Fire Engineering, the BCA (NCC) & Bushfire Calculator

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Presentation Topics

- Current Building Code (fire safety) design process
- Prescriptive versus performance based solution approach
- How existing prescriptive approach limits the use of timber construction
- MRTFC Guidelines
- Research & Testing
- The Way forward
- Conclusions on BCA
- Bushfire Calculator

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Building Code of Australia

- The use of timber in construction controlled by the requirements of the BCA now called the National Construction Code (NCC)
- This presentation considers NCC Volume 1 (Class 2 to Class 9 buildings)

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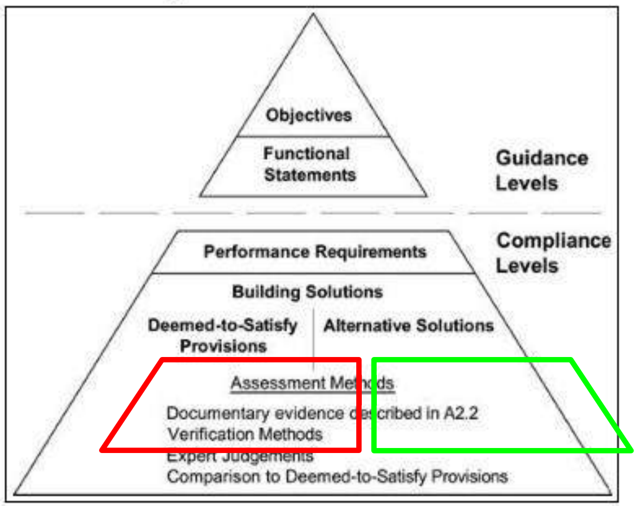
Building Code of Australia

Figure A0.3 — BCA Structure



<u>Alternative Solution</u>

Fire Safety Engineering allows for innovative design solutions that are not considered in the BCA DtS provisions

<u>Deemed-to-Satisfy Solution</u>

Generally limits the use of timber in construction and doesn't consider novel design solutions or restoration of heritage projects

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Prescriptive Requirements (DtS)

- Clause A0.4 – Compliance with the BCA

  The BCA provides prescriptive (DtS) limitations of the use of timber, but also allows for ‘Alternative Solutions
- In the BCA, the use of timber has prescriptive limitations for:
  - Internal wall & ceiling linings; and
  - Structural elements; and
  - External facades & roofs
- The limitations are a function of the building’s:
  - Occupancy group (i.e. assumed fire risk)
  - Compartment area / volume (i.e. assumed fuel load)
  - Height above ground (i.e. ease of access or egress)
- The limitations are based upon risk principles – but cannot cover *all* building design solutions!

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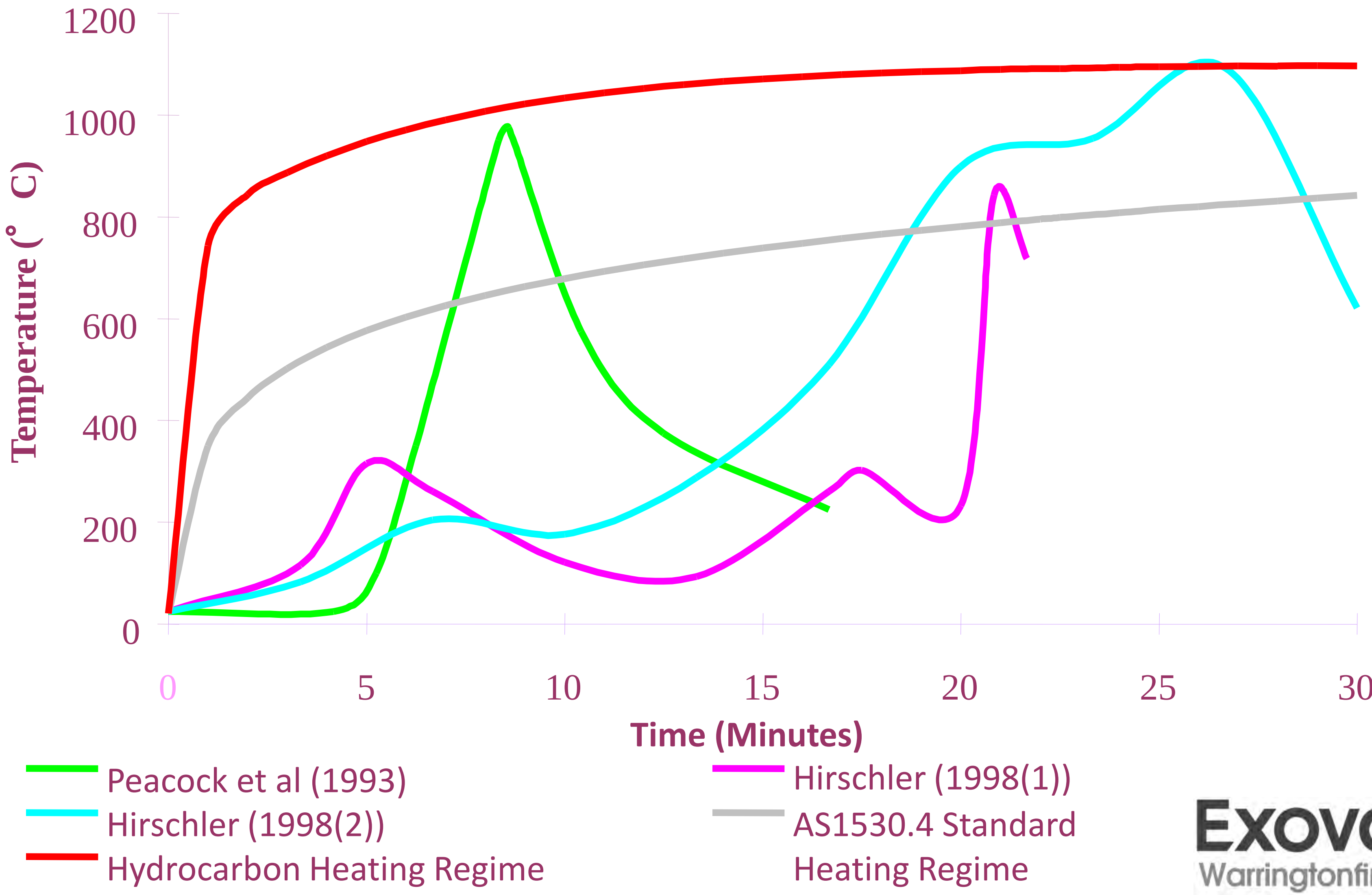
Prescriptive Approach

Prescriptive limitations within the BCA that may preclude the use of timber include:

- Fire Hazard Properties of any material of assembly used in a building (derived from fire testing)
- Fire Resistance Levels (FRL) of building elements (derived from fire testing, or empirical calculation)
- Whether 'combustible' or 'non-combustible' materials are allowed to be used (derived from fire testing)

Heating Regimes and Real Fires



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Prescriptive Provisions not allowing timber

- BCA C2.6 Spandrel Protection
- BCA C3.13 Openings in shafts Type A construction

  if it is in a sanitary compartment — a door or panel which, together with its frame, is non-combustible or has an FRL of not less than –/30/30; or
- Specification C1.1, Clause 2.5 General concessions

  (d) Curtain walls and panel walls — A requirement for an external wall to have an FRL does not apply to a curtain wall or panel wall which is of non-combustible construction
- Specification C1.1, Clause 3.1 Fire-resistance of building elements

  (d) a load bearing internal wall and a load bearing fire wall (including those that are part of a load bearing shaft) must be of concrete or masonry;

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Prescriptive Approach

- Therefore timber clad and timber framed buildings (with some concessions) are not permitted under the prescriptive DtS provisions
- Performance based - Fire Engineering is required for timber to be used in these applications

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RECENT RESEARCH:

MULTI-RESIDENTIAL TIMBER FRAMED CONSTRUCTION (MRTFC) CONCESSION

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Overview of Current Regulatory Situation

- Multi residential timber framed construction are Class 2 or Class 3 buildings can be built using timber framing.
- Two clauses in Specification C1.1 allow MRTFC for Class 2, 3 buildings :
  - Specification C1.1 Clause 3.10 (Type A) – up to 3 storeys
  - Specification C1.1 Clause 4.3   (Type B) – up to 2 storeys
  - These clauses specifically allow timber framing.
- Class 2 buildings are apartments etc. and Class 3 buildings are other residential use building like hotels and hostels.

Timber Framing & Fire Load

- The fire load from timber studs will not be involved in the early stages of the fire.
- Once the timber heats up, either via conduction through the plasterboard or via the plasterboard losing integrity, the volatiles may contribute to the fire.
- This delays the involvement of the timber in the fire. In a small fire the timber may not be involved or exposed at all.

Previous Work – Current Concession

- Current concession for Class 2 and 3 was a result of work commissioned by National Association of Forest Industries (funded by Forest & Wood Products Research & Development Corporation).
- The results compared “expected risk to life” of different construction models.
- The results showed that with a fire alarm system a timber framed building would be safer than a similar concrete building without a fire alarm.

Previous Work – 2002 VUT Report

- Victoria University of Technology investigated extending the concession to Class 3 buildings in 2002.
- The timber framing was modelled as an increase in fire load
- The results showed that an increased fire load increased the risk to occupants not in the apartment of fire origin.

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Previous Work – 2002 VUT Report

- The results found no risk increase for occupants in the apartment of fire origin.
- The work did not assess whether timber framing contributes to the fire load.
- The work did not assess how the timber framing may interact with a compartment fire, i.e. Should it be treated as a normal fire load? (remember the timber is protected).

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Testing Used to Support the Concession

- Two rooms were constructed:
  - One DtS non-combustible construction.
  - One MRTFC timber framed construction.
  - A large fire load (~40kg/m^2) consisting of timber cribs will be placed in each room.
- A corridor was attached with a fire door separating the fire room and corridor, measurements of temperatures in the corridor will be taken
- Rooms were constructed to full scale (4m x 4m x 2.4m).

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Smoke Seals - Fire Doors

- It was expected the timber framing would have a small contribution to fire severity and therefore a small increase in risk is possible – we needed a contingency
- The previous concession allows timber frames if a smoke detection system is installed
- Smoke detection system already required for Class 3 buildings, therefore we are looking at fire doors with smoke seals
- We expect a timber framed building fitted with a fire doors with smoke seals to be safer than a DtS building fitted with fire doors.

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Outcomes of Testing

- The research and experiment supported extending the concession to allow low rise Class 3 buildings to be built using MRTFC methods.
- A Proposal for Change was submitted to the ABCB by FWPA using the testing to support the change.
- As of 1 May 2014, timber framed construction is deemed-to-satisfy the BCA up to three stories in height.

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COMBUSTIBLE CLADDING ON COMMERCIAL BUILDINGS

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Introduction

- Combustible cladding is regulated in the BCA to reduce the chance of fire spread
- Fire can spread via a number of ways (Fire Code Reform Centre Report 2):
  - Window to window – "leapfrogging",
  - Via floor to exterior wall junctions,
  - Fire stopping may melt and become ineffective and allow fire spread,
  - Direct contribution from facade causing vertical fire spread (and spreading through upper level windows).

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Methodology

- Our research investigated fire spread involving combustible cladding under the following conditions:
  - Radiation from adjacent building,
  - External wall fire,
  - Flames projecting from a window opening.
- Intermediate scale tests and full scale tests were designed to investigate these mechanisms.

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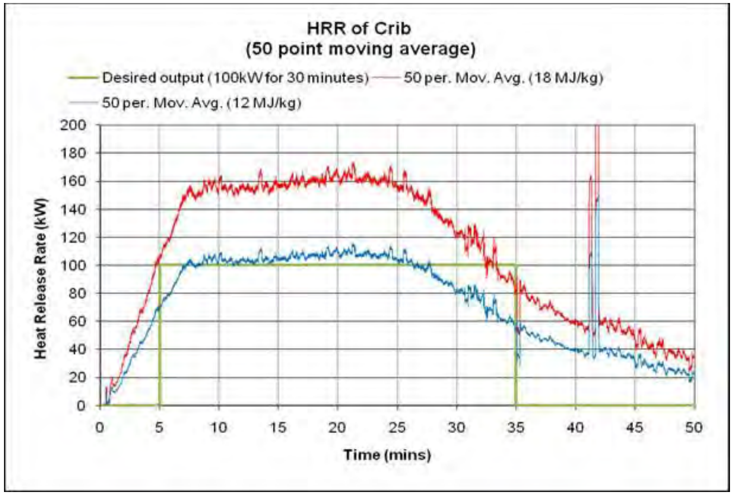
Methodology

- Intermediate scale tests
  - Based on ISO 13685 part 1.
  - Modified to use a timber crib in lieu of gas burner.
    - Timber crib simulates an external fire, for example a rubbish bin which has caught fire.
  - Modified to allow a background radiation to be imposed.
    - BCA CV1/CV2 nominates that a building must be able to withstand a certain amount of radiation if the building is close to a boundary. The amount varies by distance from boundary.
  - Acts as a screening test for the full scale tests.

Methodology

- Custom designed crib
- The predicted heat release rate is between the blue and red lines on the graph below.



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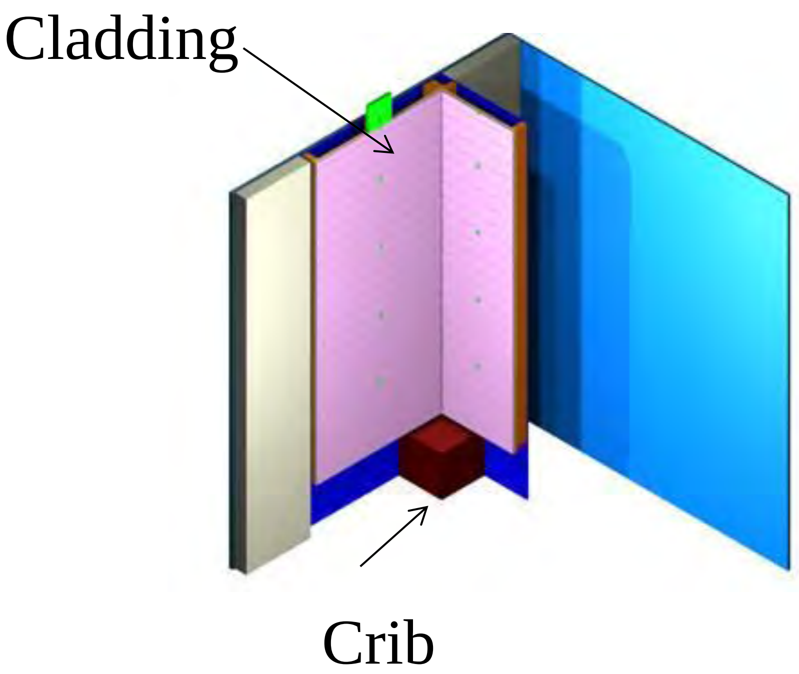
Methodology

- Intermediate scale test diagram
  - Radiant panel not shown



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Methodology

- Full scale tests
  - Based on ISO 13685 part 2.
  - Comprised a burn room and a facade.
    - The burn room was also be used in the MRTFC project.
  - The fire load was been increased from the specified load in ISO13685-2.
  - The facade was about 6 metres tall.
  - Temperature and heat flux measurements were taken at various locations on the facade.
  - Two tests will be conducted, one using a non-combustible facade and one using a timber cladding chosen after the intermediate scale tests.

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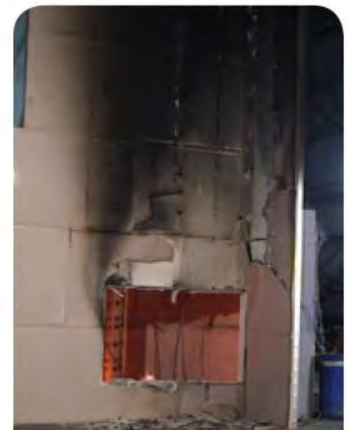
Some Results of Testing

2 mins
Growth Phase

15 mins
Fully developed ventilation controlled phase

35 mins
Transition to fuel controlled phase



50 mins
Decay

Results

- The project resulted in the development of a WoodSolutions design guide (#18) which includes a worked example detailing the results of our experiments and how the data can be applied to fire engineered solutions.
- This will aid fire engineers in using combustible cladding as an "Alternative solution" and increase combustible claddings acceptance in the industry.

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Results

- Two further WoodSolutions design guides were produced to enable an Alternative Solutions to be prepared by design professionals for Timber Structures (#17) and Internal Linings (#19)

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Design Options

- To allow the use of timber in non-DtS design options, a performance based approach may be suitable
- The selected design solution needs to satisfy:
    - BCA objectives
    - Functional Statements
    - Performance Requirements
- Early consideration of fire engineering design principles can allow for greater design flexibility

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Performance Based Approach

- BCA Objectives & Functional Statements
  - Provide guidance for alternative design solutions

SECTION C FIRE RESISTANCE

OBJECTIVE

CO1

The Objective of this Section is to—

(a) safeguard people from illness or injury due to a fire in a building; and

(b) safeguard occupants from illness or injury while evacuating a building during a fire; and

(c) facilitate the activities of emergency services personnel; and

(d) avoid the spread of fire between buildings; and

(e) protect other property from physical damage caused by structural failure of a building as a result of fire.

FUNCTIONAL STATEMENTS

CF1

A building is to be constructed to maintain structural stability during fire to—

(a) allow occupants time to evacuate safely; and

(b) allow for fire brigade intervention; and

(c) avoid damage to other property.

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Performance Based Approach

- BCA Performance Requirements
  - Specific requirements for compliance levels
  - All relevant aspects must be satisfied

PERFORMANCE REQUIREMENTS

CP1

CP1 amended by Amdt No. 5

A building must have elements which will, to the degree necessary, maintain structural stability during a fire appropriate to—

(a) the function or use of the building; and

(b) the fire load; and

(c) the potential fire intensity; and

(d) the fire hazard; and

(e) the height of the building; and

(f) its proximity to other prop

(g) any active fire safety sys

(h) the size of any fire comp

(i) fire brigade intervention; a

(j) other elements they supp

(k) the evacuation time.

CP2

CP2 amended by Amdt No. 11

(a) A building must have elements which will, to the degree necessary, avoid the spread of fire—

(i) to exits; and

(ii) to sole-occupancy units and public corridors; and

> **Application:**
>
> CP2(a)(ii) only applies to a Class 2 or 3 building or Class 4 part.

(iii) between buildings; and

(iv) in a building.

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Performance Based Approach

Fire Engineering Brief (FEB)

- Non DtS compliant Items to be addressed
- Relevant performance criteria to be addressed
- Type of analysis to be undertaken
- Fire scenarios and sizes
- Methodology of analysis
- Analysis tools and their justification
- Factors of safety
- Trial concept design

FEB to be agreed by stakeholders

Use of International Fire Engineering Guidelines

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Fire Engineering Report

- Analysis of agreed scenarios
- Report detailing results and recommendations given the results of the analysis
- Report included as part of overall building occupancy certificate

Performance Based Design using timber

Areas to assessed as part of any alternative design Incorporating the use of timber include

- Structural Failure
- Fire spread through surface
- Fire spread across surface
- Contribution to fuel load (only when available)
- Fire combustion gas production (smoke and other species
- These risks are the same if a non timber or composite material was to be selected

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Management of the identified risks

- Limit fuel load, ignition sources and interactions.
- Protection of elements using other elements (encapusulation) as a system
- Protection of elements using other fire systems (active protection, e.g. sprinklers) as a strategy

Protection through encapsulation is already accepted in the BCA for steel columns in Specification A2.3 Clause 5 – however, no such allowance is made for other materials

Performance Based Alternate Solution Timber's behaviour in fire

- Can be considered as:
  - Early fire hazard (pre-flashover)
  - Structural response (post-flashover)
- Early fire hazards include:
  - ignitability, heat release rate, release of toxic gases –
  - These are important during evacuation within the fire compartment
- Structural response:
  - How long the timber remains useful in terms of FRL minutes (load-bearing capacity/integrity/insulation)
  - Considered important for protecting escape routes away from the fire, property protection and fire brigade intervention

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Timber's behaviour in fire

- Ignition:
  - Largely a function of surface area-volume ratio
  - Solid timber – charring with piloted ignition occurs 300°C to 365°C
  - Charring rate depends upon species, density, moisture content, etc
  - Particleboard have similar ignition properties to solid wood
- Fire properties can be modified by:
  - Surface treatments
  - Impregnation with inorganic salts
  - *Ignitability & burning rate can me modified – but wood remains combustible*
- Additional protection can be provided by:
  - Timber panelling
  - Mineral board
  - Rock fibre insulation
  - Intumescent paint, etc.

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Fire Testing of Timber

- Fire Testing can be used to Validate:
  - Timber Fire Hazard Properties (AS1530.3 AS/ISO 9705 AS3837)
  - Fire Resistance of Wall and floor systems with exposed or embedded timber elements (AS1530.4)
- Fire Hazard Properties:
  - The fire hazard properties of timber improve with density, treatment and thickness
  - The fire resistance properties of timber improve with density and thickness, and less related to treatment.

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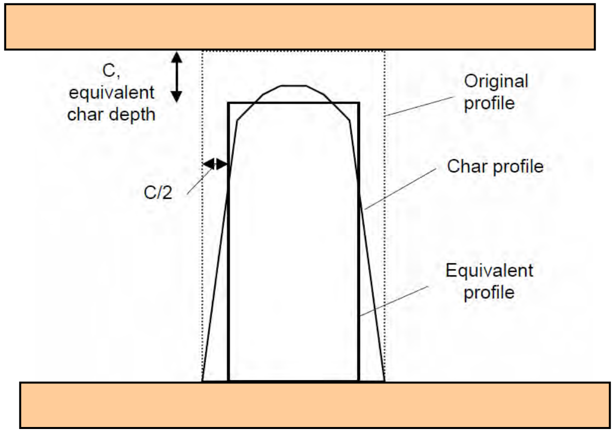
Fire Resistance Testing of Timber

- Testing of Embedded or Protected Timber Elements:
  - Timber char is small for period of structural adequacy
  - Embedded timber adds little to fire load in building for the FRL period

Fire



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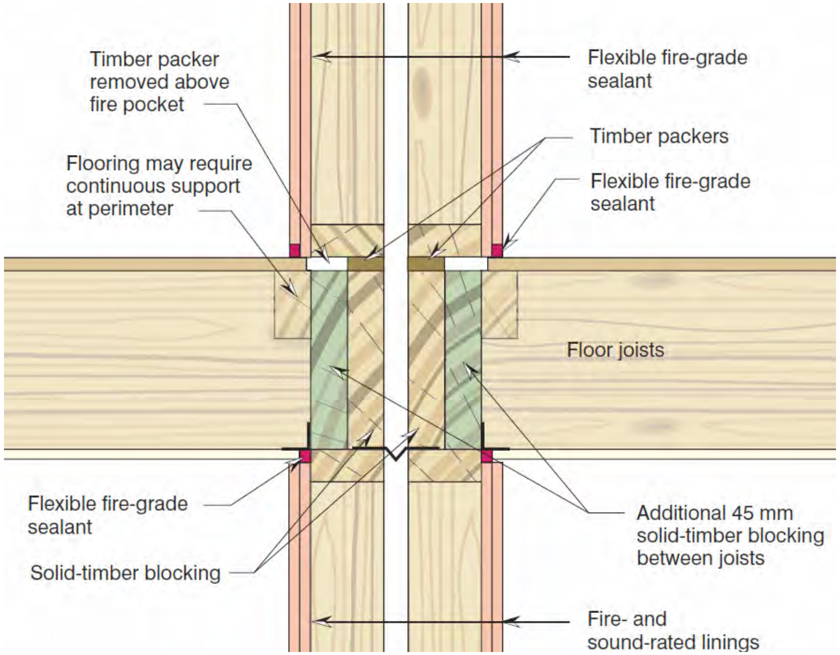
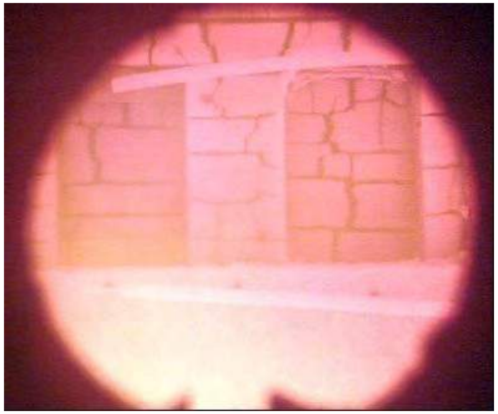
Fire Resistance Testing of Timber

- Testing of Exposed Timber Elements:
  - Testing can validate timber as a barrier where the linings are discontinuous such as floor ceiling junctions.





Joist Pocket (without Joist), after 20 minutes exposure

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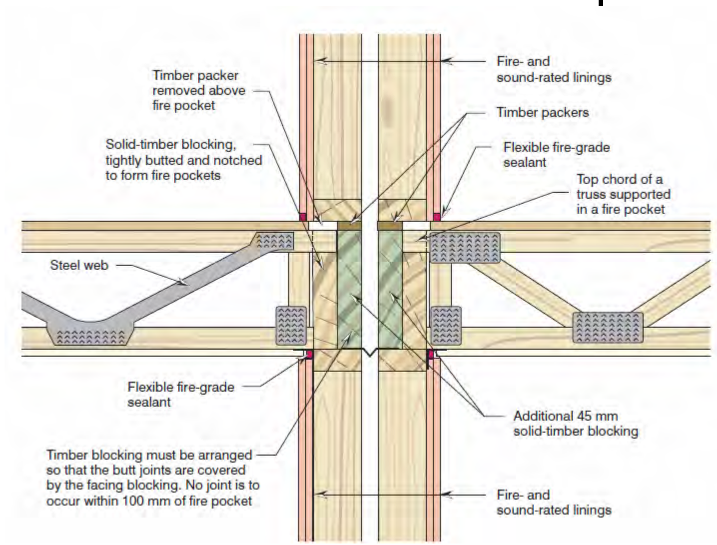
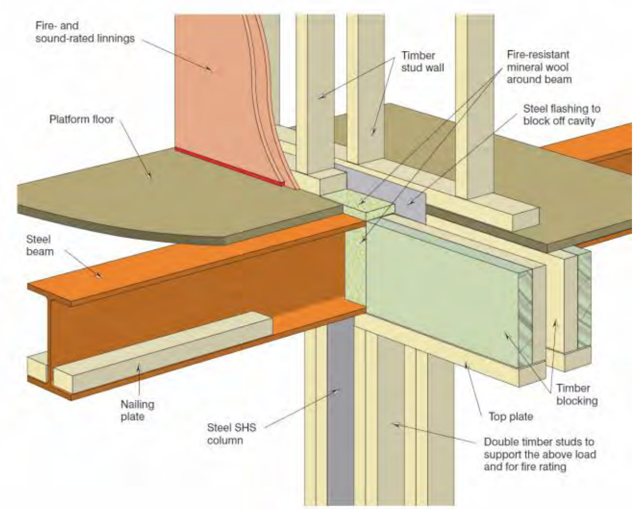
Fire Resistance Testing of Timber

- Testing Enabled
  - Traditional and practical construction methods could be retained.
  - Wall floor and beam pocket details to be designed for fire resistance without protective with linings





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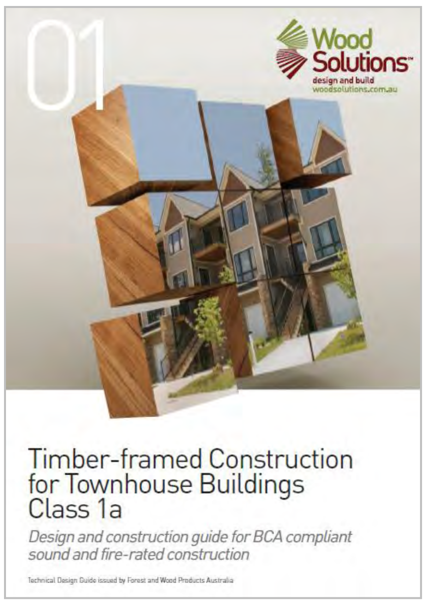
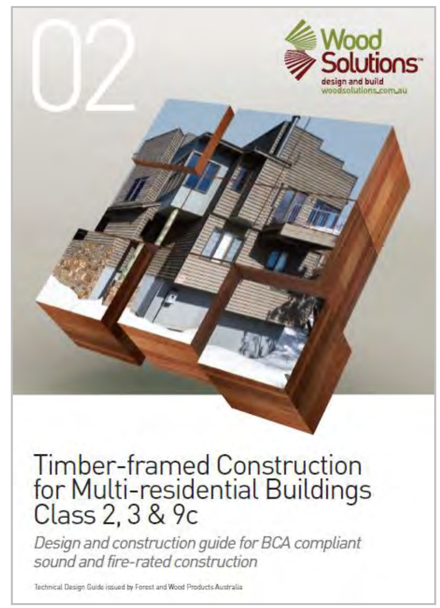
WoodSolutions technical design guides make use of test based solutions from Exova Warringtonfire





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Reinstatement of fire damaged timber frame building

Test re reinstatement of fire damaged timber framed buildings

Undertaken by Chiltern International circa 2000

Figure 1:
The six storey TF2000 building nearing completion situated inside Hangar No. 2 BRE Cardington.

Living room window of fire compartment

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Reinstatement of fire damaged timber frame building

This research project has concluded that reinstating timber frame dwellings is more cost effective than reinstating fire damaged dwellings constructed from other traditional materials such as masonry, steel and concrete.

Figure 3:
Front elevation of the TF2000 building. Flames can be seen emanating from the living room window of the fire flat.

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Going Forward BCA?

- Modifications of prescriptive provisions for material selection, favouring a performance verification based approach (Verification Methods).
- Allow increase use of timber and other materials in construction, when appropriate and verified through Fire engineering, performance verification to AS1530.4 and/or ISO9705 or other testing as appropriate for building element and the fire safety strategy

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Conclusions BCA

- Timber is a combustible material and is still currently prohibited under DtS provisions for some building uses
- DtS provisions also restrict the use of timber in restoration & recycling of existing buildings – which can affect heritage preservation and reduce ability of designers for innovation
- Future research may provide increased scope in use of timber for external cladding and facades
- Fire Engineering design can allow the timber use as part of holistic building design solution by addressing the BCA's objectives.

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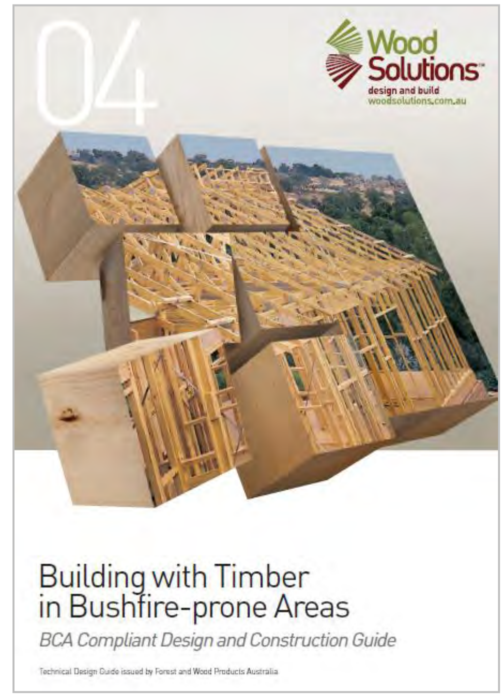
Conclusions BCA

- Many successful and innovative designs have been undertaken using timber in Australia, NZ, USA, Canada and UK
- Ignitability of timber can be improved by:
  - Reducing exposure to fire by enclosure, lining, etc
  - Fire retardant treatment
  - Increasing Timber Density
- FRL of timber can be improved by:
  - Providing sacrificial timber
  - Protecting the timber from exposure
  - Innovative design of junctions that allow for char

Other Fire Related WoodSolutions Tools

- Technical Design Guide #4 – *“Building with Timber in Bushfire-prone Areas”*
- Provides timber design and building solutions in accordance with AS 3959 *“Construction of buildings in bushfire-prone areas”* for all Bushfire Attack Levels (BAL).
- Simple timber density based solutions up to BAL–19 with fire tested (BAL–29) as well as fire rated solutions (BAL–40 and BAL–FZ).



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Other Fire Related WoodSolutions Tools

- Bushfire Attack Level (BAL) Calculator
- It can be found at the following link on the wood solutions website https://www.woodsolutions.com.au/Articles/Resources/BAL-Bushfire-Calculator-V1
- For the determination of site specific BALs

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Using the Bushfire Calculator

- Site Specific Inputs:
  - Fire danger index
  - Vegetation type
  - Distance to vegetation
  - Effective downslope
- Site specific Output:
  - BAL *plus*
  - Minimum required distance to achieve various BALs based on the specific inputs

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Thank you

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