Fact Sheet

Fire Performance

Fire resistance requirements in Australia, and how to choose the right EWPAA certified product to comply with the National Construction Code.

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Disclaimer

The advice provided in this publication is general in nature and is intended as a guide only. Whilst the information in this guide was accurate at the time of publication, it is the users' responsibility to confirm alignment with current standards and/or building codes.

You should consult the manufacturer of each product for the latest, most accurate information about the product and its use. You should check with the designer or specifier for the project you are working on to ensure the product and its method of installation are suitable for that project.

We provide this publication to you on condition that, to the maximum extent permitted by law, we will not be liable for any claim you might make for damage arising directly or indirectly from your use of the information in the publication.

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Introduction

The purpose of this fact sheet is to assist in meeting the compliance requirements of the NCC for Building Classes 2 to 9 where plywood is used in applications such as floor linings and coverings and wall and ceiling linings. It further outlines the requirements of the NCC for Building Class 1 and 10 to achieve required fire resistance levels. Details to establish the Fire Resistance Level for structural adequacy i.e. LVL beams are also provided within this fact sheet. The current NCC must be consulted to verify any information provided within this publication.

Three components are required for a fire to occur – fuel, heat and oxygen. Removing any one of these components will prevent fire. This knowledge is essential when considering the prevention and/or containment of fire and can be achieved by removing:

- heat by wetting;
- fuel by eliminating the source;
- oxygen by smothering the fire.

Wood is composed of a mixture of cellulose, hemicellulose, and lignin bound together in a complex network. Heating wood at a temperature of approximately 300°C[1] causes decomposition or pyrolysis converting it to gases, tar and charcoal. At temperatures above 300°C the gases will flame vigorously but the charcoal requires temperatures of about 500°C for its consumption. A build-up of char tends to protect the unburnt wood from rapid pyrolysis. The unburnt timber, being a good insulator, results in the timber close to the char edge being unaffected by the fire. Figure 1 shows a schematic representation of burning wood.

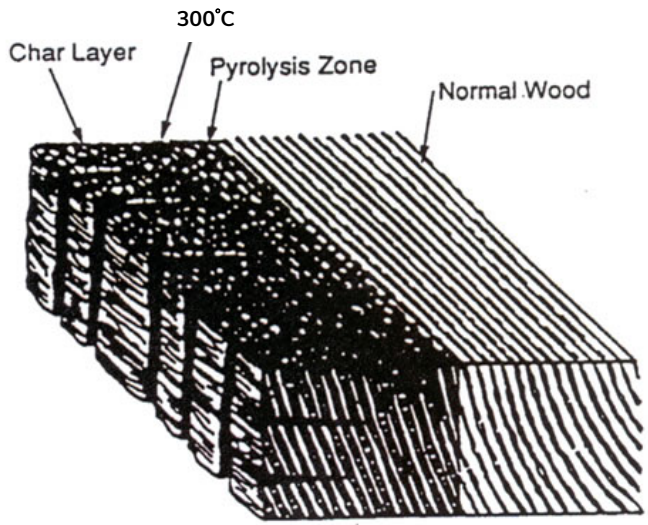


Figure 1: Shows zones of burning wood

[1] http://www.mace.manchester.ac.uk/project/research/structures/strucfire/materialInFire/Timber/default.htm

NCC and Fire Resistance

The National Construction Code (NCC), Volumes One and Two, provide a uniform set of technical provisions for the design and construction of buildings and other structures throughout Australia. The NCC Volume One, Class 2 to Class 9 Buildings includes a section on Fire Resistance, and designers and builders must ensure that their constructions satisfy this section. Fire Resistance refers to the ability of a building component to resist a fully developed fire, while still performing its function.

Complying with the NCC

The NCC documents are written as "Performance" documents. This means that the requirements are stated in terms of performance, and designers and builders must ensure that the performance criteria are achieved. Note that this is very different from "Prescriptive" requirements which state "how" the required performance can be achieved.

Example:

Prescriptive: The beam shall be of timber and 3.5 metres in length

Performance: The beam shall be able to support 1000 kg with no more than 5mm deflection.

In the above, the performance requirement allows for multiple solutions, while the prescriptive requirement only allows for one solution.

NCC Requirements

In order to comply with the NCC Volume One, the following must be satisfied:

1. Comply with the "Deemed to Satisfy" provisions which are sections in the NCC which provide building solutions "deemed to satisfy" the performance criteria.

2. Formulate a performance solution, that
    a. complies with the performance criteria, or
    b. is shown to be at least equivalent to the "Deemed to Satisfy" provisions.

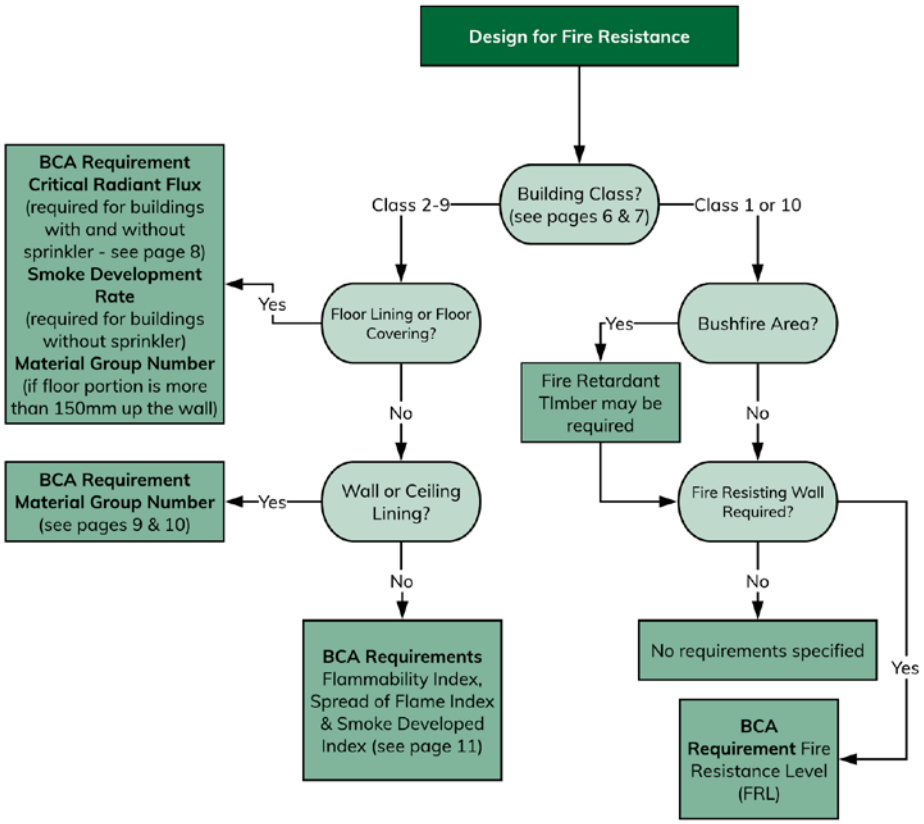
The following lists the relevant sections in the NCC for fire resistance:

Reference	Description
Part A3	NCC Building Classes
Section C	Fire Resistance section of the NCC.
Section C1.0	"Deemed to Satisfy" provisions regarding fire resistance and stability
Section C1.10	"Deemed to Satisfy" provisions for Fire Hazard Properties of materials
Specification C1.10	"Deemed to Satisfy" requirements for linings, materials and assemblies in Class 2 to 9 buildings
Specification C1.10.3 and C1.10.4	"Deemed to Satisfy" requirements for floor linings and floor coverings; and walls and ceiling linings respectively

Designing for Fire Resistance

In order to determine the correct type of plywood for your design / construction project, the following steps provide guidance:

Step 1. Determine the class of building (NCC Vol. One - Part A3, NCC Vol. Two - Part 1.3)
Step 2. Determine which NCC requirement is applicable:
Step 3. Choose plywood that achieves the relevant requirements.



The remainder of this document will guide the reader through the above steps.

Notes

When using this document for guidance, please note the following:

1. The NCC must be consulted to determine all the requirements applicable to your design / construction project.
2. Note that the NCC, clause C1.10(b) states that "Paint or fire-retardant coatings must not be used to achieve compliance with the required fire hazard properties." **However, plywood products that have been impregnated with a fire-retardant under pressure, are acceptable to achieve the required fire hazard properties. NOTE: Appropriate evidence of suitability (e.g. fire test report/assessment) should be sought from the supplier/manufacturer.**
3. Information provided is current at the time of publication. When using the information within this publication it is imperative to consult the relevant standards, NCC and others at all times.

NCC Building Classes

The various classes of buildings are described in the Part A3 of the NCC document, and are reproduced here for convenience:

Class	Definition
Class 1a	A single dwelling being – (i) A detached house; or (ii) One of a group of 2 or more attached dwellings, each being a building, separated by a fire-resisting wall, including a row house, terrace house, town house or villa unit.
Class 1b	(i)A boarding house, guest house, hostel or the like – (a) with a total area of all floors not exceeding 300 m^2 measured over the enclosing walls of the Class 1b; and (b) in which not more than 12 persons would ordinarily be resident; or (ii) 4 or more single dwellings located on one allotment and used for short-term holiday accommodation, which are not located above or below another dwelling or another Class of building other than a private garage.
Class 2	A building containing 2 or more sole-occupancy units each being a separate dwelling.
Class 3	A residential building, other than a building of Class 1 or 2, which is a common place of long term or transient living for a number of unrelated persons, including – (a) a boarding house, guest house, hostel, lodging house or backpacker's accommodation; or (b) a residential part of a hotel or motel; or (c) a residential part of a school; or (d) accommodation for the aged, children or people with disabilities; or (e) a residential part of a health-care building which accommodates members of staff; or (f) a residential part of a detention centre.
Class 4	A dwelling in a building that is Class 5, 6, 7, 8 or 9 if it is the only dwelling in the building.
Class 5	An office building used for professional or commercial purposes, excluding buildings of Class 6, 7, 8 or 9.
Class 6	A shop or other building for the sale of goods by retail or the supply of services direct to the public, including – (a) an eating room, café, restaurant, milk or soft-drink bar; or (b) a dining room, bar area that is not an assembly building, shop or kiosk part of a hotel

Class	Definition
	or motel; or (c) a hairdresser's or barber's shop, public laundry, or undertaker's establishment; or (d) market or sale room, showroom or service station.
Class 7a	A building which is a carpark.
Class 7b	A building which is for storage or display of goods or produce for sale by wholesale.
Class 8	A laboratory or a building in which a handicraft or process for the production, assembling, altering, repairing, packing, finishing, or cleaning of goods or produce is carried on for trade, sale or gain.
Class 9a	A health care building, including those parts of a building set aside as a laboratory.
Class 9b	An assembly building, including a trade workshop, laboratory or the like in a primary or secondary school, but excluding any other parts of the building that are of another Class.
Class 9c	An aged care building.
Class 10a	A non-habitable building being a private garage, carport, shed, or the like.
Class 10b	A structure being a fence, mast, antenna, retaining or free-standing wall, swimming pool, or the like.
Class 10c	A private bushfire shelter.

Class 2 – 9 Properties of Floor Linings and Coverings

Specification C1.10 of the NCC states that a floor lining or floor covering must have:

- A **Critical Radiant Flux (CRF)** not less than that listed in the table below; and
- A maximum **Smoke Development Rate** of 750 percent-minutes, if the building is not protected by a sprinkler system complying with Specification E1.5 of the NCC; and
- A group number (compliant with Clause 6 b of the NCC) for any portion of the floor covering that is continued more than 150mm up the wall.

NOTE: If there are any Table discrepancies, the NCC takes precedence.

Class of Building	General		Fire-isolated exits and fire control rooms
	Building not fitted with a sprinkler system complying with Specification E1.5	Building fitted with a sprinkler system complying with Specification E1.5	
Class 2, 3, 5, 6, 7, 8 or 9b Excluding Class 3 accommodation for the aged and Class 9b as specified below	2.2	1.2	2.2
Class 3 Accommodation for the aged	4.5	2.2	4.5
Class 9a Patient care areas Areas other than patient care areas	4.5 2.2	2.2 1.2	4.5 4.5
Class 9b auditorium or audience seating area used mainly for: Indoor swimming or ice-skating Other sports or multi-purpose functions	1.2 2.2	1.2 1.2	2.2 2.2
Class 9c Resident use areas Areas other than resident use areas	- -	2.2 1.2	4.5 4.5

Table 1: Critical Radiant Flux (CRF in kW/m^2) of Floor Materials and Floor Coverings

For a technical explanation of Critical Radiant Flux, see below.

Critical Radiant Flux

The Critical Radiant Flux (CRF) test measures the radiant energy required to just sustain burning. It is used in Australia, and in some parts of both the USA and Europe, to regulate floor coverings.

The test involves the product being held horizontally under the influence of a radiant heat source at one end. It is ignited at that end and the radiant heat flux at the point at which combustion ceases is determined. This is the Critical Radiant Flux.

During the test the floor covering is allowed to burn under the influence of the radiant heat source. There is just sufficient air movement in the test chamber to remove the products of combustion into the flue.

Data on Critical Radiant Flux testing for floor materials and coverings is published by Forest and Wood Products Australia (FWPA) – refer to WoodSolutions.com.au (fire test reports) or EWPAA for the latest report.

Regulatory Information Report RIR21419-03 Assessment of the critical radiant flux (CRF) performance of solid timber (minimum thickness 12mm) and plywood (minimum thickness 15mm) when tested in accordance with AS/ISO 9239.1-2003 includes CRF (kW/m^2) and Smoke Development Rate (%-Mins) for plywood species Radiata Pine, Hoop Pine and Slash Pine with and without substrate. Please refer to the report for details and conditions of use.

Note that when plywood flooring is used, the construction and material must meet conditions as outlined in the test report

Class 2 – 9 Properties of Wall and Ceiling Linings

In order to design wall or ceiling linings, the Material Group number applicable to the design / construction must be determined, and then a product with that material group number is selected.

Group 1 materials are suitable for the most stringent fire hazard requirements whilst Group 4 do not meet the requirements for lining materials for walls and ceilings in a Class 2-9 building.

Material Group Numbers

Material Group Number	Description
Group 1	Materials that do not reach flashover when exposed to 100kW for 600 seconds followed by exposure to 300kW for 600 seconds.
Group 2	Materials that do reach flashover following exposure to 300kW within600 seconds, after not reaching flashover when exposed to 100kW for 600 seconds.
Group 3	Materials that reach flashover in more than 120 seconds but within 600 seconds after exposure to 100kW.
Group 4	Materials that reach flashover within 120 seconds after exposure to 100kW.

Data on Material Group testing for wall and ceiling lining is published by Forest and Wood Products Australia (FWPA) – refer to WoodSolutions.com.au (fire test reports) or EWPAA for the latest report.

Test reports include the assessment i.e. Group Number and Average Specific Extinction Area of various plywood species (see below) with a minimum thickness of 9mm for use as a wall and ceiling lining. Plywood species listed in the report include;

Species Name	Material Group Number
Ash, Alpine – Eucalyptus delegatensis	3
Ash, Mountain – Eucalyptus regnans	3
Blackbutt – Eucalyptus pilularis	3
Gum, Blue Southern (TAS) - Eucalyptus globulus	3
Gum, Blue Southern (VIC) – Eucalyptus globulus	3
Gum, Blue, Sydney – Eucalyptus saligna	3
Gum, Rose – Eucalyptus grandis	3
Gum Shining – Eucalyptus nitens	3
Rosewood, Papua New Guinea – Pterocarpus indicus	3
Gum, Spotted – Corymbia maculata	3
Ironbark, Grey – Eucalyptus drepanophylla	3
Ironbark, Red – Eucalyptus sideroxylon	3
Jarrah – Eucalyptus marginata	3
Karri – Eucalyptus diversicolor	3
Messmate – Eucalyptus obliqua	3
Pine, Hoop – Araucaria cunninghamii	3
Pine Radiata – Pinus radiata	3
Gum, Spotted – Corymbia maculata	3

Regulatory Information Report RIR45981.8 Assessment of Plywood for use as a wall and ceiling lining with respect to the Building Code of Australia NCC 2015 Volume 1 Specification C1.10 includes Material Group Numbers and Average Specific Extinction Area (m^2/kg) for plywood species Radiata Pine, Hoop Pine and others. The material used must meet conditions as outlined in the test report. Please refer to the latest test reports to ensure the use of the most current information.

Specification 1.10, Table 3 of the NCC provides the Deemed-to-Satisfy Provisions for wall and ceiling lining materials, in terms of Material Group Numbers, for both sprinklered and unsprinklered buildings (compliant with NCC Specification E1.5), and is reproduced here for convenience:

NOTE: If there are any Table discrepancies, the NCC takes precedence.

Class of Building	Fire-isolated exits and fire control rooms Wall/ceiling	Public corridors		Specific Areas		Other areas Wall/ceiling
		Wall	Ceiling	Wall	Ceiling	
Class 2 or 3, Excluding accommodation for the aged, people with disabilities, and children						
Unsprinklered	1	1, 2	1, 2	1, 2, 3	1, 2, 3	1, 2, 3
Sprinklered	1	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3
Class 3 or 9a, Accommodation for the aged, people with disability, children and health-care buildings						
Unsprinklered	1	1	1	1, 2	1, 2	1, 2, 3
Sprinklered	1	1, 2	1, 2	1, 2, 3	1, 2, 3	1, 2, 3
Class 5, 6, 7, 8 or 9b schools						
Unsprinklered	1	1, 2	1, 2	1, 2, 3	1, 2	1, 2, 3
Sprinklered	1	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3	1, 2, 3
Class 9b other than schools						
Unsprinklered	1	1	1	1, 2	1, 2	1, 2, 3
Sprinklered	1	1, 2	1, 2	1, 2, 3	1,2, 3	1, 2, 3
Class 9c						
Sprinklered	1	1, 2	1, 2	1, 2, 3	1, 2, 3	1, 2, 3

For the purpose of this Table:

1. "Sprinklered" means a building fitted with a sprinkler system complying with Specification E1.5.
2. "Specific areas" means within:

(a) for Class 2 and 3 buildings, a *sole-occupancy unit.*
(b) for Class 5 buildings, open plan offices with a minimum floor dimension/floor to ceiling height ratio greater than 5.
(c) for Class 6 buildings, shops or other building with a minimum floor dimension/floor to ceiling height ratio greater than 5.
(d) for Class 9a *health-care buildings, patient care areas.*
(e) for Class 9b *theatres and halls, etc. an auditorium.*
(f) for Class 9b *schools, a classroom*
(g) for Class 9c aged care buildings, resident use areas.

NCC Specification C1.10, Table 3: Wall and Ceiling Lining Materials (Material Groups permitted)

Class 2 – 9 Properties of Other Materials

Specification C1.10, Clause 7 and Table 4 of the NCC states that for other materials and assemblies (excluding floor linings and floor coverings, wall and ceiling linings as previously described in this document) used in Class 2 to Class 9 buildings must have a:

- **Spread-of-Flame Index** of not more than 9; and
- **Smoke-Developed Index** of not more than 8, if the **Spread-of-Flame Index** is more than 5.

Spread-of-Flame Index

The scale of the Spread-of-Flame index is based on studies of actual rates of spread of flame on various wall-lining materials. Where the walls of rooms with 2.75m ceiling height were lined with materials with high spread of flame indices, flames rapidly spread up the wall and, by igniting combustible gases that had accumulated below the ceiling, rapidly involved the whole room in fire. An index of 10 indicates, from the original corner-burn experiments, that the material could be expected to cause flames to reach the ceiling of such a room within 10s of ignition; an index of zero means that the materials will not cause flames to reach the ceiling.

Smoke-Developed Index

The Smoke-Developed index relates to the optical density of smoke produced under the conditions of the standard test. Doubling of the optical density of the smoke increases the smoke developed index by unity. The higher the index, the greater the hazard is likely to be from smoke.

Specific species information can be found in AS 1684.2 Appendix G.

Class 1 and 10 Properties

Class 1 buildings are generally residential dwellings, and Class 10 buildings are structures such as carports and other non-inhabited buildings that usually accompany a residential type house.

External Walls

Section 3.7.1 from the NCC Volume Two states that external walls that are required to be fire-resisting, must have a Fire Resistance Level (FRL) of not less than 60/60/60. Walls that are less than the requirements below are required to be fire-resisting:

(a) 900mm from an allotment boundary other than the boundary adjoining a road alignment or other public space; or

(b) 1.8m from another building on the same allotment other than an appurtenant Class 10 building or a detached part of the same Class 1 building.

For details on FRL's, see the **Fire Resistance Level** section.

Walls other than those nominated above do not have to be fire-resisting. This means that plywood and LVL may be used anywhere on the external wall of a residential dwelling that is not required to be fire-resisting. On walls that are required to be fire resisting, plywood on its own cannot achieve a FRL of 60/60/60 but can be used in conjunction with a fire-protective grade lining (e.g. plasterboard) to achieve this FRL – refer fire-protective grade lining manufacturer's system recommendations.

Bushfire-prone Areas

For construction in bushfire-prone areas, the NCC Volume One, Part G5 requires that a Class 2 or 3 building; or a Class 10a building or deck associated with a Class 2 or 3 building be constructed to reduce the risk of ignition from burning embers, radiant heat or flame generated by a bushfire. NOTE: There are also some Australian state variations in the NCC that must be complied with.

Part 3.7.4 of the NCC Volume Two specifies the requirements for Class 1 buildings or a Class 10a or deck associated with a Class 1 building situated in designated bushfire-prone areas.

How do you determine the Bushfire Attack Level?

The determination of the bushfire attack level (BAL) must be in accordance with the Australian Standard AS 3959 "Construction of Buildings in Bushfire-prone Areas". Issues such as distance from vegetation, type of vegetation and slope of the land must be taken into account. AS 3959 also provides the procedure for calculating the bushfire attack level, depending on a fire danger index applicable to the Australian State the building will be situated in. Designers should contact their local government authority or building surveyor/certifier to seek guidance in determining the required BAL.

Note that these requirements are **in addition** to all other requirements that would typically apply to construction in non-bushfire-prone areas.

Fire Resistance Levels

Fire Resistance is the ability of a building component to resist a fully developed fire, while still performing its structural function. Fire resistance levels (FRL) are assigned performance criteria, in minutes, for structural adequacy, integrity and insulation. This important parameter is defined by three numbers, e.g. 60/60/60 for which the:

- first number relates to structural adequacy;
- second number to integrity;
- third number to insulation value.

Plywood is quite acceptable as a material used as part of a fire resisting system provided it is combined with other materials so as to meet the fire-resisting requirements. This can be achieved by combining plywood with materials deemed non-combustible such as fibre cement or fire-protective grade plasterboard. The FRL rating is evaluated in a Standard Fire Test as specified in AS 1530.4.

The structural fire resistance level (e.g. 60/–/–) of LVL beam or column components can be calculated in accordance with AS 1720.4 Timber Structures – Fire resistance for structural adequacy of timber members. When establishing the FRL of structural untreated wood and wood-based products, the charring rate at the surface is very important. As described in the introduction charring produces a protective layer which protects the timber. The unburnt timber can then be used in calculations to determine the structural integrity of the loadbearing member.

For an example on how to calculate an FRL, see below.

Steps in establishing the Fire Resistance Level (structural adequacy)

After a protective layer of char has developed the char rate slows considerably. The charring rate of dry wood has been shown to continue for several hours at a reasonably constant rate given in AS1720.4 by:

$$c = \frac{dh}{dt} = 0.4 + (280/\delta)^2$$

where:

$c = \frac{dh}{dt}$ = notional charring rate (mm/minute);

δ = timber density (kg/m^3) at a moisture content of 12%.

The charring rate of a typical softwood having a density of 550kg/m^3 is 0.66mm/minute. During a fire a realistic assessment of structural response can be made by neglecting 7.5mm of unburnt wood and assuming the remainder retains its full strength and stiffness.

The effective depth of charring (d_c) for each exposed surface after a period of time (t) is given by:

$$d_c = ct + 7.5$$

where:

d_c = calculated effective depth of charring (mm);

c = notional charring rate;

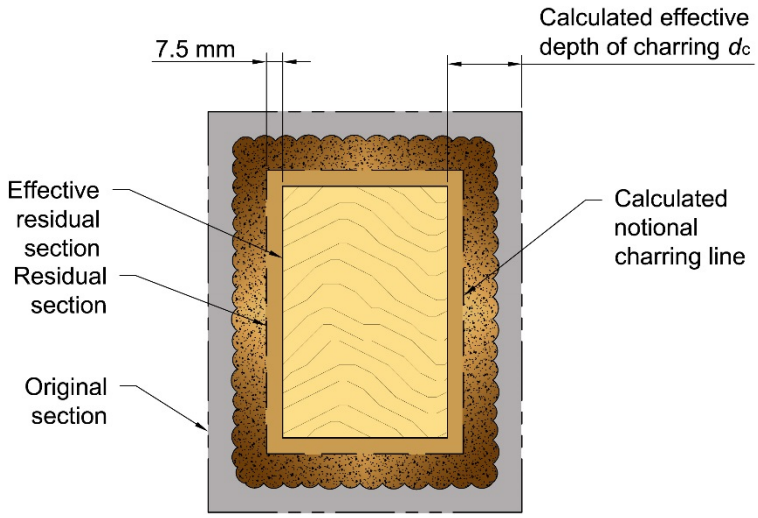
t = period of time (minutes)

NOTE: t can be taken as either the:

(a) time taken for the FRL to be achieved;

(b) fire resistance period determined by a series of successive iterations.

The effective residual section is determined by subtracting d_c from all fire-exposed surfaces of the timber member as shown below:



Designing for fire-resistance

For the typical softwood example above, a designer can calculate the additional timber thickness required for a timber post to achieve a structural adequacy fire-resistance level (FRL) 60/-/- using the following approach:

Required FRL (structural adequacy): 60/-/-

Calculate effective depth of charring (mm): $d_c = ct + 7.5$

$= 0.66 \times 60 + 7.5$

$= 47.1$ mm

Therefore, an additional protective timber layer of at least 47.1 mm would be required on each exposed face of the timber post to achieve the required FRL (structural adequacy) of 60/-/-.

If a 90 x 90 mm structural softwood post was required to support the design load, then a minimum 184.2 (i.e. 47.1 + 90 + 47.1) x 184.2 mm structural post would be required if the post is exposed on all sides. Glued-laminated timber products that are fabricated with phenol, resorcinol, phenol-resorcinol or poly-phenolic glues can be used.

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