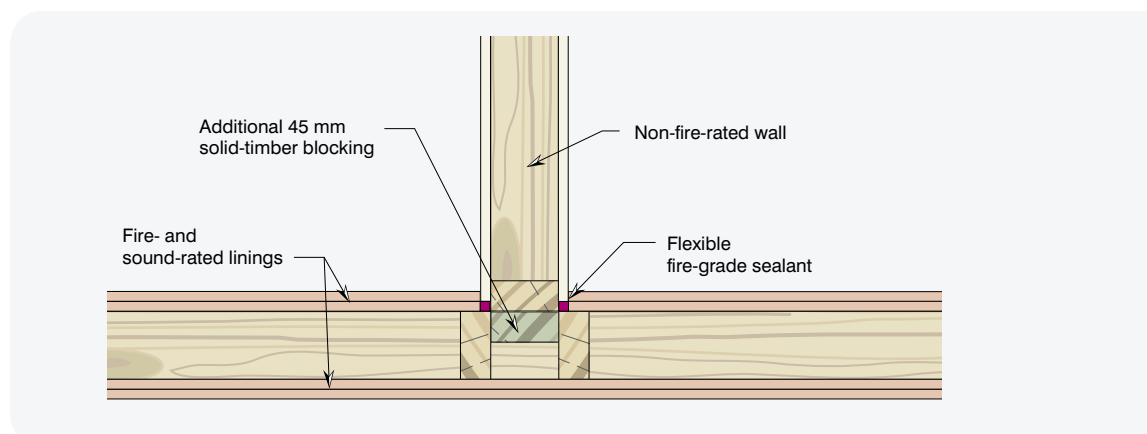


Figure 22: Non-fire resistant wall abutting a 60 minute fire-resisting wall sealed off by timber blocks – plan view.

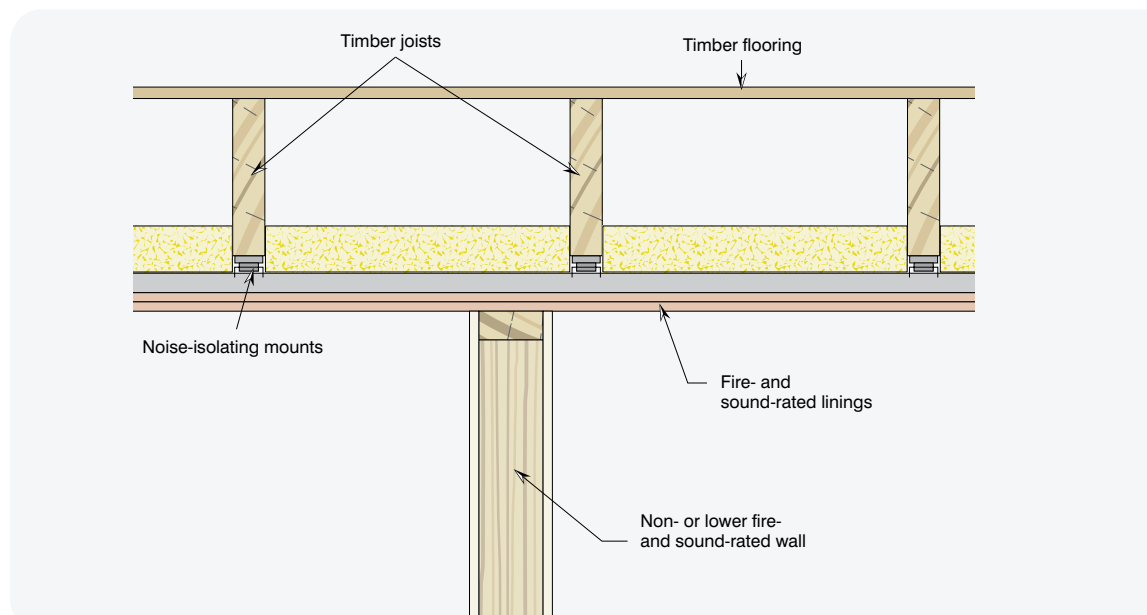


Figure 23: Non-fire resistant wall abutting a 90 minute fire-resisting wall sealed off by timber blocks and metal light gauge metal angle – plan view.

Junction between dissimilar fire-rated elements

There are instances where lower fire-resisting elements abut higher fire-resisting elements, such as a firewall abutting an external wall. The NCC allows different Fire Resistance Levels for these elements and therefore the lower fire-resisting element may be a fire path through the higher fire-resisting element. The recommended way to treat this is to design the junction to the highest fire resistance, i.e. if there is a junction between 30 and 60 minute elements, design the junction for 60 minutes.

Where the occurrence of mismatched fire-resisting elements is unavoidable, the principles of sacrificial timber blocking can also be used. For these situations, the thickness of the timber blocks must be equal to the highest fire rating of abutting elements.

3.4.2 Mass Timber and Fire Protective Lining Systems

For mass timber systems with Fire Protective Lining, there are no generic details that are available. The product manufacturer is responsible for these details in this situation; refer to Figure 25. Where there is no manufacturer's information, the principles of the systems used for timber framing could be the starting point for a performance solution.

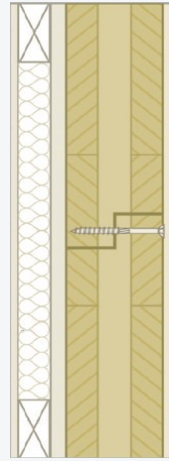


Figure 25: XLam Australia detail of fire protected CLT wall. (Image credit: XLam Australia)

3.4.3 Exposed Mass Timber

For exposed mass timber floor and wall elements, it is the same situation as the fire-protective lined mass timber systems. Again there are no generic details and the product supplier or manufacturer is responsible for the detail. For CLT this is more so, as there is no generic CLT and the performance of CLT may vary from manufacturer to manufacturer. Refer to Figure 26.

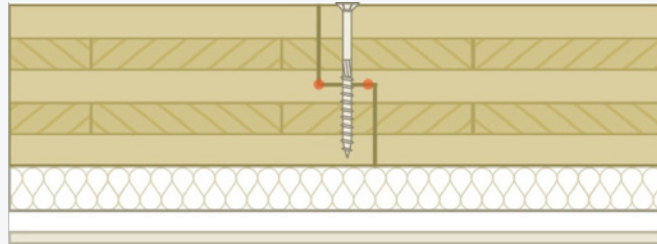


Figure 26: XLam Australia's fire resistance exposed floor detail (Image credit: XLam Australia).

For mass timber beam to columns or beam to beams connection, the Australian Standard AS/NZS 1720.4¹³ contains a method for metal connectors that are NCC Deemed-to-Satisfy. As already stated, the mass timber must be within the scope of the Standard before it can utilise this method.

3.4.4 Connection of Beam to Wall or Beam to Beam

AS/NZS 1720.4¹³ has two methods, the first is embedding the connector within the timber itself. The metal connector must be fully embedded within the timber at a depth equal to or greater than the calculated effective depth of charring, as discussed in Section 3.3. Refer to Figure 27. The holes or slots that are required for installation purposes must be filled by timber plugs glued in place.

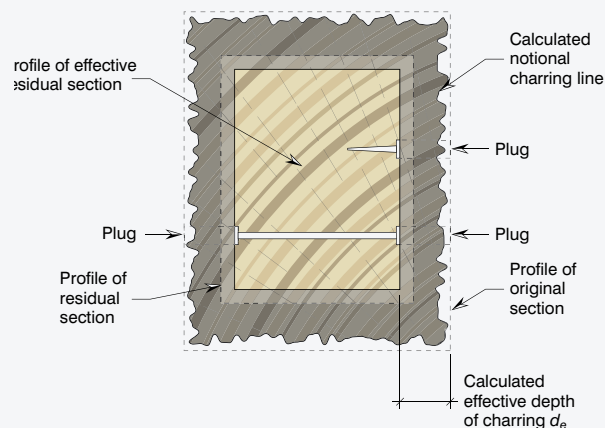


Figure 27: Protection of a metal connector using sacrificial timber covering.

An alternative method is to fix timber coverings to the element. The thickness of the timber is again must equal to or be greater than the calculated effective depth of charring (refer to Figure 28).

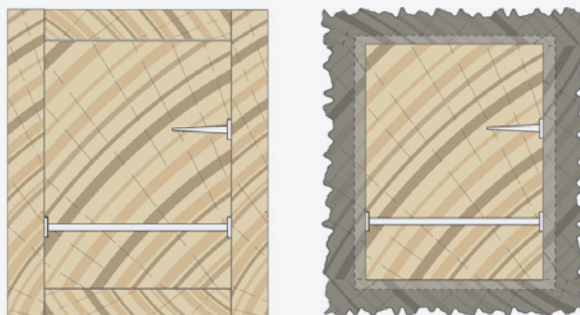


Figure 28: Timber covering used to protect timber element (pre and post-fire exposure).

Fire resisting protective insulating covering

Sacrificial timber as a means of fire protection works exceptionally well and has been demonstrated many times to exceed 120 minutes of fire resistance. However, in the placement of the various timber elements, construction gaps are often required. In these situations, it is impractical to fill the gaps with timber, requiring the need for another fire-resisting insulation material.

Fire tests and an assessment have been carried out; refer to Fire Resistance of Modern Dovetail Timber Connector (TDA 2020³⁶) for information on several means to protect metal connectors with insulating coverings. The gap between the beam end and the support structure is filled with insulating products used to seal penetrations in fire-resisting walls and floors. Refer to Figure 29.

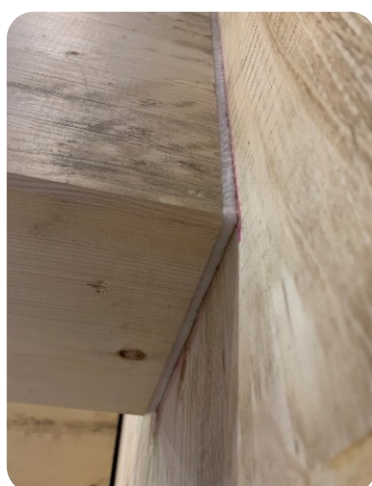


Figure 29: Fire-resisting textile used to protect the gap between beam end and wall. (Image credit: TDA)

4

Step 4 – Further Design Assistance (Appendices)

The previous Steps in the Guide require consideration of additional information on topics closely linked to the design of fire construction. The following Section covers further regulation concerns, structural design considerations, site inspection of timber-framed construction, Deemed-to-Satisfy fire requirements not covered by this Guide, other design references and a glossary.

4.1 Resolving Structural Design Considerations

The following issues should be taken into account in the structural design of Class 5 and 9b buildings:

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

For more detailed discussion in this area, refer to WoodSolutions Technical Design Guide #50 for more information on dealing with timber shrinkage and differential movement.

It is recommended that a professional structural engineer is employed to address the above issues and structural performance in general. The following standards and Guidelines should be called upon to assist:

- AS1170.0 – Structural design actions – General Principles³⁷
- AS1170.1 – Structural design actions – permanent, imposed, and other actions provide the basis for determining appropriate dead, live design loads and loads combinations³²
- AS 1170.2 – Structural design actions – wind actions – which provides the basis for wind loads³⁸
- AS 1170.4 – Structural design actions – Earthquake actions in Australia – which provides guidance and design procedures for earthquake forces³⁹
- AS1720.1 – Timber structures – design methods³¹. Though written for Class 1 buildings, AS 1684 – Residential timber-framed construction – can be used as a general guide for construction practices and some design of members in buildings up to two storeys provided the appropriate adjustments are made to the relevant criteria including: permanent, imposed and wind loads. This Standard includes allowable notching into framing members. More specific engineering design of members is required for taller timber buildings.

4.2 Deemed-to-Satisfy Fire Requirements Not Covered By This Guide

This publication tries to assist users wanting to use timber construction under the NCC's Deemed-to-Satisfy fire-resistance provisions. Even so, many of these provisions extend beyond the scope of this publication. To help users obtain a more holistic understanding of the NCC requirements, checklists are provided in Tables 11, 12 and 13. These lists cover the main issues raised in Parts C1, C2 and C3 of the NCC, the three essential parts of the Deemed-to-Satisfy Provisions that meet the NCC's Performance Requirement for fire resistance.

The checklists aim to inform readers of what is and is not covered in this Guide. By knowing this, users can confidently speak with construction certifiers, regulatory bodies, designers, head contractors, and subcontractors about the role of timber-framed construction in complying with the NCC's Deemed-to-Satisfy Provisions.

One aspect that is not touched on is State and Territory variations. As this Guide is focused on the body of the NCC, it is left to readers to determine the effect of State and Territory variations on a building design.

Table 11: Checklist for NCC Part C1: Fire-Resistance and Stability.

NCC Clause	Issue	Is assistance on this issue provided in this publication
C1.0	Deemed-to-Satisfy Provisions	Yes
C1.1	Type of Construction	Yes – refer Section 2.2
C1.2	Calculating the 'rise in storeys'	No
C1.3	Buildings of multiple classification	Yes – refer Section 4.1
C1.4	Mixed types of construction	Yes – refer Section 4.2
C1.5	Two storey Class 2, 3 or 9c buildings	No – refer to WoodSolutions Technical Design Guide #2 (Class 2 and 3) ³ and #28 (Class 9c) ⁵
C1.6	Class 4 parts of buildings	No
C1.7	Open spectator stands and indoor sports stadiums	No
C1.8	Lightweight construction	Yes – but only for the timber parts of lightweight construction. Requirements for fire-grade linings and other components are the responsibility of others
C1.9	Non-combustible building elements	Yes, fundamental is defining what elements can be exposed timber or fire-protected timber – refer to Section 2.3
C1.10	Fire hazard properties	No – advice on suitable species and applications can be found on www.woodsolutions.com.au
C1.11	Performance of external walls in the fire	No – This item only applies to concrete external walls
C1.12	No requirements	
C1.13	Fire – protected timber concession	Yes – describes that fire-protected timber can be used for elements required to be non-combustible – refer to Section 2.3
C1.14	Ancillary elements	No – however, they list the attached items to an external wall that are not required to be non-combustible.

Table 12: Checklist for NCC Part C2: Compartmentalisation and Separation.

BCA Clause	Issue	Is assistance on this issue provided in this publication
C2.0	Deemed-to-Satisfy Provisions	Yes
C2.1	Application of Part	Yes – general information on relevant clauses required to be considered for a design
C2.2	General floor area and volume limitations	No – but it may be relevant
C2.3	Large isolated buildings	No – but it may be relevant
C2.4	Requirements for open spaces and vehicular access	No – but it may be relevant
C2.5	Class 9a and 9c buildings	No – but relevant to Class 9c buildings, refer WoodSolutions Technical Design Guide #28
C2.6	Vertical separation of openings in external walls	Yes – designer to interpret relevance then if required, select an appropriately rated timber detail
C2.7	Separation by firewalls	Yes – designer to interpret relevance then if required, select an appropriately rated timber detail
C2.8	Separation of classifications in the same storey	Yes – refer to Section 4.2
C2.9	Separation of classifications in different storeys	Yes – refer to Section 4.2
C2.10	Separation of lift shafts	No – designer to interpret relevance then if required, select an appropriately rated timber detail
C2.11	Stairways and lifts in one shaft	No
C2.12	Separation of equipment	No – designer to interpret relevance then if required, select an appropriately rated timber detail
C2.13	Electricity supply system	No – designer to interpret relevance then if required, select an appropriately rated timber detail
C2.14	Public corridors in Class 2 and 3 of buildings	No – refer to WoodSolutions Technical Design Guide #2 ³

Table 13: Checklist for NCC Part C3: Protection of Openings.

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

A

Appendix A – Further Regulatory Considerations

The following discusses other regulatory considerations to assist in the determination of the NCC's building classification and Type of Construction.

A.1 Adjusting for Multiple Building Classifications

Where multiple building classifications occur within the same building, NCC Provision C1.3, the Type of Construction for the entire building is determined by the building classification at the topmost storey and the total 'rise in storeys' of that building. This 'rise in storeys' of that building determines the building's classification and, in turn, the Type of Construction that affects the Deemed-to-Satisfy fire resistance. Understanding this is best explained by way of example.

Example: Topmost Storey Determines Classification

Figure A1 shows two buildings; the left-hand building is defined as a Class 9b school building, Type C construction, with a rise of one storey; the right-hand side is defined as a Class 5 (office) building, Type C construction, with a rise of two storeys. Both buildings can be built using Deemed-to-Satisfy timber construction.

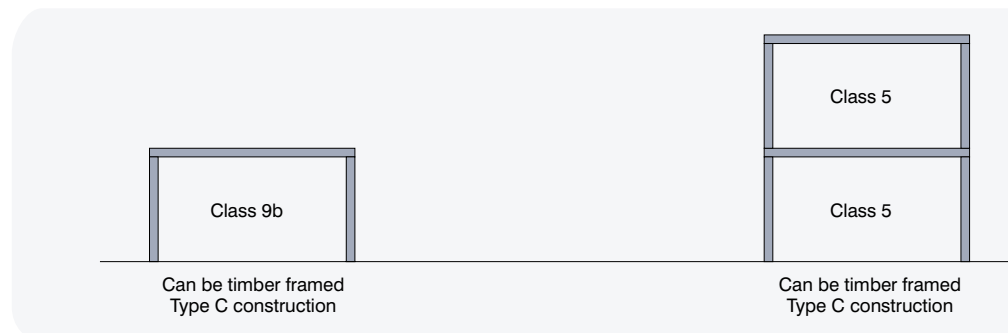


Figure A1: Mixed construction example – elevation view.

If the right-hand side building has its lowest storey replaced with a Class 9b, refer to Figure A2, the combined buildings must now comply with Clause C1.3 of the BCA. Clause C1.3 requires buildings with mixed classification to apply the topmost storey's classification (Class 5 in our example case) to all other storeys, but only for determining the construction type. This results in the entire building for the purpose of determining the construction type is now considered to be Class 5 with a rise of two storeys, and by the NCC Provision, C1 Table C1.1 is a Type C construction. The Fire Resistance Level and associated construction for the 9b part of the building may, in fact, it may have different requirements to a Class 5 building. The associated Fire Resistance Level for each construction type must be applied to the respective parts.

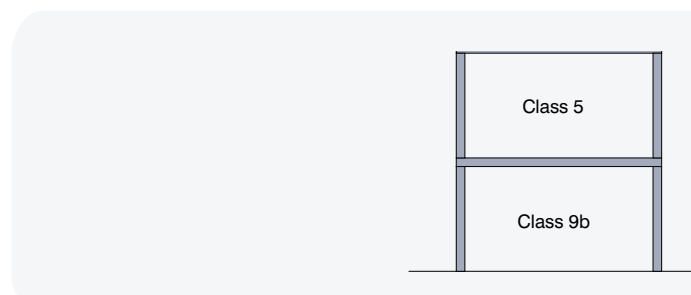


Figure A2: Mixed construction example – elevation view.

To extend the example further, it is worthwhile reversing the Class 9b portion of the building from being the bottom floor to the top floor; refer to Figure A3.

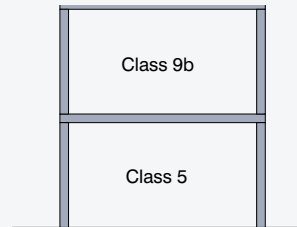


Figure A3: Mixed construction example – elevation view.

There is still a rise of two storeys in the building, but now the topmost storey is a building Classification Class 9b. This process means the building would now be considered a Type B construction (refer to Table 1 of this Guide). The Deemed-to-Satisfy Provisions in the NCC require such construction to have internal walls and external walls built of fire-protected timber.

The NCC requires a building element that supports a fire-resistant building element or has higher fire resistance (and also required to be non-combustible) to be the higher fire resistance and be non-combustible. Therefore, the Class 5 portion of the building is also required to have its internal and external walls built of fire-protected timber. In addition, the higher Fire Resistance Level of the Class 9b portion is also required for the lower storey.

A.2 Adjusting for Mixed Types of Construction

Some buildings may benefit from being considered as mixed types of construction; refer to the NCC Provision C1.4, especially where they can be vertically separated by a 'firewall'. Here, the compartments are considered separate buildings only for the purpose of determining fire resistance. This concession allows parts of the building to have a different Type of Construction, reducing the fire-resistance requirements. The potential benefits of this are demonstrated by way of an example.

Example: Use of Fire Walls

For the following two buildings, the left-hand building is defined as a Class 5 building (office), Type C construction, with a rise of two storeys; the right-hand side is defined as a Class 9b (theatre) building, Type C construction, with a rise of one storey. Under the Deemed-to-Satisfy Provisions, both can be built separately using timber construction. Refer to Figure A4.

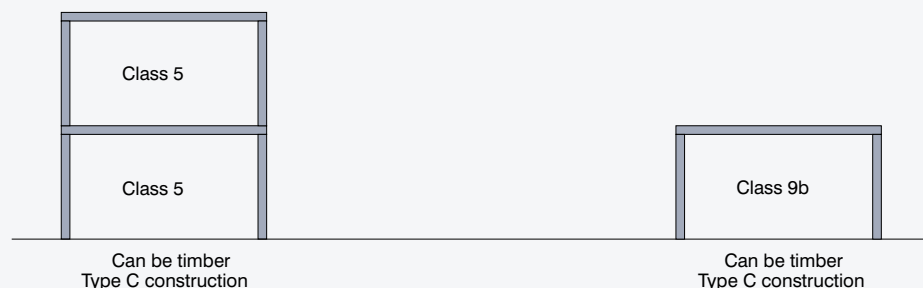


Figure A4: Firewall example – elevation view

If the two buildings are combined side by side, refer to Figure A5, we now have one building with a rise of two storeys. As discussed in the previous section, the uppermost storey is now a Class 5. For the purpose of determining the building's construction type, Class 5 is applied across the whole building. In this example, the building classification is now Type C.

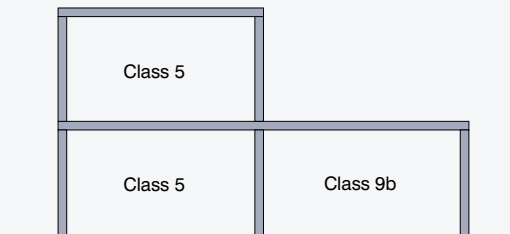


Figure A5: Firewall example – elevation view.

Now, if it was the other way around, such that the left-hand building is defined as a Class 9b building (theatre), and the right-hand side is defined as a Class 5 (office) building. Therefore, as the uppermost storey is now a Class 9b with a rise in storey of two, the building classification is now a Type B, which does not allow a Deemed-to-Satisfy exposed timber solution for the walls. Refer to Figure A6.

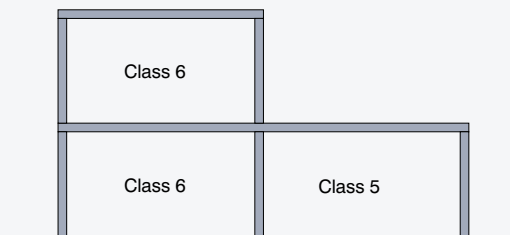


Figure A6: Firewall example – elevation view.

To overcome this, the NCC Provision C1.4 allows the building to be separated by a 'firewall' constructed to NCC Provision Clause C2.7. This Provision allows the building to be considered for the purpose of fire resistance, as two separate buildings; refer to Figure A7.

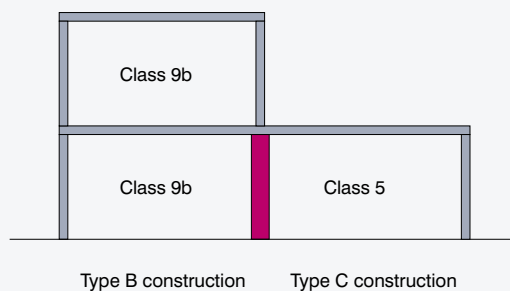


Figure A7: Firewall example – elevation view.

The firewall has to be constructed to the highest Fire Resistance Level of the two Construction Types, and due to the different heights of the building, there are requirements as to where the firewall is required to finish. Refer to NCC Clause C2.7. In this case, the Class 5 load-bearing walls, except the firewall, can be built in exposed timber.

The same is not allowed for horizontal separation. In this case, a Performance Solution would be recommended.

B

Appendix B – References

1. Building Code of Australia Volume One, Australian Building Codes Board, 2019
2. WoodSolutions Technical Design Guide #1. Timber-Framed Construction for Townhouse Buildings Class 1a
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Notes

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