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Alternative Solution Fire Compliance

Timber Structures

Technical Design Guide issued by Forest and Wood Products Australia

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Introduction

Timber has been used for many building applications and has many advantages over other building products, including its environmental sustainability credentials and comparatively light weight.

In recent times, timber has not been used in multi-storey buildings because the prescriptive requirements of the National Construction Code (NCC)[1], the Deemed-to-Satisfy Provisions do not allow some building elements to be constructed from combustible materials.

Alternative Solutions may be developed by an accredited/registered Fire Safety Engineer as part of a building solution to allow the use of timber in specific applications not covered by the Deemed-to-Satisfy Provisions of the NCC.

This guide provides a summary of the Alternative Solution process for timber structures and outlines a case study where Alternative Solutions are developed to allow the use of timber within a five–storey residential apartment (Class 2) building. It is intended to provide methods that could be employed by design professionals to develop an Alternative Solution. To get the best out of this guide it is recommended that it be read in conjunction with the NCC.

1

Deemed-to-Satisfy or Alternative Solution

1.1 NCC Compliance

The NCC Performance Requirements can be met in two ways:

- Meeting the Deemed-to-Satisfy Provisions in full – construction that is acknowledged as complying with the NCC's Performance Requirements.
- Completing an Alternative Solution – a solution that differs from the Deemed-to-Satisfy Provisions and must be proven to satisfy NCC Performance Requirements. Suitable assessment methods are identified in the NCC, Volume 1: Section A0.9.

A mixture of Deemed-to-Satisfy Provisions and Alternative Solutions can be used to develop a solution for a building that will meet the Performance Requirements of the NCC.

This guide demonstrates how Alternative Solutions can be developed to allow the use of timber-framed construction systems in situations not covered under the Deemed-to-Satisfy Provisions of the NCC.

1.2 Use of Timber

The Deemed-to-Satisfy Provisions of the NCC provide a set of technical provisions for the design and construction of buildings. The type of construction required by the Deemed-to-Satisfy Provisions is based on the number of storeys and the use of the building. For a residential apartment (Class 2) building, Type A construction is required once the building has a rise in storeys of three or more (refer to Clause C1.2 of the NCC *Guide to the BCA*[2]).

Under Specification C1.1 of the NCC, Volume 1:

- Clause 3.1 states that Type A and B construction requires external and common walls to be non-combustible and load-bearing internal walls to be concrete or masonry.
- Clause 2.2 states that *"Where a part of a building required to have an Fire Resistance Level (FRL) depends upon direct vertical or lateral support from another part to maintain its FRL, that supporting part must ... be non-combustible ... if the part it supports is required to be non-combustible"*. Therefore, where a floor provides lateral support to an external wall or common wall required to be non-combustible, then the floor is also required to be non-combustible.

Timber is determined as a combustible material in accordance with *AS 1530.1:1994 - Methods for fire tests on building materials, components and structures - Combustibility test for materials*[3]. As such, the Deemed-to-Satisfy Provisions do not permit the use of timber in these applications within Type A buildings. The main Deemed-to-Satisfy Clauses relevant to this issue are Clauses 2.2, 3.1 and 3.10 of Specification C1.1.

For low-rise buildings, a concession is provided for Class 2 buildings, under Clause 3.10 of Specification C1.1. This concession allows a three–storey Class 2 building to be constructed with timber framing throughout, provided that any insulation in the wall cavities is non-combustible and the building is fitted with an automatic smoke alarm system which would be required for a building of this type anyway). Additionally, the concession applies to a four–storey Class 2 building, provided that the lowest storey is constructed of concrete or masonry and used for car parking or other ancillary purposes.

Table 1.1 indicates the Class of building against the rise in storey, giving the building's Type of Construction. Type A and B have limits regarding the use of timber as a structural element throughout. Type C has no non-combustible or material limitation on timber construction.

For timber to be used as a structural element throughout a Type A building with a rise in storeys of four or more an Alternative Solution, substantiated through fire safety engineering, is required. An Alternative Solution compliance path may be acceptable to a Building Certifier or Building Surveyor and any relevant referral authorities, with appropriate substantiation through fire safety engineering assessment.

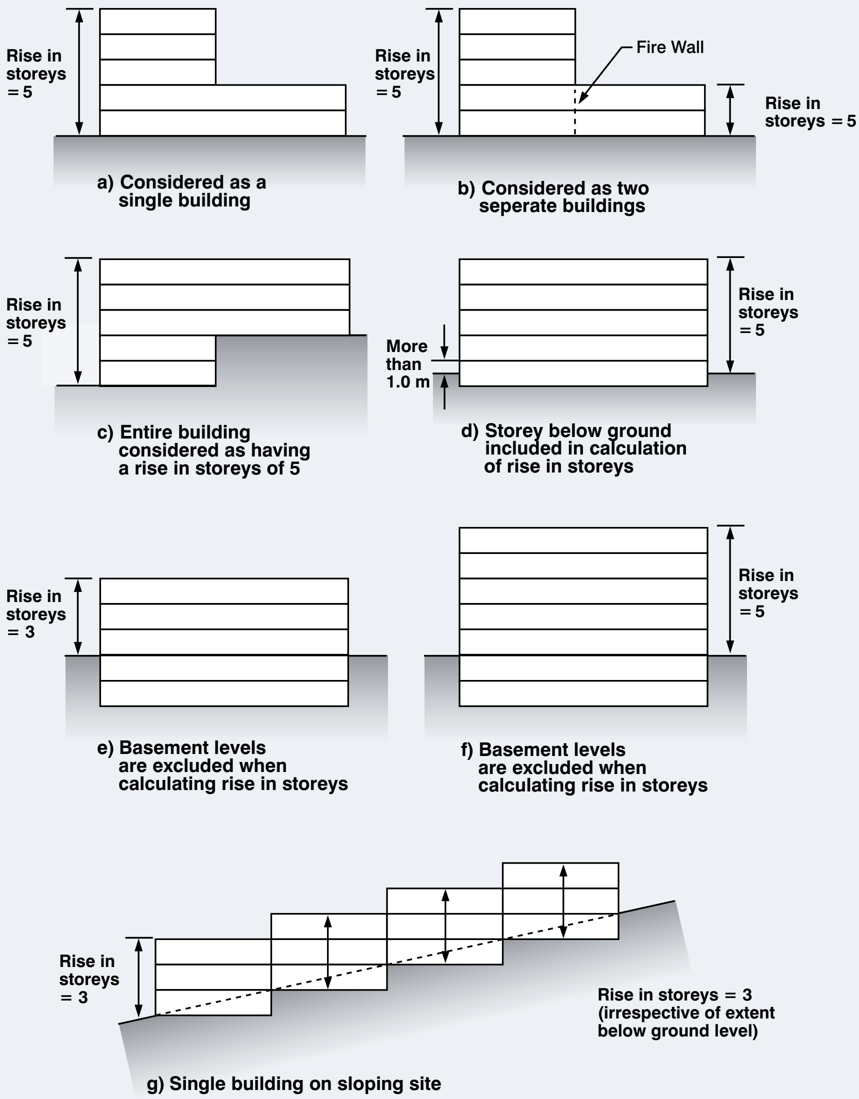

Figure 1: Examples of calculating rise in storeys of a building

Table 1: Type of construction required
Source: NCC, Volume 1 2012, Clause C1.1.

Rise in storeys	Class of building	
	2, 3, 9	5, 6, 7, 8
4 or more	A	A
3	A	B
2	B	C

2

Alternative Solution Process

2.1 Overview

To provide consistency in the methodology of formulating fire safety engineering solutions, the Australian Building Codes Board published the International Fire Engineering Guidelines (IFEG)[4]. The IFEG provide a recommended approach for completing fire safety engineering solutions for an Alternative Solution.

The Alternative Solution process generally begins when a review of the design by the Building Certifier/Surveyor identifies whether the building complies with the Deemed-to-Satisfy Provisions of the NCC. Where the design does not comply, Alternative Solutions are developed and documented through a two-stage reporting process, where a Fire Safety Engineer gains approval for a Fire Engineering Brief (FEB) and a Fire Engineering Report (FER) for inclusion in the building approval documentation.

The FER, along with all design documentation, requires approval by the Building Certifier or Building Surveyor. In many cases, the Fire Brigade is also considered a 'referral authority', requiring the design to be discussed with the local Fire Brigade. The Building Certifier/Surveyor should be consulted early to determine the approvals process and timelines for a project.

The decision to carry out a fire safety engineering solution has to be carefully considered by the client and the design team as being of value to the project. There is an inherent risk associated with obtaining approval of Alternative Solutions, which can result in project delays and uncertainties with the design (and overall project costs). A design compliant with the Deemed-to-Satisfy Provisions of the NCC carries no such design risk for fire safety.

2.2 Development of Alternative Solutions

An Alternative Solution is defined in the NCC as follows:

"Alternative Solution means a building solution which complies with the Performance Requirements other than by reason of satisfying the Deemed-to-Satisfy Provisions."

When the Building Certifier/Surveyor reviews the building design an NCC Report is developed, which identifies any non-compliances with the Deemed-to-Satisfy Provisions of the NCC and the Performance Requirements applicable to those non-compliances.

To demonstrate that a fire safety engineering solution meets the Performance Requirements (and is therefore an Alternative Solution for the purposes of the NCC), a fire safety engineer is required to provide sufficient technical justification. Each specific qualitative Performance Requirement has to be shown to be satisfied with the use of engineering principles and calculations, supported by referenced methodologies, standards and analysis.

The Performance Requirements of the NCC, however, are a set of qualitative statements: they do not contain numerical values or acceptance criteria, but describe how specific fire safety aspects are to be addressed when being assessed for compliance. Thus, the approach required for showing compliance when developing an Alternative Solution is to provide a quantifiable response to a qualitative statement. This scheme can naturally result in competent fire safety engineers developing a range of different opinions and differences in their professional judgement.

However, the exercise of judgement is not completely unconstrained. Clause A0.9 of the NCC Assessment Methods provides the methodology for showing how a fire safety engineering solution will meet the Performance Requirements. There are four methods:

a) using the methods stated in Part A2.2 to support the use of a material, form of construction or design

b) use of a verification method

c) comparison with the Deemed-to-Satisfy provisions

d) use of expert judgement.

Of the four methods, the most common for engineering design are a comparison with the Deemed-to-Satisfy provisions, use of a verification method, or meeting the methods described in Specification A2.2 Evidence of Suitability.

2.2.1 Documentation of Alternative Solutions

During the development of Alternative Solutions, fire safety engineers generally produce two reports; a Fire Engineering Brief (FEB), followed by a Fire Engineering Report (FER).

The purpose of the FEB is to communicate to the relevant stakeholders and approval authorities the objectives and basic strategy by which the fire safety engineering analysis will be completed. The FEB outlines the proposed Alternative Solutions, including information on the acceptance criteria and any input parameters expected to be used in each Solution.

The FEB is distributed for comment and approval by stakeholders, including the Building Certifier/Surveyor and Fire Brigade. Once agreement is received on the FEB, the FER is developed.

The FER contains all the analysis, and documents the results and conclusions of the fire safety engineering analysis for use by relevant stakeholders in the design documentation process and beyond. It includes justification for the required fire safety systems and lists the detailed requirements necessary for inclusion in the design documentation. The final Fire Engineering Report is to be written so that it can be used during construction, commissioning, use and maintenance, and can also be considered for any future alteration or change of use of the building.

The FER is also part of the design documentation reviewed in the regulatory approvals process by the Building Certifier/Surveyor.

2.2.2 Approvals Process

As the NCC is called into legal effect by each State and Territories' legislation, the approvals process varies between the States and Territories. The Building Certifier/Surveyor should be consulted early to determine the approvals process and likely timelines for each project.

Generally, the Building Certifier/Surveyor is responsible for identifying any deviations from the Deemed-to-Satisfy Provisions and the relevant Performance Requirements to be addressed. They are to review and be responsible for the approval of both the Fire Engineering Brief and Fire Engineering Report. If necessary (for example, due to the complexity of the design), they may seek a third party review of the fire safety engineering design as part of the approvals process.

In many cases, the Fire Brigade is also considered as a 'referral authority', requiring the design to be discussed with the local Fire Brigade.

In NSW, for example, where Alternative Solutions are required to meet 'Category 2 fire safety provisions' (i.e. Performance Requirements CP9, EP1.3, EP1.4, EP1.6, EP2.2 and EP3.2 according to Clause 144 of the Environmental Planning and Assessment Regulation 2000), the fire safety engineering design is required to be referred to Fire & Rescue NSW (FRNSW) for review and comment.

This would typically involve meeting with FRNSW during the FEB process to discuss the design and proposed Alternative Solutions. Once the FER is developed, the report is referred to FRNSW which has 23 days to provide comment. If comment has not been received after 23 days, the Building Certifier may issue the Construction Certification, however, they may require a third party review if FRNSW comment has not been provided.

Due to the time associated with reviews by approvals authorities and the inherent risk associated with obtaining approval of Alternative Solutions, sufficient time for the completion of the approvals process needs to be allowed for in the project timeline. It is recommended that the Building Certifier/Surveyor is consulted as early as possible as to the circumstances under which they would require a third party review of the fire engineering strategy, and whether they would approve the FER without having received Fire Brigade comments (as is permitted by the legislation).

3

Supporting Evidence for an Alternative Solution

In the development of an Alternative Solution relating to the use of structural timber framed construction, supporting evidence can be valuable in strengthening a discussion that the use of timber in a particular scenario is acceptable. Different varieties of supporting evidence are outlined below:

- Timber–framed construction has been the subject of a number of fire performance tests
- Plasterboard manufacturers provide specifications for standardised solutions for timber systems
- Other WoodSolutions Technical Design Guides provide information on the application of these standardised solutions; refer to the Further Reading section of this guide.

Having an understanding of how international building codes and regulations allow the use of timber framed construction can also provide some guidance in the development of Alternative Solutions, in the context of the fire safety strategy. The prescriptive requirements of selected international building regulations are outlined for the purposes of comparison.

Further, a technical guideline relating to fire safety in timber buildings has been developed for use in Europe (Fire Safety in Timber Buildings: Technical Guide for Europe[5]). The findings of this document are also discussed below.

3.1 Timber-framed Fire Testing

Forest and Wood Products Australia (FWPA) has invested in a number of research projects to investigate issues limiting the use of timber in buildings. One particular test related to the extension of Class 2 (Multi-Residential Timber Framed Construction, MRTFC) timber concession in Specification C1.1 to include Class 3 buildings. These tests are documented in the FWPA report 'Reducing Fire Regulatory Barriers and Standards on Timber and Wood Products'[6].

As part of this test, two full scale experiments were designed to compare the fire severity of a timber–framed building fire with an identical steel–framed building fire. Two identical room enclosures were constructed with the dimensions 4 m x 4 m x 2.4 m. One room was built using timber–framed construction techniques, while the other was constructed from non-combustible steel–framed construction.

Table 2: Test room enclosures

	Steel–framed enclosure	Timber–framed enclosure
Linings	13 mm fire rated plasterboard	13 mm fire rated plasterboard
Dimensions	4 m x 4 m x 2.4 m	4 m x 4 m x 2.4 m
Framing system	Fire–rated steel–framed	Fire–rated timber–framed
Cavity insulation	Non-combustible	Combustible

A fire load of 41 kg/m^2 (kg wood per m^2 floor area), which equates to about 740 MJ/m^2, was placed within each enclosure, to generate a severe fire exposure. This fire load exceeded common fire loads expected for Class 2 and Class 3 buildings.
A protected steel column was located in the centre of the room, which was used as the primary tool for comparing the severity of the fires in each enclosure. Thermocouples measured the increase in temperature of the steel column, and several other thermocouples measured temperatures at the wall surface, wall cavity, timber studs and ceiling.

The analysis of the experimental results indicated that the timber framing and combustible insulation did not result in a significantly increased fire severity. None of the measured parameters indicated that the enclosure constructed with timber framing was more severe than the steel–framed enclosure. Thus, the recommendation of the experiment was that the concession for Class 2 buildings allowing three storey timber–framed buildings should be extended to Class 3 also, and that the timber framing and combustible insulation did not increase the fire hazard for the type of construction.

This testing information is highly relevant for the formulation of an Alternative Solution as it clearly indicates that using timber within a fire–rated plasterboard wall is not detrimental to the achieved FRL.

3.2 Plasterboard Manufacturers

Plasterboard manufacturers have produced design guides which serve as a reference to all the tested systems for steel, timber and masonry wall systems (as well as other systems such as ceilings and services). Fire testing in accordance with *AS1530.4 - Fire Resistance Tests of Elements of Building Construction*[7] has been completed on all the fire-rated systems documented in the design guides to meet the requirements of NCC Deemed-to-Satisfy Clause A2.2 'Evidence of Suitability'.

The table below summarises some of the types of tested systems. If the plasterboard systems are installed in accordance with the specifications within the plasterboard manufacturer's design guide, the Fire Resistance Level (FRL) of the system can be deemed to be achieved.

Table 3: Summary of Plasterboard Systems

System	Description
Fire–resisting walls	Fire–resisting walls can be either 'one way' or 'two way'. The wall systems generally consist of frames and columns contained completely within the wall, with layers of fire-resistant plasterboard on one or both sides to provide the required FRL. The walls may be load-bearing or non-load-bearing. The cavity within the wall is generally filled with insulation for acoustic absorption or thermal resistance.
Floor/Ceilings	Generally, floor and roof/ceiling systems are assessed with regards to fire resistance from below only, as the test method described in *AS1530.4 - Fire Resistance Tests of Elements of Building Construction*[7] only allows this.
Penetrations	The ability for a fire–resisting wall, floor or ceiling to minimise the spread of fire can be significantly reduced by unsealed penetrations. Power outlets, light switches, cable penetrations and any other services which pass through a fire–resisting wall or floor are all required to be sealed with a fire–sealant or other fire–rated system (e.g. fire rated switch boxes, fire collars).

3.3 WoodSolutions Technical Design Guides

WoodSolutions have produced a number of technical design guides, which provide information to help architects, designers, builders and owners to understand how to comply with the NCC when using timber materials.

Several of these guides are particularly relevant for designing timber-framed buildings complying with the Deemed-to-Satisfy Provisions of the NCC, and provide useful information and references to form a basis for the development of an Alternative Solution:

- Design Guide #1: Timber-framed Construction for Townhouse Buildings Class 1a – design and construction guide for NCC compliant sound and fire-rated construction[8]
- Design Guide #2: Timber-framed Construction for Multi-residential Buildings Class 2, 3 & 9c – design and construction guide for NCC–compliant sound and fire-rated construction[9]
- Design Guide #3: Timber-framed Construction for Commercial Buildings Class 5, 6, 9a & 9b – design and construction guide for NCC–compliant fire-rated construction[10]
- Design Guide #18: Alternative Solution Fire Compliance, Facades – information about using timber facades not covered by the Deem-to-Satisfy Provisions of the NCC. Includes a case study on the use of combustible facades.
- Design Guide #19: Alternative Solution Fire Compliance, Internal Linings – information about using timber linings not covered by the Deem-to-Satisfy Provisions of the NCC. Includes a case study on the use timber linings in a school building corridor.

The guides discuss important issues for the design of timber–framed buildings, including appropriate design of connections and sealing of penetrations to minimise the spread of fire.

3.4 International Precedents

International building codes and regulations have requirements for the use of timber and timber–framed construction that differ from those in Australia. The prescriptive requirements of these international codes and regulations can also provide some guidance in the development of Alternative Solutions, in the context of the greater fire safety strategy.

3.4.1 Britain

In England and Wales, Approved Document B[11] is the guidance document that is offered as a means of compliance with the requirements of the Building Act 1984[12]. In Scotland, the Domestic Technical Handbook[13] is the equivalent document providing a means of compliance with the requirements of the Building (Scotland) Regulations 2004[14].

As with the NCC, Approved Document B and the Domestic Technical Handbook offer only one method of compliance and fire safety engineering can be used to allow alternative methods of compliance.

Prescriptively, timber framed construction can be used in buildings where the topmost storey height is below 18 m from ground level, corresponding to approximately six storeys. Anything above this is classed as high rise and as such should be constructed from non–combustible materials.

3.4.2 Europe

A research paper was published in 2002 regarding the use of wood, as allowed by national fire regulations, in European and other countries[15]. The prescriptive requirements for the maximum number of storeys allowed to be built using a timber load-bearing structure for a number of European countries was summarised in a marked-up map.

The European guide 'Fire Safety in Timber Buildings'[5] updated this map in 2010, as the prescriptive requirements of the national fire regulations for several of the countries had changed since the year 2000.

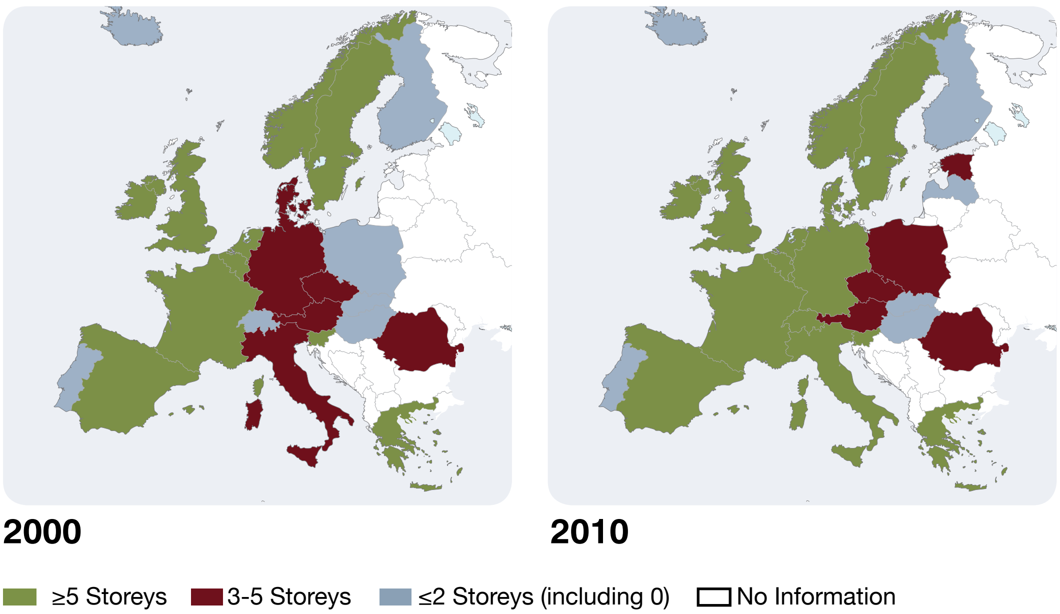

Figure 2: Drawings extracted from Fire Safety in Timber Buildings[5]

A summary of some of these countries is found below:

• **Spain**: In Spain and many parts of Europe, the most referenced codes are the Eurocodes[16]. In Spain, the fire safety regulations do not put any restrictions on the height of timber–framed buildings. That is, as long as the structural fire resistance of the building elements can be achieved, a building can be of any height whether the structural elements are concrete, steel or timber.

Typically, performance–based fire engineering is required in order to address the timber not achieving the required fire resistance. Performance–based engineering is not required to address the combustibility of the timber.

• **Germany**: In Germany, there are 16 building codes, one for each federal state. The building codes across the country are more or less similar. According to these codes, as long as the structure is able to achieve the required fire resistance, there are no objections against the use of timber for 'low rise' buildings. Once a building exceeds 22 m in height, the building is considered 'high rise' and the structure is required to be constructed from non-combustible materials.

• **Sweden/Norway:** Similarly, in Sweden and Norway the national building regulations do not put any restrictions on the height of timber–framed buildings. Timber is permitted as long as the required structural fire resistance levels can be achieved.

3.4.3 United States

The International Building Code (IBC)[17] has been adopted throughout the United States.

The IBC has two designations for combustible construction. The first is Type IV, which is for heavy timber buildings. The second is Type V, which is traditionally solid-sawn timber (light recycled timber-framed buildings, referred to as 'stick' buildings).

• For heavy timber buildings (Type IV):

The prescriptive code allows up to five storeys to be built for office / business occupancies. For residential occupancies, the IBC limits Type IV construction to four storeys.

• For stick-frame buildings (Type V):

The prescriptive code allows up to three storeys to be built.

One other major requirement is the required fire resistance rating. For Type IV, the IBC presents minimum sizes for structural members (as opposed to hourly ratings). For Type V, elements of structure are required to have at least a 60 minute fire rating.

Some regions or cities in the USA have local authorities that allow higher timber buildings, such as Seattle City Council.

3.4.4 New Zealand

In New Zealand, the Compliance Document for New Zealand Building Code Clauses C1, C2, C3, C4 Fire Safety[18], also known as C/AS1, is used for compliance with the New Zealand Building Codes.

C/AS1 allows the use of timber as a structural element, as long as the elements are able to achieve the required fire resistance level. Therefore, there is no restriction on the height of a timber–framed building, as long as the required FRLs are achieved.

3.5 Fire Safety in Timber Buildings: A European Guide

Fire Safety in Timber Buildings[5] is a European guideline that brings together the latest knowledge in Europe on the safe use of timber structures in buildings. The guideline discusses:

- The European system for the design and construction of timber–framed buildings, application on building elements including guidance on:
  - timber connections – the requirements of timber connections, including both timber-to-timber and steel-to-timber connections
  - fire stopping of service installations – outlining the need for appropriate sealing of penetrations to minimise the risk of fire spread
  - the importance of construction workmanship and inspections to check whether all the fire safety measures are installed and operational.
- Details of new products and design techniques, and the process for the implementation of these products in the market (including fire testing of the products).
- The concept of performance based design in Europe (there are slight differences between Australia and Europe regarding the process of performance based design, however the concept is the same) and details on calculation methods, risk analysis and structural analysis for the development of a performance–based design.

4

Case Study

4.1 Building Description

A case study is provided to practically discuss the process involved with developing a fire safety engineering Alternative Solution. The building is a five storey residential building using fire and sound rated timber framed construction technique (MRTFC), with a rise in storey of six.

Table 4: Summary of building characteristics

Element	Description
Building use	• Basement: car park (Class 7a) • Ground: retail (Class 6) • Levels 1-5: residential (Class 2)
Structure	The timber–framed MRTFC construction technique is used and floors are constructed completely from timber. Walls are load-bearing throughout. The building roof is constructed with steel roof sheeting, with timber rafters and beams. The building facade is brick veneer.
Egress	The building is served by two fire–isolated stairs and travel distances to these exits are in accordance with the Deemed-to-Satisfy Provisions of the NCC. The fire–isolated stairs are constructed from concrete and masonry. If the stair shafts were proposed to be timber–framed, this would likely need to be discussed and agreed with the Fire Brigade. In some States and Territories, this may be a high approvals risk due to Fire Brigade preference for non-combustible stairwells.
Fire Safety Measures	The building is provided with the following fire protection measures, to meet the Deemed-to-Satisfy Provisions: • Smoke detection system (Specification E2.2) • Building occupant warning system (Clause 2.33 of AS1670.1) • Emergency lighting and exit signage (Part E4 of the NCC Volume 1 and AS2293.1[19]) • Hydrants (AS 2419.1[20]) • Fire hose reels (AS 2441[21]) • Fire extinguishers (AS 2444[22]).

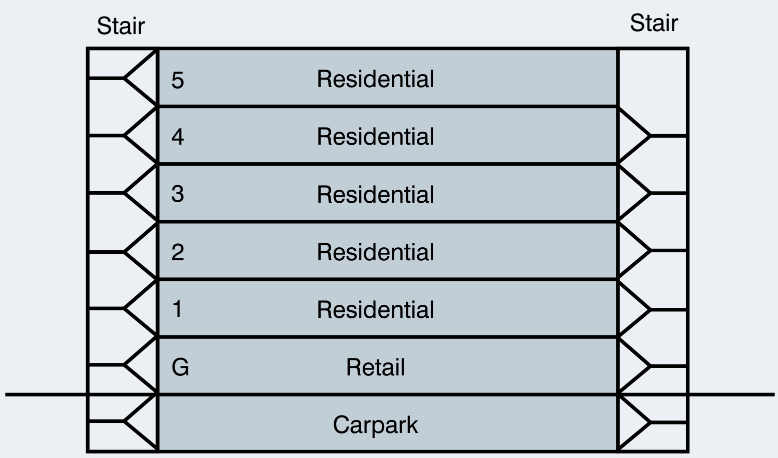

Figure 3: Indicative section of case study building

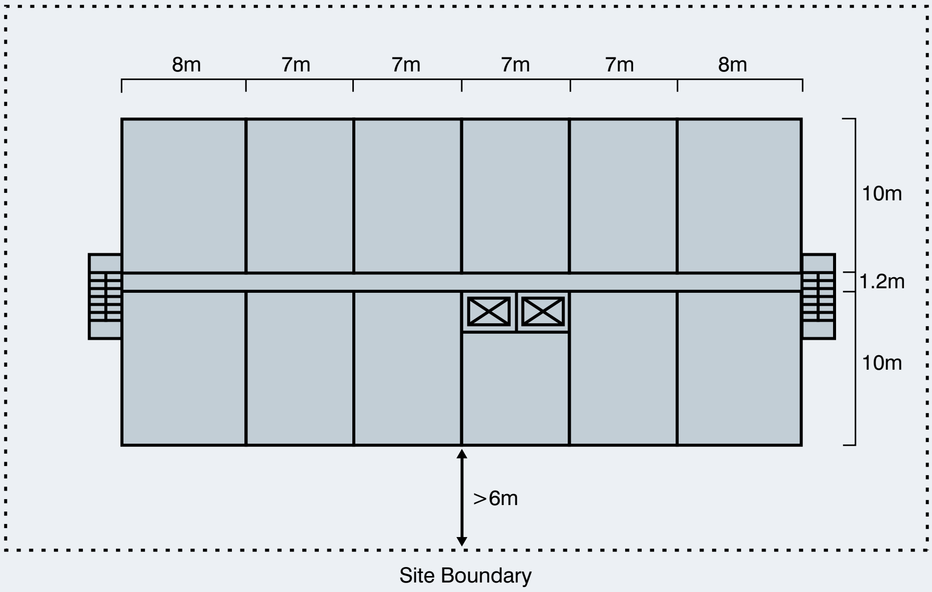

Figure 4: Floor plan of building

The case study building is located in suburban Sydney. Due to the State variations in the NCC, the State in which the building is located can affect the Alternative Solution and approvals process. It is recommended that a Building Certifier is consulted early regarding each project.

The intent of the above assumptions is so that the building can be considered to be compliant in all respects except for the use of timber (combustible material) as part of the load-bearing structure. The NCC non-compliances and relevant Performance Requirements are then as follows:

Table 5: Summary of building non-compliances

Deemed-to-Satisfy Clause	Steel–framed enclosure	Relevant PR
Specification C1.1, Clause 2.2	Generally, there is no material limitation for floors, but since the Fire Resistance Level (FRL) of the building's external walls depends on the lateral support provided by the floors, the floors are then required by *Specification C1.1. Clause 2.2: fire protection for a support of another part*, to be non-combustible. The floors, are to be constructed from timber, hence non–compliant.	CP1, CP2
Specification C1.1, Clause 3.1(b, d, e)	The following walls are required to be of non–combustible construction: • External walls. The following walls are required to be constructed from concrete/masonry only. • Load-bearing internal walls. All walls are to be timber framed–construction, hence non-compliant.	CP1, CP2

The use of timber as a combustible structural form for the proposed height of the building will be the key issue to be addressed for the Alternative Solution.

When developing an Alternative Solution, the hazards caused by deviating from the Deemed-to-Satisfy Provisions of the NCC should be identified and addressed in the proposed Alternative Solution.

The Deemed-to-Satisfy Clauses being deviated from relate to specific Performance Requirements in the NCC, in this case, CP1 and CP2. These Performance Requirements should also be considered so that they can be addressed in the proposed Solution.

4.2 What is the Building?

The case study building is a five–storey residential building, with a Ground Level retail floor and Basement Level car park.

Timber–framed construction techniques are used for the load-bearing structure. This structure generally consists of timber studs and other structural elements which are covered by fire–rated plasterboard to achieve the required FRLs.

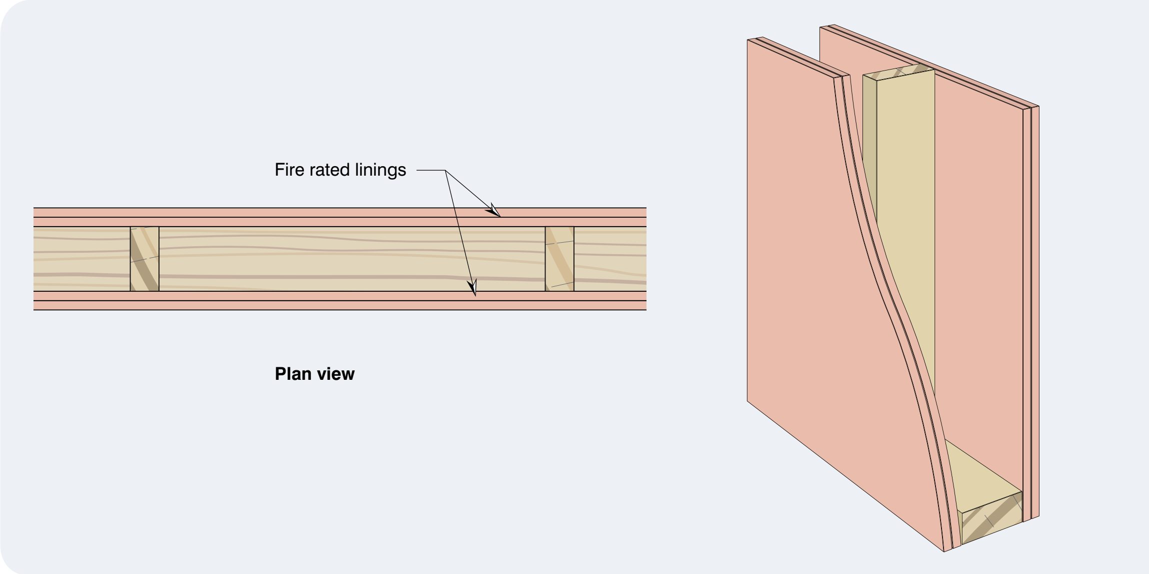

Figure 5: Fire–rated plasterboard protecting timber framing

4.3 What are the Issues?

The load-bearing timber framing inside the plasterboard walls and floors is combustible, which is a non-compliance to Deemed-to-Satisfy provision of the NCC for a Class 2 buildings more than four storeys in height and with mixed occupation, i.e. ground floor retail.

4.4 What are the Hazards?

When using timber as part of the load-bearing structure for a building, there is the perception that the timber framing will combust, leading to premature failure of the load-bearing walls and floors. The main hazards are considered as:

- Fire during construction

Timber–framed buildings are potentially at risk of a major fire when the building is partly constructed without the fire–rated plasterboard.

- Fire spread leading to significant load-bearing failure

The risk associated with a combustible structure is that if the building structure is not appropriately designed it could lead to greater spread of fire to the structural elements and potentially lead to structural failure. For example, in the event of an SOU fire which causes the FRL of the plasterboard wall to fail, the timber studs within the wall could also burn and fail, causing significant load-bearing failure of the building if not appropriately designed.

- Fire fighting operations in a building that is not 'stable':

Part of fire fighting operations include maintaining the safety of the fire fighters themselves. There is a risk that fire fighters may have the perception that the timber–framed building does not achieve an FRL and they may not enter the building, due to the perceived risk of the floors and walls failing.

- Fire spreading at joints, wall/floor interfaces

As the timber framing is combustible, incorrectly sealed (or unsealed) joints and interfaces could lead to ignition of the timber studs or other timber elements concealed behind the fire–rated plasterboard.

4.5 What are the Solutions?

The Alternative Solution is to consider and address the relevant Performance Requirements and hazards.

Performance Requirements CP1 and CP2 relate to a building having elements which will:

- avoid the spread of fire to and within the building
- maintain structural stability during a fire.

As discussed in the Supporting Evidence section, plasterboard manufacturers have produced design guides which outline a number of timber wall systems, all tested and approved to meet the requirements of NCC Deemed-to-Satisfy Clause A2.2 Evidence of Suitability. These systems are familiar to the construction industry and easily costed and constructed.

If the structural systems are installed in accordance with the specifications within the plasterboard manufacturers' design guide, the Fire Resistance Level (FRL) as required by the Deemed-to-Satisfy Provisions of the NCC can be deemed to be achieved.

These installed fire–rated systems are able to avoid the spread of fire and maintain the structural stability of the systems and therefore meet the Performance Requirements of the NCC.

The Alternative Solution would emphasise that the fire–rated plasterboard is providing the fire resistance and the load-bearing timber structural elements are concealed behind the fire rated plasterboard.

A five–storey building is not significantly different to a three–storey timber–framed building, which the NCC allows. The building proposed is to have the same construction, but a few storeys higher. As discussed in the Supporting Evidence section, many countries allow timber–framed buildings to be built higher, as long as the required FRLs can be achieved.

There is a potential for fire spread if the building is not designed or constructed properly (for example, poorly sealed penetrations), however, the combustibility of structural elements is to be addressed by the design of individual elements, to minimise fire spread by minimising voids and appropriate sealing of penetrations (refer to Section 3.27 Construction and Maintenance Issues of this guide for further discussion).

4.6 Sprinklers

A sprinkler system is not required by the Deemed-to-Satisfy Provisions of the NCC if a building is less than 25 m in effective height.

Installing a sprinkler system however, significantly reduces the risk of large fires developing and may provide additional flexibility in the design of a building, potentially allowing additional Alternative Solutions, refer to other timber fire engineering guides on timber linings and cladding[23,24].

4.7 Fire Brigade Issues

In order to aid fire–fighting operations, the following issues are important to consider:

- Vehicular and/or pedestrian access to and around the building (if possible) allows rapid access to the building
- Hydrants in accordance with AS 2419.1 - *Fire hydrant installations - System design, installation and commissioning*[20] within the fire stairs allow attending fire brigades to connect to a hydrant within a place of relative safety (within the fire-isolated stair) prior to entering the fire–affected area.
- Fire–isolated stairs provide attending fire brigades with a protected place from which to begin fire fighting operations. It should be noted that if a timber–framed stair is considered, this should be discussed with the Fire Brigade early in the design process. This may be a high approvals risk due to Fire Brigade preference in some states for non-combustible stairwells. There are examples throughout Australia of combustible stair shafts, normally in combination with other fire resistance solutions and they are considered on a case–by–case basis. A stairwell constructed of concrete/ masonry may resolve this issue.
- The installation of a sprinkler system may also resolve concerns fire fighters may have regarding fire spread.

4.8 Construction and Maintenance Issues

Due to timber being a combustible material, it is important to minimise the paths of fire spread through the fire–rated plasterboard of the wall and floor systems.

Issues discussed below include minimising voids and unsealed penetrations, appropriately constructed connections and maintaining the correct FRLs for the life of the building. WoodSolutions Technical Guide #2[9] provides guidance and recommendations for methods of addressing these issues.

4.8.1 Fire Risk During Construction

Fire during construction is a key issue with timber–framed buildings as the timber framing is exposed and hence at risk of major fire, until all fire–rated plasterboard is in place. Some significant fires have occurred in the past, both inside and outside of working hours, resulting in the loss of the building. The threat to life however, is significantly less as the building is unoccupied.

The risk during construction needs to be addressed by the principal contractor. There are a number of publications which provide guidance and recommendations to promote best practice processes and reduce the risk of fire and/or fire damage. It is recommended that one or more of these publications (or similar publications) are referred to in the construction of mid-rise timber frame buildings:

- Design Guide to Separating Distances during Construction: Parts 1-3 [25-27];
- Fire Safety in Construction[28];
- 16 Steps to Fire Safety on Timber Frame Construction Sites[29];
- Fire Prevention on Construction Sites (7th Edition)[30].

Some measures outlined in these documents should be considered as follows:

- On-site procedures during construction need to be observed and applied; for instance, no smoking on–site and no hot works permitted around the areas where timber is stored.
- Secure the job site, include fencing and out–of–hours monitoring.
- The timber storage on–site should be minimised and managed so that it will not form a single large collection of fuel load.
- The construction of timber-framed buildings creates a heightened risk of a fire spreading beyond the site to neighbouring buildings. The UK Timber Frame Association provides guidance based on the building (and site) characteristics and construction methods to reduce the risk of fire spread to neighbouring properties[25-27].
- Install fire protection and occupant warning measures as soon as possible throughout the construction phase.

4.8.2 Intersections of Fire–Rated Elements

Where different fire–rated elements meet, such as a floor/ceiling to a wall, there is a need to minimise the risk of fire spread to the timber elements through these intersections. Most intersections cannot support plasterboard, which generally provides most of the fire resistance in a framed building. Therefore sacrificial timber blocks are used to substitute the plasterboard in these situations. This works well as the timber blocks can be incorporated into the framing installation stage of the building's construction.

WoodSolutions Technical Guides #2 and #3[9,10] provide guidance and recommendations for protection of intersections for a number of different scenarios, including where the elements at the intersection are of the same FRL or not. Systems are limited to FRL 90/90/90.

The design philosophy is to ensure that the intersection has at least equivalent (or better) fire resistance than the highest fire rating of the building elements that are intersecting.

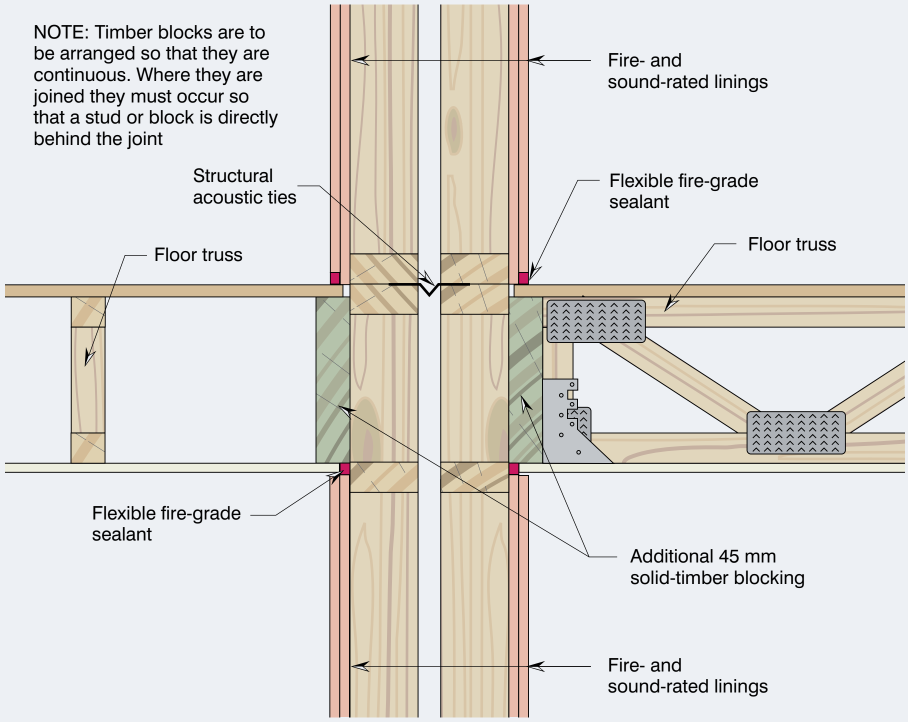

Figure 6: One recommended method for protection of floors intersecting a wall

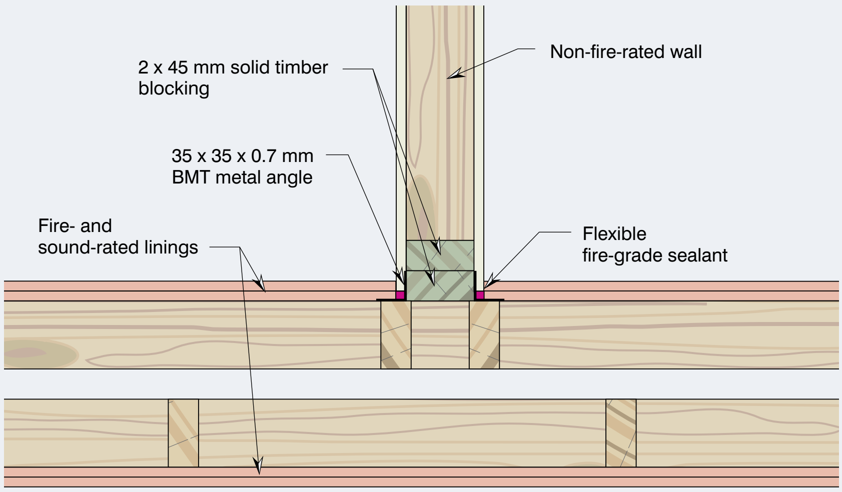

Figure 7: One recommended method for the intersection of an internal non-fire rated wall to a bounding fire and acoustic–rated wall

4.8.3 Voids and Penetrations

Penetrations through fire separations will need to be addressed carefully. The WoodSolutions Technical Guides #2 and #3[9,10] provide guidelines for addressing penetrations and services in timber structures.

During construction, on-site management of penetrations through fire separations needs to be monitored as they can be formed more easily (with a saw) compared with concrete construction.

Void spaces also need careful attention to prevent spread of fire. Often, voids can be located along the facade of the building, between the cladding and the external walls of the building or on bounding walls to apartments given that frames are separated to increase acoustics performance. In principle, these voids should be designed to avoid continuous cavities to connecting floors, limiting the spread fire up the building.

The use of cavity barriers to minimise fire spread is discussed in further details in the WoodSolutions Technical Guides #2 and #3[9,10].

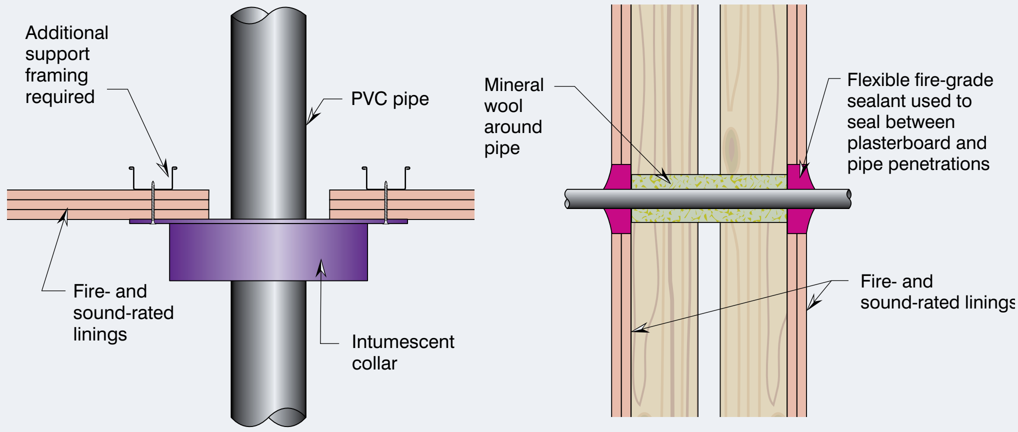

Figure 8: Some recommended methods of penetration sealing

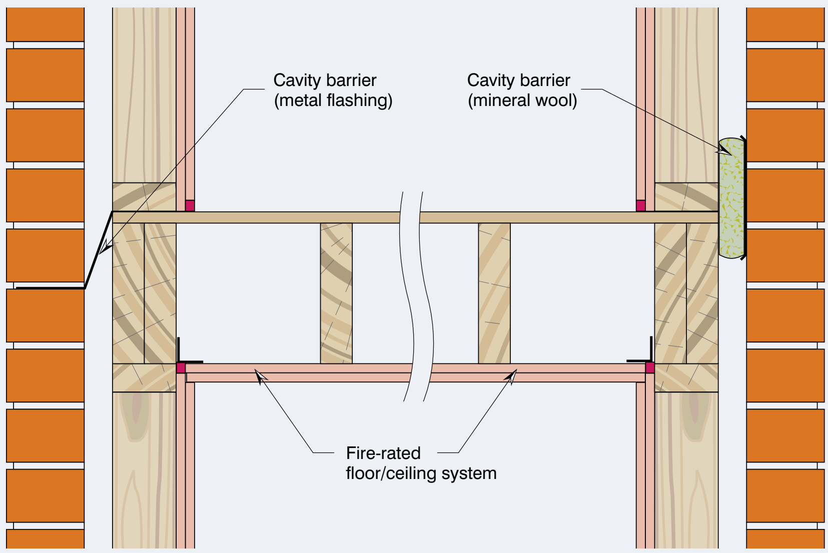

Figure 9: Void spaces protected by cavity barriers

4.8.4 Maintenance and Renovations

In Class 2 buildings, there is a risk that occupants may choose to renovate their apartments (such as changes to bathrooms or kitchens) or add items such as downlights, which require cutting through the walls or ceilings of the apartments. Renovations and modifications such as this are difficult to control and may lead to an occupant voiding the FRL of the building element by cutting holes into the fire rated plasterboard and not sealing the voids correctly (or at all).

As a solution, it is recommended that a document should be developed for all owners, outlining the fire safety measures within the building and the importance of maintaining the FRL of the wall and ceiling systems, especially when considering renovations.

Further, there are measures that can be employed to minimise the risk associated with these occurrences:

Walls

Holes in walls are less likely to occur in a Class 2 building, generally because this may lead to openings or reduced acoustic separation between neighbouring apartments.

The risk of this occurring is the same for a stee–framed building as for a timber–framed building. The consequences would also be similar: if an occupant cut a hole in the wall which in the event of a fire allowed significant heat to spread into the wall cavity, the steel frame may also be compromised in its load–bearing capacity.

To reduce the risk of this event occurring, the following measures could be utilised:

- *Compressed Fire Cement (CFC) sheeting* – a layer of CFC sheeting could be added to the outside of the fire–rated wall system. CFC is a high density material, which is more difficult to cut through than standard plasterboard. Special tools are required and as such, may serve as a deterrent to DIY modifications and lead to builders.
- *Netting* – Netting could be installed behind the layer of plasterboard, so that large holes are difficult to be cut through the plasterboard. Although this method does not prevent the holes from being made, it intends to reduce the size of potential holes.
- *Management* – Ensuring that the resident's manuals for owners and tenants are clear about the requirements to maintain the fire ratings between units at walls.

Ceilings

Minimising the likelihood of occupants cutting through the ceiling and incorrectly re–sealing the hole is more important in a timber–framed building as the plasterboard ceiling forms part of the fire–rated floor/ceiling system. The impact of new holes in the ceiling, negating the FRL, is also a problem for steel–framed buildings, which utilise a plasterboard floor/ceiling system with a steel support structure. In a building with concrete floor slabs, an occupant cutting through the plasterboard ceiling would not affect the FRL of the concrete slab.

To reduce the risk of this event occurring, the following measures could be utilised:

- *False ceiling* – A non fire–rated false ceiling could be installed below the floor/ceiling system. Thus, if holes are cut through the false ceiling, the FRL of the floor/ceiling system above is not compromised. Additionally, this would mean that fire–rated light fittings would no longer be required as the lighting would be located under the fire–rated ceiling.
- *Compressed Fibre Cement Sheeting* – a layer of CFC sheeting could be added to the outside of the fire–rated floor/ceiling system as described above.
- *Management* – Ensuring that the resident's manuals for owners and tenants are clear about the requirements to maintain the fire ratings between units at walls.

5

Further Reading

Wood Solutions Technical Design Guides

The WoodSolutions technical design guides are available to download for free from www.woodsolutions.com.au in the resources section.

#1 Timber-framed Construction for Townhouse Buildings Class 1a – information about complying with the fire safety and sound insulation performance requirements in the BCA for Class 1a attached buildings.

#2 Timber-framed Construction for Multi-residential Buildings Class 2, 3 & 9c – information about complying with the fire and sound performance requirements in the BCA for Class 2, 3 and 9c buildings.

#3 Timber-framed Construction for Commercial Buildings Class 5, 6, 9a & 9b – information about complying with the fire performance requirements in the BCA for Class 5, 6, 9a and 9b buildings.

#6 Timber-framed Construction - sacrificial timber construction joint – this provides common details for using sacrificial timber blocks to maintain a Fire Resistance Level.

#18 Alternative Solution Fire Compliance, Facades – information about using timber facades not covered by the Deem-to-Satisfy Provisions of the NCC. Includes a case study on the use of combustible facades.

#19 Alternative Solution Fire Compliance, Internal Linings – information about using timber linings not covered by the Deem-to-Satisfy Provisions of the NCC. Includes a case study on the use timber linings in a school building corridor.

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20. AS 2419.1 Fire hydrant installations - System design, installation and commissioning 2005

21. AS 2441- Installation of fire hose reels 2005

22. AS 2444-Portable fire extinguishers and fire blankets - Selection and location Fire extinguishers 2001

23. Guide on Alternative Solution Compliance – Timber Linings, FWPA, 2012

24. Guide on Alternative Solution Compliance – Timber Cladding, FWPA, 2012

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26. Design Guide to Separating Distances during Construction: For timber frame buildings and projects above 600m2 total floor area. Part 2 – Standard timber frame and construction process mitigation methods (Version 1). The UK Timber Frame Association, December 2011.

27. Design Guide to Separating Distances during Construction: For timber frame buildings and projects above 600m^2 total floor area. Part 3 – Timber frame build methods to reduce the separating distances (Version 1). The UK Timber Frame Association, December 2011.

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A

Appendix A – Glossary of Terms

Combustible

Defined in Clause A1.1: "Combustible means – (a) Applied to a material – combustible as determined by AS 1530.1. (b) Applied to construction of part of building – constructed wholly or in part of combustible material".

Fire Engineering Brief or Fire Safety Engineering Brief (FEB)

Defined in the International Fire Engineering Guidelines: "A documented process that defines the scope of work for the fire engineering analysis and the basis for analysis as agreed by stakeholders".

Fire Resistance Level (FRL)

Defined in Clause A1.1: "FRL means the grading periods in minutes determined in accordance with Specification A2.3, for the following criteria –

a) structural adequacy
b) integrity;
c) insulation.
and expressed in that order."

Fire-resisting

Defined in Clause A1.1: "Fire-resisting, applied to a building element, means having an FRL appropriate for that element".

Fire wall

Defined in Clause A1.1: "Fire wall means a wall with an appropriate resistance to the spread of fire that divides a storey or building into fire compartments".

Load-bearing

Defined in Clause A1.1: "Load-bearing means intended to resist vertical forces additional to those due to its own weight".

Non-combustible

Defined in Clause A1.1: "Non-combustible means –

a) Applied to a material – not deemed combustible as determined by AS 1530.1 – Combustibility Tests for Material.

b) Applied to construction or part of a building – constructed wholly of materials that are not deemed combustible".

Rise in storeys

Defined in Clause A1.1: "Rise in storeys means the greatest number of storeys calculated in accordance with C1.2".

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