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Alternative Solution Fire Compliance

Facades

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Introduction

The demand for the use of sustainable materials such as timber in the design of buildings is increasing. Timber claddings are also popular due to their inherent architectural aesthetic appearance and ease of use. Often designers can be frustrated and regulators constrained because the existing deemed-to-satisfy provisions in the National Construction Code (NCC) Series (Building Code of Australia[1]) limit the locations and types of buildings in which timber claddings can be used. Fortunately, the NCC allows variations from deemed-to-satisfy provisions (known as Alternative Solutions) to be assessed using fire engineering principles to verify compliance with the Building Code of Australia. Using this approach, the use of timber can be expanded in many circumstances without compromising safety while improving the architectural design.

In modern buildings, it is common for there to be a number of variations from the deemed-to-satisfy building regulation provisions of which the use of timber linings are just one. Fire engineering undertaken by an accredited/registered Fire Safety Engineer can provide a holistic approach to fire safety by working with the design team to ensure aspirations and innovative ideas can be implemented, without compromising safety or delaying the approval process for a building.

This guide is intended to provide methods that could be employed by design professionals to develop an Alternative Solution. It is recommended that the guide be read in conjunction with the NCC.

1 Fire Spread Scenarios for Building Facades

There are four principal fire spread scenarios that need to be considered when assessing combustible facades.

Scenario 1: Fire spread from adjacent buildings (or the fire source features defined in the NCC) to the subject building. For most applications, the analysis is limited to assessing the risk of ignition when the facade is exposed to radiant heat under pilot ignition to address burning embers. Where buildings are close together the analysis may need to be expanded to consider flame contact.

Scenario 2: Fire spread from the subject building to adjacent buildings (or the fire source features defined in the NCC). For combustible facades, it is necessary to consider the contribution of heat from the burning facade if ignition occurs, as well as radiant heat from openings and flames extending from openings in the facade.

Scenario 3: Fire spread from an external fire source adjacent to the facade other than adjacent buildings, e.g. car fire, waste bin fire, etc.

Scenario 4: Vertical fire spread between openings from a fully developed fire within the subject building.

These scenarios are discussed in more detail in Fire Safety Engineering Design of Combustible Facades published by Forest and Wood Products Australia[2].

The NCC deemed-to-satisfy provisions described in Section 3 address the above scenarios mainly by specification of the material properties of the facade to reduce the risk of ignition and fire propagation, specification of separation distances between buildings and between openings in the subject building and take into account the impact of automatic suppression measures.

Combustible facades can also influence the exposure of external structural elements and as part of an alternative solution it may be necessary to consider the required fire resistance of external structural elements. However, this assessment lies outside the scope of this document.

2 Alternative Solution Process

2.1 NCC Compliance Structure

To demonstrate that a building solution complies with the NCC it is necessary to show that it meets the relevant performance requirements of the NCC. The performance requirements can be met by either complying with the Deemed-to-Satisfy (prescriptive) requirements or demonstrating that an Alternative Solution satisfies the performance requirements using an appropriate assessment method. Objectives and Functional Statements provide guidance to assist in the interpretation of the performance requirements. The NCC compliance structure is shown in Figure 1. For further information reference should be made to Part A0 of the NCC.

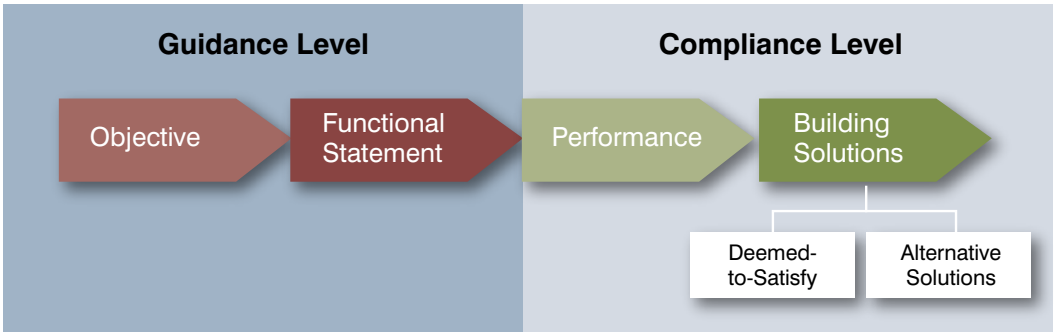

Figure 1: NCC compliance structure

2.2 Demonstration of Compliance of a Deemed-to-Satisfy Provision

Deemed-to-Satisfy Provisions are specified in the relevant sections of the NCC. In many instances a Deemed-to-Satisfy Provision may reference another document, rule, specification, standard or provision. The NCC includes a number of specifications which may, in turn, reference other documents, standards or similar documents. Part A1.2 to A1.7 of the NCC and referenced Specifications describe the hierarchy for the various types of documents and how they should be interpreted.

2.3 Demonstration of Compliance of an Alternative Solution

Most medium to large–scale projects in Australia rely on Alternative Solutions to demonstrate compliance with the NCC with respect to fire safety irrespective of whether or not timber is used as a construction material to enable the design objectives for a building to be attained cost effectively.

Evidence of compliance for nominated variations to the Deemed-to-Satisfy Provisions is commonly in the form of a Fire Engineering Report (FER) prepared by a registered/accredited fire safety engineer. These reports are specific to a subject building and cannot be directly applied to other buildings. Often FERs will nominate levels of performance to be achieved by timber products in fire tests, in which case supplementary documentation will need to be submitted to the regulatory authorities.

Fire safety engineers are normally appointed to prepare an FER in accordance with the method and process described in the International Fire Engineering Guidelines[3] (IFEG), which is submitted to the independent regulatory authorities, e.g. the building surveyor or building certifier for approval. Most States and Territories have specific requirements for registration of fire safety engineers and building certifiers.

Generally, a two–stage process is adopted involving relevant stakeholders, which in addition to the design team, client and building certifie may include the fire brigade, Council, insurer and other interested parties, depending, among other things on the type and significance of the variation from the Deemed-to-Satisfy Provisions.

The first stage is the development of a Fire Engineering Brief (FEB), which, among other things, documents:

- the stakeholder objectives
- a trial fire safety strategy for the building
- potential variations from the Deemed-to-Satisfy Provisions for the trial fire safety strategy
- relevant performance requirements
- engineering / assessment method to the adopted
- fire scenarios to be assessed, if appropriate
- the acceptance criteria.

The FEB / FER will need to determine the relevant performance requirements to be satisfied. The NCC requires the following approach to be adopted:

(a) Identify the relevant deemed–to–satisfy provision of each Section or Part that is to be the subject of the Alternative Solution.

(b) Identify the Performance Requirements from the same Sections or Parts that are relevant to the identified Deemed-to-Satisfy Provisions.

(c) Identify Performance Requirements from other Sections and Parts that are relevant to any aspects of the proposed Alternative Solution or are affected by the application of the Deemed-to-Satisfy Provisions that are the subject of the Alternative Solution.

The second stage is the development of the FER, which details the formulation and analysis of the fire safety design solutions against the fire safety objectives developed in the FEB process. The fire engineering report contains all required calculations, analysis of test evidence and fire modelling to support the recommendations for the formulated fire safety design solution for the building. The FEB and FER process is generally undertaken as the design is developed and tender documentation prepared ensuring that the process does not affect the construction program.

Typically, the FER will make use of one or more of the following assessment methods permitted by the NCC:

- Verification methods specified by the NCC, e.g. NCC's CV1 or CV2
- Comparison with the NCC's Deemed-to-Satisfy Provisions
- An analysis of the holistic fire safety strategy performed by a registered fire safety engineer using methods agreed during the FEB process and demonstrating compliance with the acceptance criteria also agreed during the FEB process.

2.4 NCC Deemed-to-Satisfy Provisions for Fire Spread to the External Facades (excluding requirements for fire resistance)

2.4.1 Overview

There are a number of Deemed-to-Satisfy Provisions that relate to fire spread via the external facade of a building that are relevant to timber construction. Requirements relating to general Fire Resistance Levels of materials lie outside the scope of this document and the case study provided and will not therefore be detailed in this section.

The Deemed-to-Satisfy requirements for fire resistance are provided in Section C of the NCC, which specifies required types of construction based on a simple risk assessment which considers the height of a building and type of occupancy. Type A construction is required to be the most fire resistant, Type C the least. Table 1 has been adapted from the table in Clause C1.1 of the NCC with examples of building use based on the definitions of building class in Section A of the NCC. The green shading within the table illustrates building types and rise in storeys, where timber facades meet the Deemed-to-Satisfy provisions of the NCC.

Higher levels of fire protection are required for multistorey buildings and for buildings where evacuation of the occupants is likely to be slow.

Table 1: Type of construction required

Building Classification	Condition	Rise in Storeys			
		1	2	3	4 & above
Class 2 Residential Apartments		C	B	A	A
Class 3 Short–term Accommodation		C	B	A	A
Class 3 Short–term Accommodation	At least two exits or direct exit to road or open space[2]	C	C	A	A
Class 5 Office		C	C	B	A
Class 6 Retail		C	C	B	A
Class 7 Carpark		C	C	B	A
Class 8 Factory or Laboratory		C	C	B	A
Class 9a Health-care		C	B	A	A
Class 9b Schools or Assemble buildings		C	B	A	A
Class 9c Aged Care		C	B	A	A
Class 9c Aged Care	At least two exits or direct exit to road or open space[2]	C	C	A	A

Notes: 1. Green shading indicates NCC DTS building type that allows timber facades
2. Refer to NCC Clause C1.5

The primary Deemed-to-Satisfy Provisions applicable to external walls are summarised in Table 2.

Table 2: Relevant Deemed-to-Satisfy clauses

Hazard to be mitigated	Deemed-to-Satisfy Provisions
Ignition of facade and fire propagation across the facade	C1.1 Non Combustibility C1.10 / Specification C1.10 – Fire Hazard properties
Fire spread through openings in external walls	C2.6 Vertical separation of openings in external walls
External fire spread between buildings and parts of buildings	C3.2 Protection of openings in external walls C3.3 Separation of external walls and associated openings in different fire compartments

2.4.2 Specification C1.1 Non–Combustibility Provisions

Specification C1.1 Sections 3 to 5 contain the requirements summarised in Table 3 relating to controls of the combustibility of external walls.

Table 3: NCC deemed-to-satisfy combustiblity requirements for external walls

Type A	Type B	Type C
External walls required to not be combustible when tested to AS 1530.1	External Walls required to not be combustible when tested to AS 1530.1	No requirement for combustibility (Spec C1.10 requirements still apply)

Note: Class 2 Type A and B construction has a concession relaxing requirements for combustibility for three–storey buildings, or four–storey buildings where the lowest storey is concrete.

When timber is tested in accordance with AS 1530.1[4], it is combustible, whether a fire retardant is used or not. Consequently, an Alternative Solution will be required if timber forms an integral part of the external walls of a building required to be of Type A or Type B construction, unless the building is of Class 2 and complies with the Class 2 concessions provided in Specification C1.1.

The Class 2 concessions apply to Multi-Residential Timber Framed Construction (MRTFC) buildings with a rise of storeys of not more than three (four if the lowest storey is a car park constructed from concrete and masonry with the specified fire separation). The concession, among other things waives the requirements for external walls to be non-combustible. Further information is provided in the NCC and in WoodSolutions Technical Design Guides, No 2[5].

For Type C construction and timber framed MRTFC buildings to which the Class 2 concessions apply there are no general restrictions or minor restrictions on the combustibility of walls but the Fire Hazard Properties of C1.10 below will still apply.

2.4.3 General Provisions from C1.10

NCC's Subclause C1.10(a) outlines fire hazard properties required for timber lining materials for floors, walls (including external walls) and ceilings, fixed seating in an auditorium, escalators and certain types of stairways and ramps and attachments to floors walls and ceilings. These materials must comply with Specification C1.10.

There are a number of exclusions in subclause C1.10(c) permitting the use of timber in the following applications irrespective of the Group Number requirements:

- Fire Protective Covering (defined by the NCC in Part A1.1 Definitions)
- Timber framed windows
- Solid timber handrails
- Solid timber skirtings
- Timber faced solid core and fire doors
- A joinery unit, cupboard, shelving, or similar
- Materials (timber) that does not increase the fire hazard significantly.

The last point is an unqualified catch-all exclusion for building components that, due to their size, construction or location are unlikely to significantly contribute to the spread of fire and smoke in the building.

The Guide to the NCC[6] also explains the exclusion elements within buildings such as joinery units, cupboards, shelving and the like. These elements do not form part of the structure and generally are not considered within the building's approval and are typically attached to the building structure for their support and as such, in most instances are low contributors to the spread of fire and smoke in the building. The NCC guide suggests that these items should be likened to the building's furniture, which is generally not considered for fire hazard properties.

This approach can be extended when considering Alternative Solutions involving timber where timber linings may not completely cover all surfaces.

2.4.4 Fire Retardant Coatings

The NCC Deemed-to-Satisfy Clause C1.1(b) excludes the use of fire-retardant coatings to comply with fire hazard properties. Fire-retardant coatings are applied to the surface of an element and differ from fire-retardant products that penetrate into the timber.

One reason often given for prohibiting the use of paint or fire-retardant coatings to make a substrate comply with the required fire hazard properties in subclause C1.10 (b) is the perception that the coating is susceptible to damage from wear and tear or abrasion. The NCC guide clarifies that subclause C1.10 (b) does not prohibit the use of impregnated (infused) fire-retardants to achieve the relevant fire hazard properties.

There are, however, precedents in the Deemed-to-Satisfy Provisions in the NCC where the use of paints, coatings, lightweight construction and other treatments are permitted for various fire–related applications where susceptibility to damage is either not considered or has been addressed through additional requirements including the following:

- NSW variation to clause C1.10(b) for Class 9b entertainment venues, allows the modification to fire hazard properties by paints or fire-retardant coatings for treatment of fabrics for seating and cinematograph screens. There are additional requirements to provide certification that the fire hazard performance has been met and testing is be performed after cleaning cycles.
- Clause C1.8 (b) provides a concession where lightweight construction such as sheet or soft materials can be used for the fire-resisting covering of a steel column providing that if the material is not in continuous contact with the column, the void between the column and the covering is filled with solid material that prevents denting to a height of at least 1.2 m above the floor. In addition, if equipment, vehicles or materials are liable to damage the columns, then the material must be further protected by steel or the like. It should be noted there are no other specific prohibitions relating to the use of boards or coatings for the protection of structural steel in the NCC.

  Part G5 Construction in Bushfire Prone Area requires Class 2 or 3 building or Class 10a building or deck associated with a Class 2 or 3 building, must comply with AS 3959[7].

  AS 3959 Appendix F Bushfire-Resisting Timber includes requirements for an accelerated weathering procedure for fire retardant treated timber prior to undertaking fire tests to AS/NZS 3837[8].

These examples provide useful benchmarks when considering Alternative Solutions.

2.4.5 NCC's Specification C1.10 Requirements for Wall Linings

Specification C1.10 requires wall linings to be capable of achieving nominated group numbers that correlate to time taken for flashover to occur in a small room with a controlled ignition source which can be considered to represent a single burning item.

This group number of the material can be determined by either physical testing in accordance with AS ISO 9705[9] (room burn test) or prediction using empirical correlations based on a test in accordance with AS/NZS 3837 (cone calorimeter test). The required group number is dependent on the classification of the building, whether the building is sprinkler protected or not, and where the lining is located within the building.

The group number of a material can be Group 1 (least hazardous), Group 2, Group 3 or Group 4 (most hazardous).

External walls fall under the definition of other areas and therefore linings need only satisfy the requirements for Group 3. Group 3 materials include most timbers and also some fire–retardant treated plastics and other materials that reach flashover in more than 120 seconds but within 600 seconds when exposed to 100 kW during an AS ISO 9705 test. Therefore, in most instances this Deemed-to-Satisfy requirement can be satisfied by most timbers and has been confirmed by all of the timbers tested to date.

Specification C1.10 also places the following limits on the smoke produced if buildings are not protected by a sprinkler system, depending on the applicable test procedure:

(i) a smoke growth rate index not more than 100 if tested in accordance with AS ISO 9705; or

(ii) an average specific extinction area less than 250 m^2/kg if tested in accordance with AS/NZS 3837.

The NCC is silent on whether the smoke criteria apply to external walls but, notwithstanding this, most timbers would be expected to meet these requirements.

Further information on common timbers species and panel product group numbers and smoke growth / specific extinction refer to WoodSolutions website, www.WoodSolutions.com.au.

2.4.6 Vertical Separation of Openings in External Walls

The NCC Deemed-to-Satisfy Clause C 2.6, is the Deemed-to-Satisfy Provision relating to fire spread to upper floors through openings in the facade or external walls. Combustible facades may have an impact on the efficacy of this provision and therefore the timber facade needs to be considered in an Alternative Solution.

The NCC Clause C2.6 provides Deemed-to-Satisfy solutions and they are summarised here as for Type A Construction only:

An opening in an external wall (including windows) that is above another opening in the storey next below requires protection as specified below unless the opening are horizontally offset by a minimum of 450 mm or protected by an element such as a window having an FRL of 60/60/60.

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

Spandrel: A wall above a opening, curtain wall or panel that is 900 mm or higher and extends at least 600 mm above the upper floor surface and is made from non-combustible material with a minimum FRL of 60/60/60, refer Figure 2.

Where curtain or panel walls are used they must have any gaps between the surface and the building's structure packed with a non-combustible material that will withstand thermal expansion and structural movement of the walling without the loss of seal against fire and smoke.

Horizontal Projection: projects outwards from the external face of the wall not less than 1,100 mm; and extends 450 mm beyond the openings and is made from non-combustible material with a minimum FRL of 60/60/60, refer Figure 2.

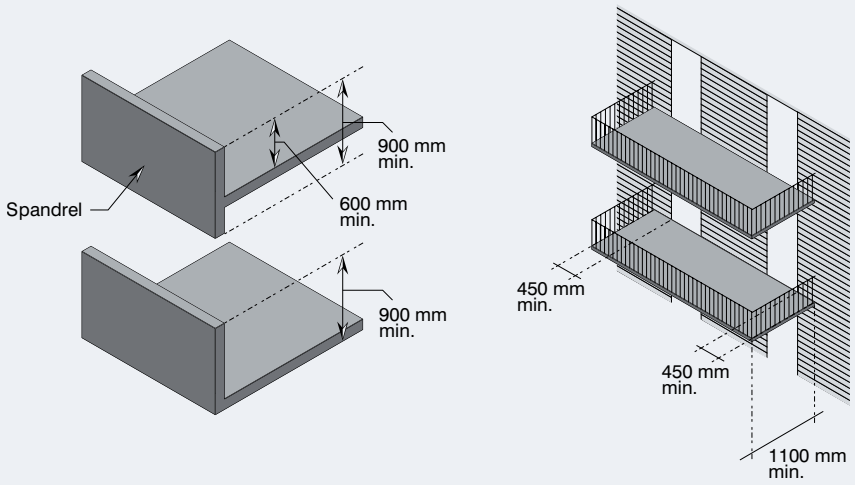

Figure 2: Illustration of fire protection to openings

NCC Clause C2.6 waives the above requirements for:
- an open–deck car park
- spectators stands
- a building with a complying automatic sprinkler system
- openings into the same stairways
- where the floor separating the storey is not required to provide fire separation with respect to integrity and insulation under the NCC Deemed-to-Satisfy Provisions.

The Guide to the NCC provides the following reasons for these concessions:

- a complying sprinkler system prevents the fire developing to the stage where it could spread to the next floor.
- openings in a fire-isolated stairs are not considered separate storeys and that fire spread between floors will not occur via the stairway
- with respect to open-deck car parks and open spectator stands it is unlikely that fire would spread between floors in these types of buildings as their open construction reduces the effects of fire.

Some of the above reasons may be applicable to Alternative Solutions involving timber facades.

2.4.7 External Fire Spread between Buildings and Parts of Buildings

The relevant Deemed-to-Satisfy clauses that relate to the fire spread between buildings and parts of building or from an adjoining allotment are NCC Clauses C3.2, C3.3 and C3.4. These Clauses apply to all building classifications from Class 2 to 9, even where the building is protected by a sprinkler system.

The purpose of the clause is to limit the effects of radiant heat from an adjoining building or allotment moving through a building opening and affecting the building's content or structure.

The openings such as a door, window or similar in an external wall that is required to have an FRL, must be protected in accordance with NCC Clause C3.4. If wall-wetting sprinklers are used, they are located externally, if the distance between the opening and

- side or rear boundary of the allotment is 3.0 m or less, or
- 6 m from the far side of boundary of a road, river, lake or the like neighbouring the site if the opening is not located in a storey at or near the ground.
- within 6.0 m of another building classification except a Class 10 building.

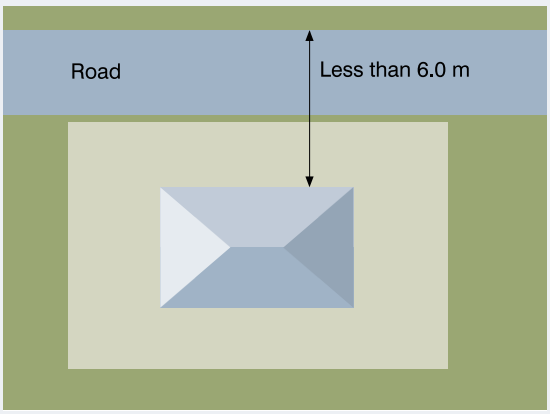

Figure 3: Separation distance far side boundary

The size of the opening is also limited to not more than one-third of the area of the external wall of the storey where it is located except for open spectator stands.

NCC Clause C3.3 considers separation of external walls and openings in different fire compartments within the one building and storey. The NCC places distance limits on openings dependent on the angle between neighbouring walls, refer Table 4. The larger the angle between the walls, the lower the distance between openings where addition construction is required. Once the wall reaches 180 degrees, there are no limits.

The requirement is not applicable to external walls that have an FRL of 60/60/60 or less or units in a Class 2 or 3 buildings.

If the distances can't be met in Table 4 then the opening is required to be protected in accordance to NCC Clause C3.4.

Table 4: Minimum distances NCC clause C3.3 allows between openings in different fire compartments

Angle Between Walls	Minimum Distance
0° (walls opposite)	6 m
more than 0° to 45°	5 m
more than 45° to 90°	4 m
more than 90° to 135°	3 m
more than 135° to less than 180°	2 m
180° or more	Nil

For applications where the building's Deemed-to-Satisfy Provisions require the external facade to be non-combustible (e.g. Type A and B construction) an Alternative Solution to these clauses will need to be considered. Radiant heat and burning embers from an adjacent building or part of the building may ignite the facade, or if the subject building is on fire, the radiant heat from the facade may be increased due to flame spread.

Clause 3.4 of the NCC provides an indication of methods of protection that may assist in the development of an Alternative Solution.

Clause C3.4 describe complying protection methods such as:

- Door openings
- internal or external wall-wetting sprinklers with a door that are self or automatic closing; or
- –/60/30 fire doors that are self-closing or automatic closing and comply with Specification C3.4.

- Windows
- internal or external wall-wetting sprinklers with a windows door that are automatic closing or permanently closed; or
- –/60/30 fire window that are automatic closing or permanently closed and comply with Specification C3.4., or
- 60/– automatic closing fire shutters, comply with Specification C3.4.

- Other openings (excluding voids)
- internal or external wall-wetting sprinklers; or
- construction having an FRL not less than –/60/–.

2.5 NCC / BCA Performance Requirements for Fire Performance of Combustible Facades

The following process is required to be used to identify relevant performance requirements:

- identify NCC Performance Requirements from the same Sections or Parts that are relevant to the identified Deemed-to-Satisfy Provisions are identified
- then identify relevant performance requirements from other parts and sections

Typical outcomes are summarised in Table 5 and the individual performance requirements from the NCC are discussed. It is recommended that the NCC and the NCC's Guide be read in conjunction with the following to gain a better understand of the issues that need to be considered.

Table 5: Typical relevant performance requirements

Hazard to be mitigated	Deemed-to-Satisfy provisions	Performance requirements from Part C	Requirements from other Parts
Ignition of facade and fire propagation across the facade	C1.1 Non Combustibility C1.10 / Specification C1.10 – Fire Hazard properties	CP2, CP4	EP2, CP8
Fire spread through openings in external walls	C2.6 Vertical separation of openings in external walls	CP2, CP8	EP2
External Fire Spread between buildings and parts of buildings	C3.2 Protection of openings in external walls C3.3 Separation of external walls and associated openings in different fire compartments	CP2	See Note 1

Note 1: If analysis showed that fire spread occurs to the subject building and then propagates other performance requirements will become relevant such as EP2.

Performance Requirement CP2

The intent of CP2 is to deal with the spread of fire within and between buildings.

Performance Requirement CP2 (a) points to specific areas of a building to be considered – exits, sole-occupancy units and public corridors for residential types of buildings, in addition to fire spread between buildings and in a building.

The aim is to allow the building's occupants to evacuate a building without endangering them or preventing or impeding fire authorities from entering, fighting the fire or rescuing occupants if required. Limiting fire spread between buildings protects occupants in adjacent buildings but also provides an element of property protection by restricting the fire to a single building.

Performance Requirement CP2 (b) describes consideration to avoid the spread of fire, these include:

- risk of fire occurring in the building in the first instance
- the intensity, duration or size of the fire in the building
- the size and height and of the building, and proximity to neighbouring buildings
- difficulty to evacuate occupants or rescue them
- fire safety system that affect rate of the fire spread, such as sprinklers
- the ability of fire brigades to fight the fire
- consequence of elements failing due to fire and this affect on other elements
- time it takes to evacuate the building.

Performance Requirement CP4

CP4 considers the affects of fire on materials used in the construction of a building including the materials resistance to fire spread. These include such matters as smoke, toxic gases and heat generated from the materials used.

The requirement also requires consideration of:

- the evacuation time
- characteristics of occupants such as the number, and their mobility
- the purpose or use of the building
- any fire safety systems installed in the building.

Performance Requirement CP8

CP8 requires any building elements used in a building to limit the spread of fire from any penetrations of services, openings or construction joints used in a building.

Performance Requirement EP2.2

EP2.2 considers the requirement to minimise the hazard of smoke from a fire within a building.

The requirement specifies that evacuation routes in building should be maintained such that the temperatures, visibility and toxicity of smoke will not endanger the evacuating occupants for the period of time required for evacuation. This time period is dependent on:

- the type of occupants,
- the number and their mobility of the occupants
- the function of the building
- travel distance of occupants to evacuate a building
- the intensity, duration or size of the fire in the building
- fire safety system that affect rate of the fire spread, such as sprinklers
- the ability of fire brigades to fight the fire, evacuate occupants or rescue them.

Depending on the nature of an Alternative Solution and method of demonstrating compliance, other performance requirements may also be relevant.

2.6 NCC Verification Methods

The NCC includes verification methods to assess the adequacy of measures to avoid fire spread between buildings. The requirements are quantifiable, such that the building itself will not cause heat flux greater than limits specified in Table 5, for various distances from the boundary of an adjoining property or road or another building on the same allotment. The building is also required to resist ignition when exposed to the heat flux stated in Table 5 if it is constructed within the nominated distances of another building or boundary.

Table 5: Maximum Heat Flux allowed and distance from properties' boundary

Distance from Boundary	Distance between buildings (m)	Maximum heat flux kW/m²
On the boundary	0	80
1 m from the boundary	2	40
1 m from the boundary	6	20
1 m from the boundary	12	10

2.7 International Approaches for Evaluation of Combustible Facades

2.7.1 European Approaches

In Europe, the classification system for fire hazard for internal linings, is heavily reliant on the Single Burning Item test (EN 13823)[10], is also applied to external facades with additional criteria being applied to multistorey buildings in some countries. This approach is similar to the Australian Deemed-to-Satisfy approach whereby reliance is placed on the Group 3 classification of linings from Specification C1.10 for low–rise buildings (Type C construction).

The Deemed-to-Satisfy approaches for multi-storey buildings vary considerably, with the Australian approach (for Buildings of Type A and B construction) relying heavily on a requirement for external walls to not be non-combustible when tested to AS 1530.1 whereas many European countries are more advanced in this area requiring facade testing for multi-storey buildings with combustible facades as shown in Table 6 which has been extracted from Fire Safety in Timber Buildings – Technical Guideline for Europe[11].

Table 6: Additional Fire Performance Requirements on Facades in some European Countries*

Country	Facade fire requirements		Fire scenario	Test method	Exposure levels	Measurements	Facade test needed for wooden facades	Comments
	Upward Flame Spread	Falling parts						
Austria	-	-	Flames out of a window	ÖNORM B3800-5	About 40 kW/m² in 20 min	Damage, Temp.	4-5 storeys (ÖNORM B 3806)	Timber Constructions ÖNORM B 2332
France	-	-	Flames out of a window	Aréte 10/09/1970	15-75 kW/m² in 15-20 min	Flame spread, Damage, Temp.	Depends on building type	Distance between buildings also to be respected
Germany	-	-	Flames out of a window	DIN 4120-20 (draft)	20-65 kW/m² (350-400 kW) in 20 min	Flames, Glowing, Damage, Temp.	≥ 4 storeys	Evaluation criteria to be decided by DIBT
Sweden	-	-	Flames out of a window	SP Fire 105	15-75 kW/m² in 15-20 min	Damage, Heat flux, Temp.	> 2 storeys	
Switzerland	-	-	Flames out of a window	Large scale test	600-800 kW in 15-20 min	Damage, Temp.	4-8 storeys	Reference no 20 in [4.18]
UK	-	-	Flames out of a window	BS 8414	15-75 kW/m² in 15-20 min	Damage, Heat flux, Temp.	> 2 storeys	

**from Fire Safety in Timber Buildings – Technical Guideline for Europe*

Many of the above test procedures allow features such as cavities and spacing of combustible elements to be evaluated together with the efficacy of cavity barriers.

2.7.2 International Standards

ISO 13785-2 2002[13] describes a full–scale reaction to a fire test for facades incorporating a simulated interior compartment fire, with flames emerging through a window opening and impinging directly on the facade. The test procedure can provide robust data for evaluation of Alternative Solutions in the Australian market and may form the basis of Deemed-to-Satisfy Provisions for combustible facades over time.

Data from tests performed following the general principles of this standard with non-combustible facades that can be used as comparative data are available on the FWPA web site – Fire Safety Engineering Design of Combustible Facades[14]. This publication also includes more details on fire safety engineering approaches that can be adopted.

Figure 4 below shows a typical control test with a control non-combustible lining with key results provided in Table 7.

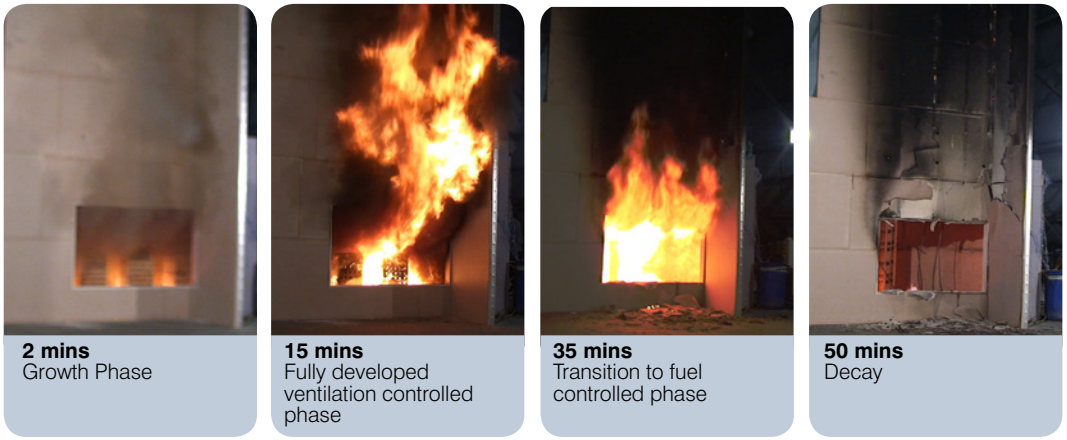

Figure 4: Photographs of a control test to ISO 13785-2 2002 with a non-combustible facade

Table 7: Results from flat facade tests and 0.6 m horizontal projection (balcony test

	Test Time (mins)	Burning Regime	Enclosure Temperature (Co)	Heat flux 1.5 m above opening (kW/m²)	Heat flux 3 m above opening (kW/m²)	Temperature 1.5 m above opening (°C)	Temperature 1.5 m above opening (°C)
Flat Facade	2	Growth (fuel controlled)	50	2	1	46	39
Horizontal Projection			67	1	1	53	24
Flat Facade	20	Strong vent controlled	813	104	43	1000	741
Horizontal Projection			831	67	15	639	461
Flat Facade	28	Vent controlled	1018	65	29	777	433
Horizontal Projection			1029	41	11	467	386
Flat Facade	35	Stoichiometris (approximately)	1090	30	18	636	417
Horizontal Projection			1088	13	5	312	313
Flat Facade	40	Decay phase (fuel controlled)	785	20	12	467	303
Horizontal Projection			763	17	5	420	262

From the above results it can be seen that with strong ventilation controlled burning regime, heat fluxes greater than 100 kW/m² can be experienced 1.5 m above the opening which would be expected to cause rapid failure of non fire resistant glazing. Since the NCC Deemed-to-Satisfy Provisions only specify a vertical separation of 900 mm it can be concluded that the NCC Deemed-to-Satisfy Provisions will only provide limited protection against vertical fire spread via the facade under some fire scenarios.

Comparison with Deemed-to-Satisfy Provisions is a practical approach to demonstrating compliance with the NCC under these circumstances but the Fire Engineering Brief process should highlight the residual risks if such an approach is adopted. The comparison could include a repeat of the test referred to above but with a combustible facade feature. The balcony test indicated that if horizontal projections can be included in the facade the risk of vertical flame spread can be significantly reduced.

Since ful–scale tests are costly to perform, the International Standards Organisation also published an Intermediate scale test method ISO 13785-1:2002[15], which specifies a screening method for determining the reaction to fire of materials and constructions of facades or claddings when exposed to heat from a simulated external fire with flames impinging directly upon a facade. It is intended for use by producers to reduce the burden of testing in ISO 13785-2:2002 by eliminating those systems that fail the tests described in ISO 13785-1:2002.

The test method consists of observing the behaviour of the facade panel construction to fire and the resulting flame spread on or within the facade construction.

If a facade incorporates timber in discrete locations it may be possible to derive the likely exposure conditions of the timber by calculation or from tests such as those described in "Fire Safety Engineering Design of Combustible Facades"[2]. ISO 13785-1:2002 intermediate tests can then be undertaken or calculation methods used (if sufficient data already exists) to determine if ignition occurs and if subsequent fire propagation is likely when the timber is exposed to these exposure conditions.

A modification to the intermediate procedure which allows the behaviour of a facade to be evaluated with an imposed radiant heat flux and flaming source is described in Test Procedure for Combustible Facades (Intermediate Scale) which is available from the FWPA web site[16]. This enables the use of the test to be extended to assess the behaviour of a facade when exposed to radiant heat from a fire in an adjacent building.

3

Case Study – Use of Combustible Facades

3.1 General Description of Case Study

This case study relates to a multi-storey building comprising two levels of retail (Class 6), a three–level car park above the retail outlets (Class7a) and 10 residential levels (Class 2) above the car park. The car park and retail facades are set back 3 m from the boundaries of the allotment whilst the facades for the residential units are set back a further 6 m to avoid overshadowing and provide a private garden area for residents.

The building is protected by an automatic fire sprinkler system throughout. The external facade of the car park levels are faced with hardwood timber strips each one having the dimensions of 86 mm × 19 mm, with a clear space of 25 mm between adjacent strips.

3.2 Assessment Against the Deemed-to-Satisfy Provisions

The Building Certifier has identified that under the Deemed-to-Satisfy Provisions the building is to be of Type A construction and since the timber cladding is combustible an Alternative Solution has to be provided to address the variation from NCC Clause C1.1 and Specification C1.1.

- The relevant NCC Deemed-to-Satisfy requirements are listed in Table 8 together with notes on whether they have been satisfied or whether an Alternative Solution is required.

The separation of openings in the external walls meets the Deemed-to-Satisfy Provisions of the NCC since the building is sprinkler protected.

Table 8: Relevant NCC Deemed-to-Satisfy Provisions

Hazard to be Mitigated	Deemed-to-Satisfy Provisions	DtS satisfied?	Comments
Ignition of facade and fire propagation across the facade	C1.1 Non Combustibility	No	Alternative Solution required.
	C1.10 / Specification C1.10 – Fire Hazard properties	Yes	Timber used achieves Group 3.
Fire spread through openings in external walls	C2.6 Vertical separation of openings in external walls,	Yes[1]	Sprinkler system provided therefore separation not needed under DtS. Impact of combustible linings will need to be evaluated as part of Alternative Solution to allow combustible facades
External fire spread between buildings and parts of buildings	C3.2 Protection of openings in external walls C3.3 Separation of external walls and associated openings in different fire compartments	Yes[1]	Separation distances meet the NCC DtS provisions. Impact of radiant heat on the selected combustible linings will need to be evaluated as part of alternative solution to allow combustible materials on facade.

Note 1: The effect of combustible linings still needs to be considered, refer Section 3.3.

3.3 Relevant Performance Requirements

Table 9 indicates the performance requirements relevant to the specific Deemed-to-Satisfy clauses with the variation to the Deemed-to-Satisfy Provision relevant to this case study highlighted. It can be noted that the variation to the non-combustibility provision captures all the performance requirements relevant to fire spread via the facade of a building.

Table 9: Relevant Performance Requirements

Hazard to be Mitigated	Deemed-to-Satisfy Provisions	Performance from Part C	Requirements from other Parts
Ignition of facade and fire propagation across the facade	C1.1 Non Combustibility C1.10 / Specification C1.10 – Fire Hazard properties	CP2,CP4,CP8	EP2
Fire spread through openings in external walls	C2.6 Vertical separation of openings in external walls,	CP2, CP8	EP2
External Fire Spread between buildings and parts of buildings	C3.2 Protection of openings in external walls C3.3 Separation of external walls and associated openings in different fire compartments	CP2	

3.4 Fire Scenario Review and Selection of Design Actions

3.4.1 Scenario 1 Fire Spread from Adjacent Buildings

During the Fire Engineering Brief, it was decided that the exposure conditions specified in verification method CV1 would be adopted and since the facade is 3 m from the boundary the facade will be exposed to a design imposed radiant heat flux of 20 kW/m^2. Since a fire in an adjacent structure could produce embers, it will be assumed that a small pilot ignition source would be coincident with the radiant heat flux.

3.4.2 Scenario 2 Fire Spread from the Subject Building to Adjacent Buildings

The separation distance from the boundary complies with the NCC Deemed-to-Satisfy Provisions and the building is protected by an automatic fire sprinkler system, therefore substantially reducing the risk of a fully developed internal fire or fire spread to involve the combustible facade. The FEB process led to a consensus view that there was no need for further consideration of this fire scenario subject to Scenario 3 not causing ignition of the facade.

3.4.3 Scenario 3 Fire Spread from an External Fire Source Adjacent to the Facade

The area in front of the building below the timber facade is paved with bollards on the boundary, preventing vehicular access to the facade of the building. The facade in question has retail windows facing the paved area. It is a thoroughfare for pedestrians and is served by security staff overnight. The FEB process led to a consensus view that the risk of collection of combustible materials, vehicles or other potential fire sources close to the facade would be very low and, since the lower edge of the timber facade will be located at least 7.5 m above the external ground level, it is extremely unlikely there would be a sufficiently large external fire source capable of igniting the facade therefore there is no further need to consider this option.

If the above measures were not in place, the FEB process would define a fire source and plume / flame length calculations would be undertaken to ascertain the likelihood of the timber facade igniting.

3.4.4 Scenario 4 Vertical Fire Spread Between Openings from a Fully Developed Fire within the Subject Building

For sprinkler protected buildings, the NCC Deemed-to-Satisfy Provisions allow requirements for vertical separation of openings to be waived based on the following basis, which is taken from the Guide to the NCC.

The requirement for separation of openings does not apply to:

- sprinkler–protected buildings because the sprinklers should prevent the fire developing to the stage where it could spread to the floor above
- openings in a fire-isolated stair shaft, because the stair shaft is not considered to be separate storeys and it is assumed that fire spread between floors will not occur via the stairway
- open-deck car parks and open spectator stands because it is unlikely that fire would spread between floors in these types of buildings as their open construction allows the dissipation of the effects of fire.

In this instance, the car park is sprinkler protected and therefore it was concluded that the risk of vertical fire spread resulting from a fire within the building had been adequately addressed.

3.4.5 CV1 Assessment

Based on the discussion above the only fire scenario requiring further analysis is the risk of fire from adjacent buildings, which will be assessed based on the NCC Verification Method CV1.

The relevant parts of NCC's CV1 is to avoid the spread of fire between buildings on neighbouring properties. This can be verified by demonstrating that the ignition of the facade will not occur at the relevant heat flux. The relevant heat flux can be found from NCC' s Table CV2 or this Guide's Table 5 and is dependent on the distances from the allotment boundary.

From Section 4.4.3 above the facade is required to be resistant to an imposed radiant heat flux of 20 W/m^2 at 3 m from the boundary but CV1 does not specify an exposure period.

A practical approach is to consider Fire Brigade Intervention and estimate the time taken (after flashover) for the Fire Brigade to protect exposures (termed t_{FB}) and compare this with the time to ignition for the timber (termed t_{ig}).

If $T_{fb} < t_{ig}$ with a reasonable margin of safety it can be considered that Verification Method CV1 has been satisfied.

T_{fb} can be determined using the Fire Brigade Intervention Model

1. For timber the time to ignition can be determined by test methods such as the cone calorimeter method (AS/NZS3837) for the specific timber at the required radiant heat flux or by reference to published data e.g. The piloted ignition of timbers exposed to radiant heat

In this case study the selected timber is Grey Iron Bark.

Using the Janssen's correlation the following relationship was derived for Grey Iron Bark in the piloted ignition of timbers exposed to radiant heat reference document.

$$t_{ig} = (0.003\dot{q}''_e - 0.0367)^{-\frac{1}{0.55}}$$

Where t_{ig} is the time to ignition in seconds and

$\dot{q}''_e$ is the imposed radiant heat flux kW/m^2.

For an incident radiant heat flux of 20 kW/m^2 the time to ignition was calculated to be approximately 15.5 minutes.

If T_{fb}<15.5 minutes then CV1 is satisfied and performance requirement CP2 can be considered to have been satisfied together with related performance requirements CP4,CP8 and EP2.2.

If T_{fb}>15.5minutes then CV1 is not satisfied but for this particular example it may be possible to prove compliance with CP2 directly if it can be shown that if the timber facade is ignited, fire spread would be limited to part of the timber facade and not spread to the rest of the building. Since the residential levels are set back 6 m the primary risk would be fire spread to the car park levels which could be addressed by providing fire separation behind the timber facade. During the Fire Engineering Brief process or subsequent stakeholder meetings it would be necessary to gain agreement that some damage to the facade would be acceptable in the unlikely event of a flashover fire developing in an adjacent building.

4 Further Reading and References

Wood Solutions Technical Design Guides

The WoodSolutions technical design guides are available to download 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.

#17 Alternative Solution Fire Compliance, Timber Structures – information about using alternative solutions to allow the use of timber in structural applications not covered by the Deem-to-Satisfy Provisions of the NCC. Includes case study of a five–storey residential apartment (Class 2) building.

#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.

References

1. Building Code of Australia Volume 1 NCC 2012, Australian Building Codes Board
2. England and Eyre. Fire Safety Engineering Design of Combustible Facades – A report from the Alternative solution compliance resource for fire safe timber design project, Project No PNA217-1011 Forest and Wood Products Australia Ltd Melbourne 2011
3. International Fire Engineering Guidelines, 2005, Australian Building Codes Board
4. AS 1530.1 – 1994 Methods for fire tests on building materials, components and structures Part 1: Combustibility test for materials, Standards Australia
5. WoodSolutions Technical Design Guide #2 Timber-framed Construction for Multi-residential Buildings Class 2, 3 & 9c
6. Guide to NCC
7. AS 3959 – 2009 Construction of Buildings in Bushfire-Prone Areas, Standards Australia
8. AS/NZS 3837:1998 Method of test for heat and smoke release rates for materials and products using an oxygen consumption calorimeter, Standards Australia
9. AS ISO 9705 – 2003, Fire tests – Full scale room test for surface products, Standards Australia
10. EN 13822: 2010 Reaction to fire tests for building products – Building products excluding flooring exposed to thermal attack by a single burning item
11. Fire safety in Timber Buildings – Technical Guideline for Europe SP Technical Research Institute of Sweden, Stockholm Sweden 2010
12. Fire safety in Timber Buildings – Technical Guideline for Europe SP Technical Research Institute of Sweden, Stockholm Sweden 2010

13. ISO 13785-2:2002 Reaction-to-fire tests for facades – Part 2: Large-scale test International Standards Organisation 2002
14. England and Eyre. Fire Safety Engineering Design of Combustible Facades – A report from the Alternative solution compliance resource for fire safe timber design project, Project No PNA217-1011 Forest and Wood Products Australia Ltd Melbourne 2011
15. ISO 13785-1:2002 Reaction-to-fire tests for facades – Part 1: Intermediate-scale test. International Standards Organisation 2002
16. England and Eyre. Test Procedure for Combustible Facades – A report from the Alternative solution compliance resource for fire safe timber design project, Project No PNA217-1011 Forest and Wood Products Australia Ltd Melbourne 2011
17. Fire Brigade Intervention Model, Australasian Fire and Emergency Service Authorities Council 2006
18. Richardson and England. The piloted ignition of timbers exposed to radiant heat. Warrington Fire Research 2005.

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 as "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.".

MRTFC

Abbreviation for Multi Residential Timber Frame Construction

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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