Encapsulated Mass Timber: a new construction type for the 2020 NBC

Toronto Wood Solutions Fair

November 22, 2018

Marc Alam
Technical Specialist, Codes and Standards – Fire
Canadian Wood Council

Canadian Wood Council Conseil canadien du bois

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National federation of associations

ENGINEERED WOOD SYSTEMS APA EWS

APA

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The Canadian Wood Truss Association
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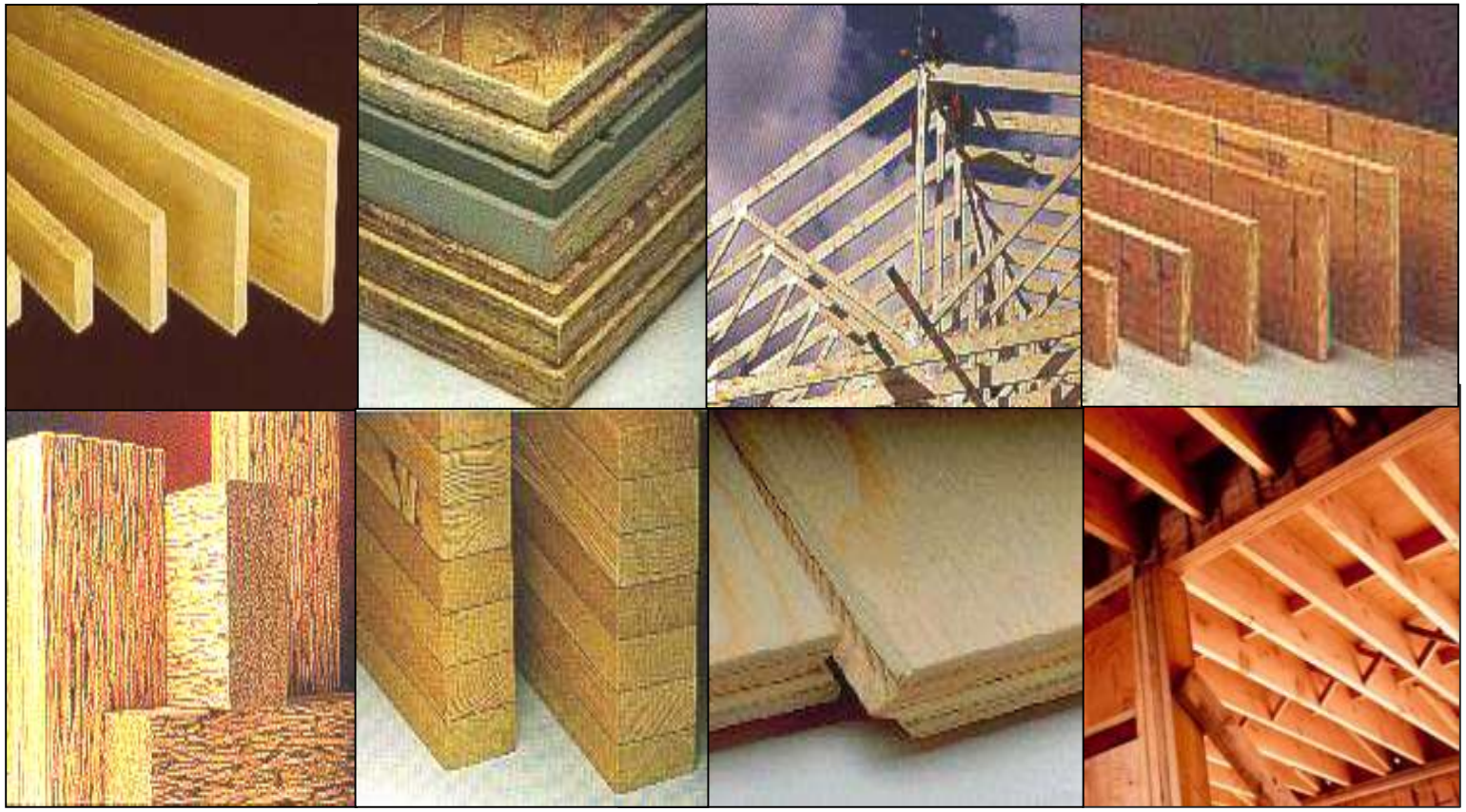

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CWC - Principle Activities

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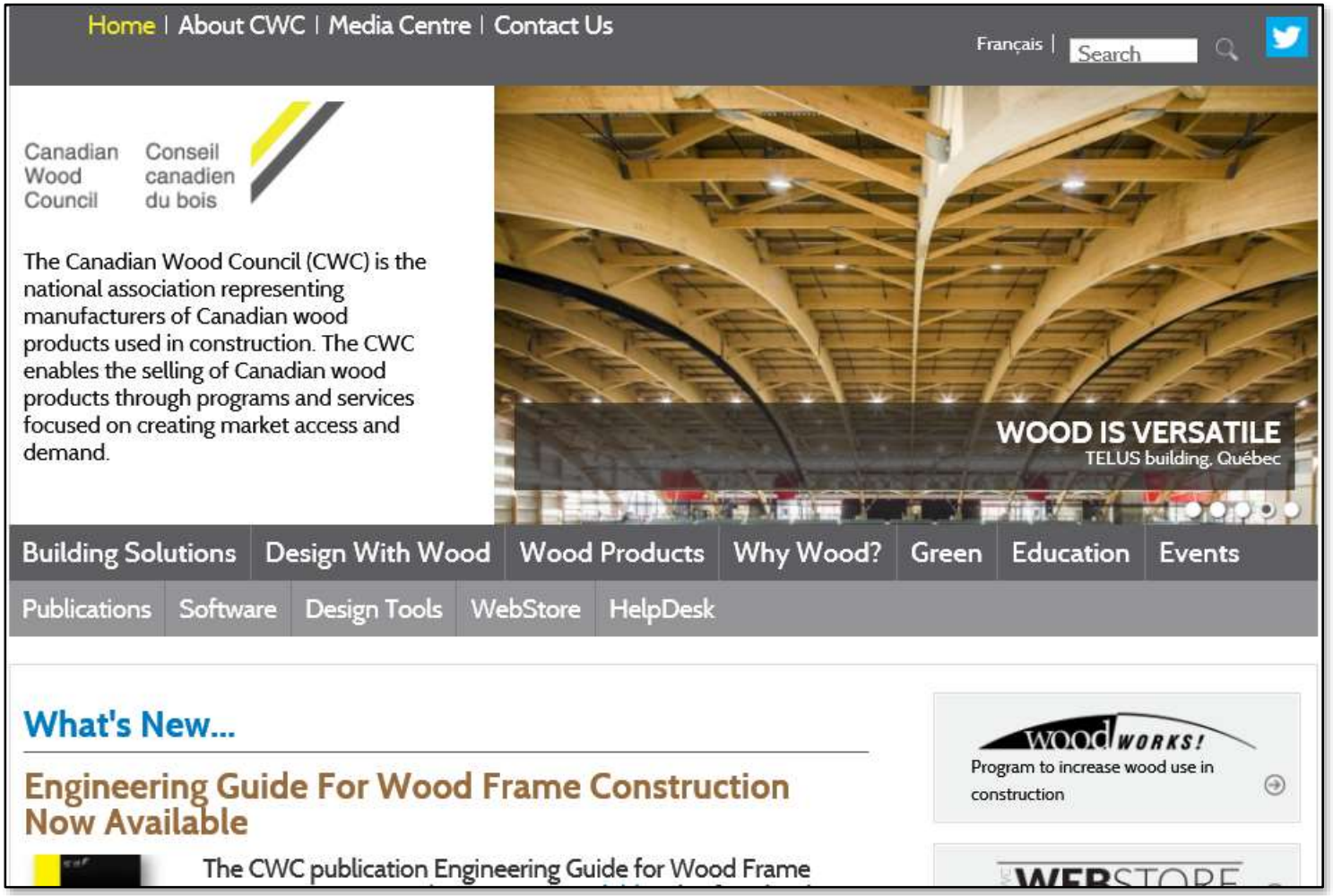
CWC - Principle Activities

Technical Information

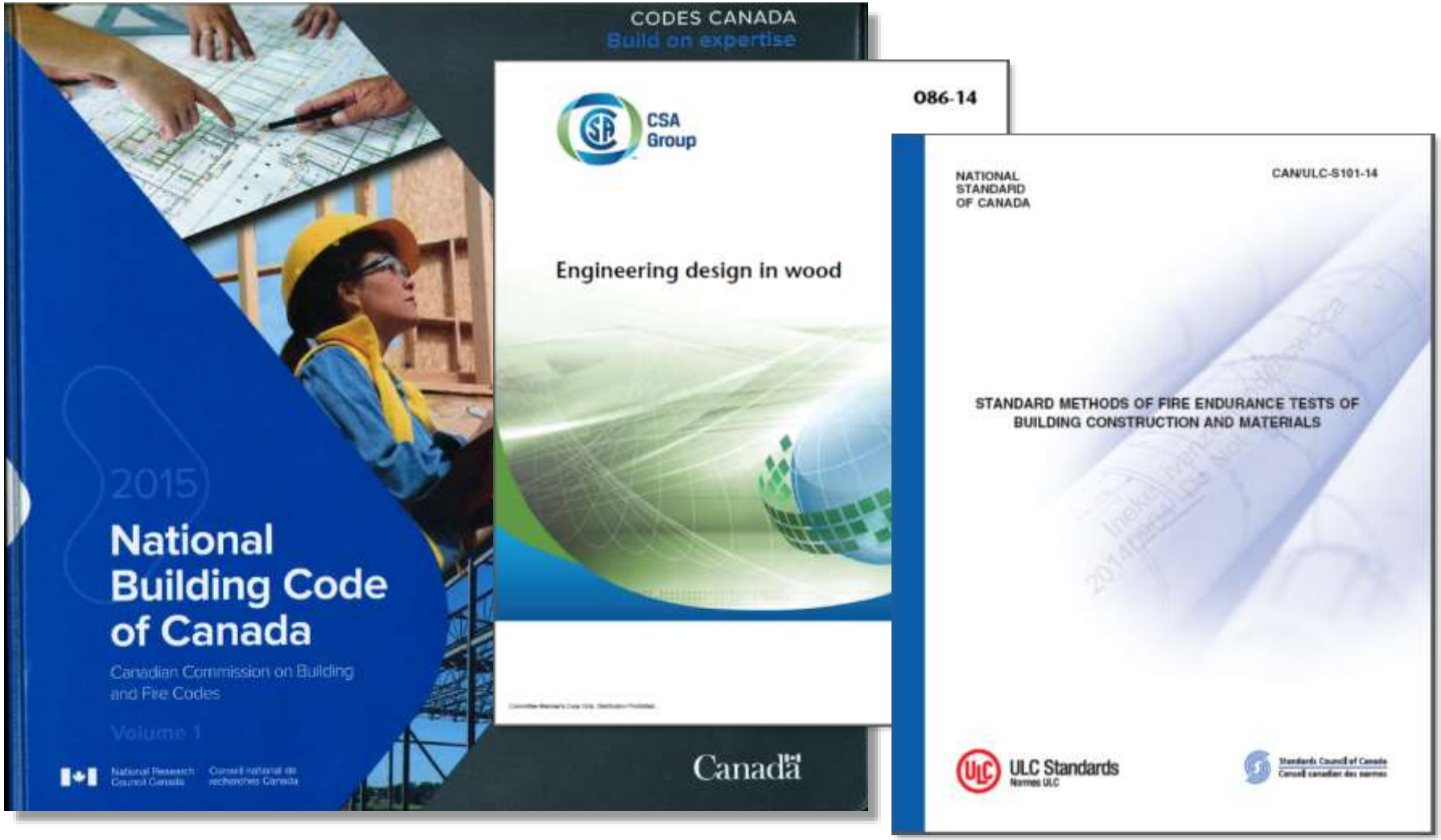
CWC - Principle Activities

Technical Information: www.cwc.ca



CWC - Principle Activities

Codes & Standards



Proposed Changes for the 2020 NBC: Encapsulated Mass Timber Construction

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Division B – 2020 NBC: Prescriptive Tall Wood Buildings

- Code Change Request package submitted by Canadian Wood Council
- Standing Committee on Fire Protection → Task Group → 5 Sub-Task Groups
- List of 25 potential issues/concerns developed
- Draft Proposed Code Changes submitted to public consultation in Fall 2017

Division B – 2020 NBC: Prescriptive Tall Wood Buildings

Current Code:

- ***"Noncombustible construction*** **means that type of construction in which a degree of fire safety is attained by the use of *noncombustible* materials for structural members and other *building* assemblies."**
- ***"Combustible construction*** **means that type of construction that does not meet the requirements for *noncombustible construction*."**

Division B – 2020 NBC: Prescriptive Tall Wood Buildings

Tall buildings in current Codes:

- **“noncombustible construction”**
- **fire-resistance rating of structural members of 2 h**
- **automatic fire sprinklers**
- **unlimited height, unlimited area**

Division B – 2020 NBC: Prescriptive Tall Wood Buildings

"Noncombustibility is an elemental concept, but 'noncombustible construction' is only a standard that has proved satisfactory for tall buildings and some other situations. When construction using combustible materials is developed that satisfies the conditions, the standard should be changed to permit it.... Noncombustibility will always be one, but not necessarily the only, solution."

R.S. Ferguson, *The Problem of "Noncombustible"*
Technical Note No. 428
National Research Council of Canada
1964

Division B – 2020 NBC: Prescriptive Tall Wood Buildings

General Premise:

Develop a set of provisions that achieves the current level of fire safety when wood structural elements are substituted for structural elements of noncombustible materials.

Division B – 2020 NBC: Prescriptive Tall Wood Buildings

General Premise

"Noncombustible Construction"

(i.e. all the current material restrictions and fire safety provisions required for NC)

+

Structural elements currently required to be of noncombustible material replaced with wood elements

+

Additional requirements - ??

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Division B – 2020 NBC: Encapsulated Mass Timber Construction

So, proposing 3rd "type" of construction -

- ***"Noncombustible construction*** **means that type of construction in which a degree of fire safety is attained by the use of *noncombustible* materials for structural members and other *building* assemblies."**
- ***"Encapsulated mass timber construction*** **means that type of construction in which a degree of fire safety is attained by the use of encapsulated mass timber elements with an *encapsulation rating* and minimum dimensions for the structural timber members and other *building* assemblies."**
- ***"Combustible construction*** **means that type of construction that does not meet the requirements for *noncombustible construction* or *encapsulated mass timber construction*."**

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Division B – 2020 NBC: Encapsulated Mass Timber Construction

Encapsulation rating:

- ***"Encapsulation rating*** **means the time in minutes that a material or assembly of materials will delay the ignition and combustion of encapsulated mass timber elements when it is exposed to fire under specified conditions of test and performance criteria, or as otherwise prescribed by this Code."**

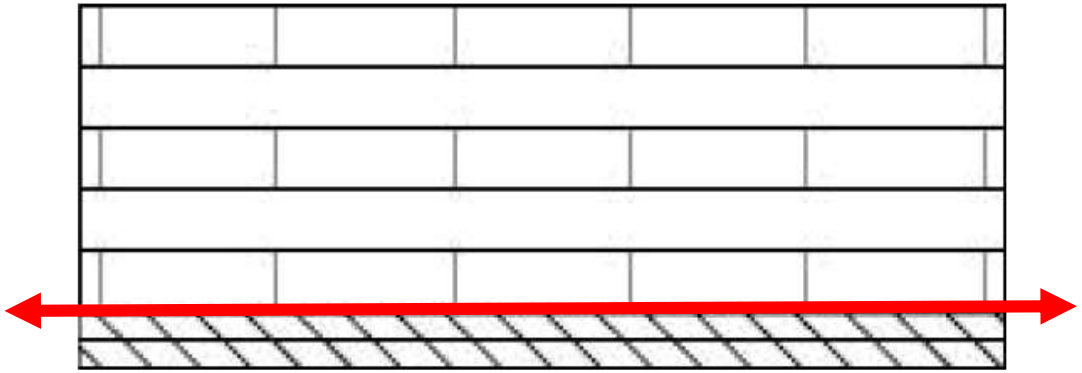
- **Encapsulation rating determined via new test method**
  - **Draft Standard: ULC S146-XX *Standard Method of Test for the Evaluation of Encapsulation Materials and Assemblies of Materials for the Protection of Mass Timber Structural Members and Assemblies***

Division B – 2020 NBC: Encapsulated Mass Timber Construction

Draft test method ULC S146-XX

- Standard time-temperature curve from CAN/ULC-S101
- Horizontal configuration (fire from underside)
- Minimum size of assembly: 3.66m x 3.66m
- Maximum average temperature increase of 250°C at the interface of the encapsulation material(s) and the wood substrate
- Maximum temperature increase at any individual point of 270°C at the interface of the encapsulation material(s) and the wood substrate

Division B – 2020 NBC: Encapsulated Mass Timber Construction



Encapsulation rating not less than 50 minutes

- **2 layers of not less than 12.7-mm-thick Type X gypsum board,**
- **Not less than 38-mm-thick gypsum-concrete or concrete topping, or**
- **Other noncombustible material or assembly of materials that provides an "encapsulation rating" of at least 50 minutes**

Division B – 2020 NBC: Encapsulated Mass Timber Construction

Mass Timber:

- **Minimum size requirements for structural timber elements to be considered "mass timber"**

Table 3.1.18.3.
Minimum Dimensions of Structural Timber Elements in Encapsulated Mass Timber Construction
Forming Part of Sentence 3.1.18.3.(2)-2020

Structural timber elements	Type of Dimension	Minimum Dimensions (mm)
Wall, floor and roof assemblies	thickness/depth	96
Beams, columns and arches with 2-sided or 3-sided fire exposure	cross-section	192 x 192
Beams, columns and arches with 4-sided fire exposure	cross-section	224 x 224

Division B – 2020 NBC: Encapsulated Mass Timber Construction

Table 3.1.18.3.
Minimum Dimensions of Structural Mass Timber Elements in Encapsulated Mass Timber Construction

Structural Wood Elements	Minimum Thickness, mm	Minimum Width x Depth, mm x mm
Wall that is a fire separation or exterior wall	96	-
Wall that requires a fire-resistance rating but is not a fire separation	192	-
Floors and Roofs	96	-
Beams, columns and arches (2- or 3-sided fire exposure)	-	192 x 192
Beams, columns and arches (4-sided fire exposure)	-	224 x 224

Division B – 2020 NBC: Encapsulated Mass Timber Construction

Requirements:

- Limited height of 12 storeys
- Sprinklered throughout to NFPA 13
- 2 hour fire-resistance rating
- Limited maximum building area (for any height):
  - Group C: 6,000 m^2
  - Group D: 7,200 m^2

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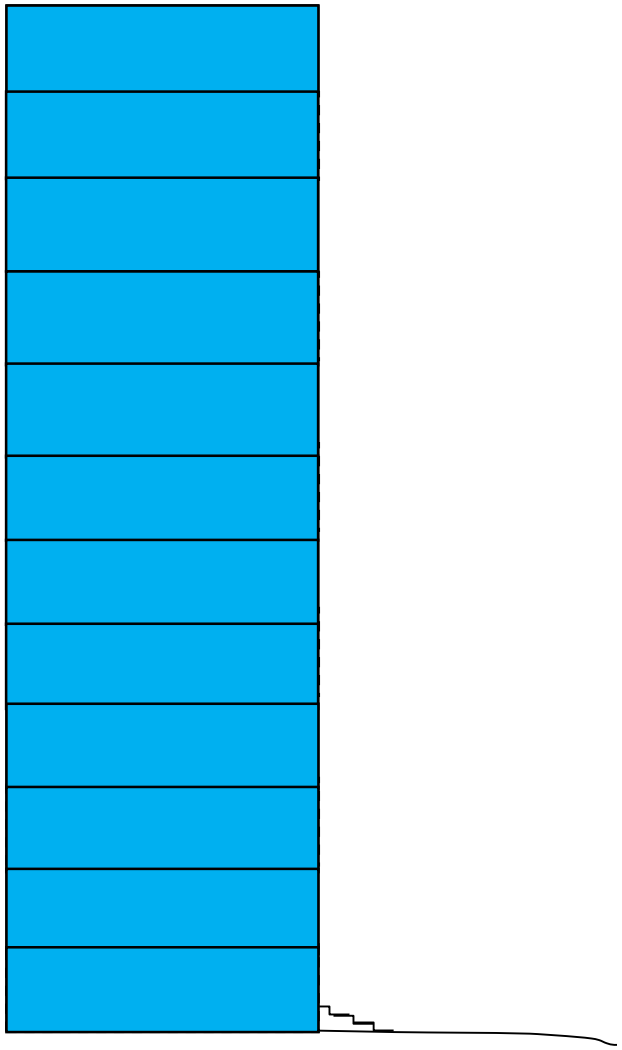

Permitted – all storeys:

- Group C
- Group D

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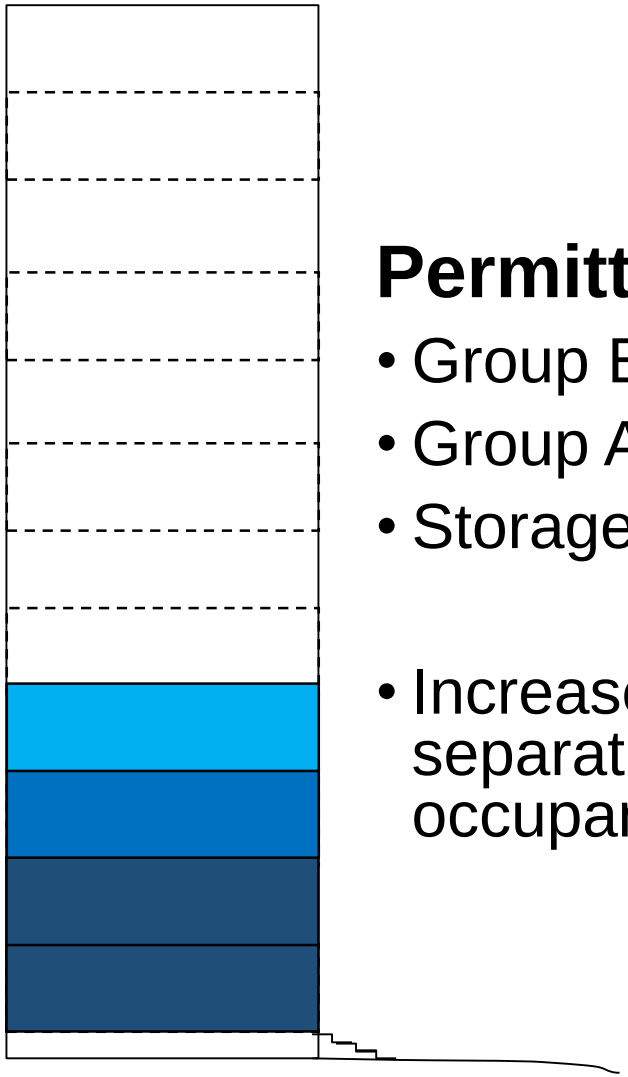
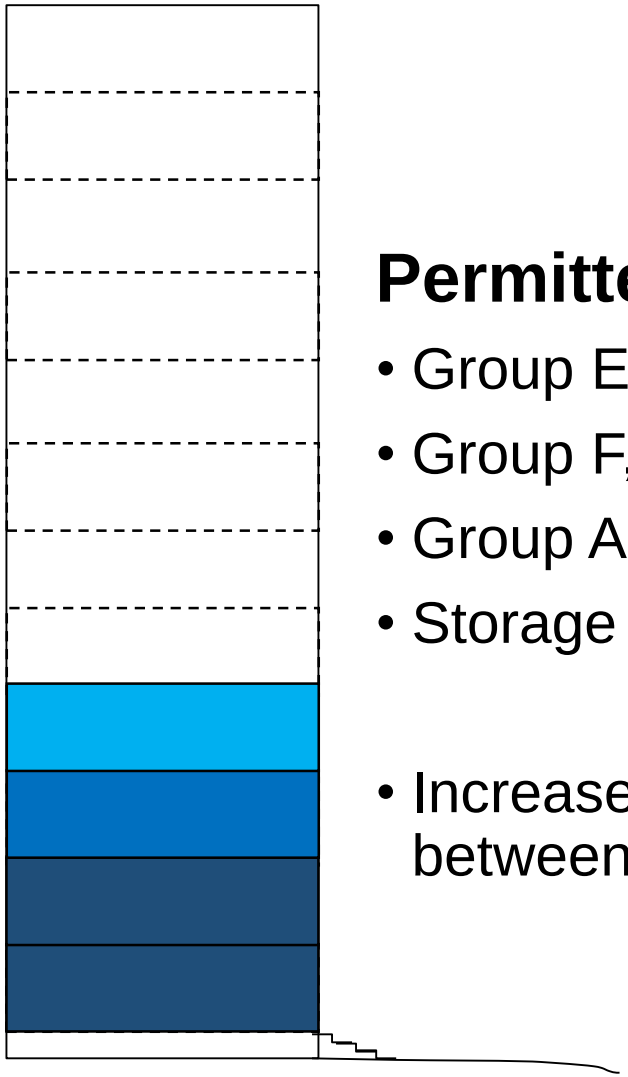


Permitted with Group C:

- Group E – 1st & 2nd storeys
- Group A, Division 2 - 1st, 2nd & 3rd storeys
- Storage garages – below 5th storey

- Increased fire-resistance rating for separation between some major occupancies

Division B – 2020 NBC: Encapsulated Mass Timber Construction



Permitted with Group D:

- Group E – 1st & 2nd storeys
- Group F, Division 2 or 3 – 1st & 2nd storeys
- Group A, Division 2 - 1st, 2nd & 3rd storeys
- Storage garages – below 5th storey

- Increased fire-resistance rating for separation between some major occupancies

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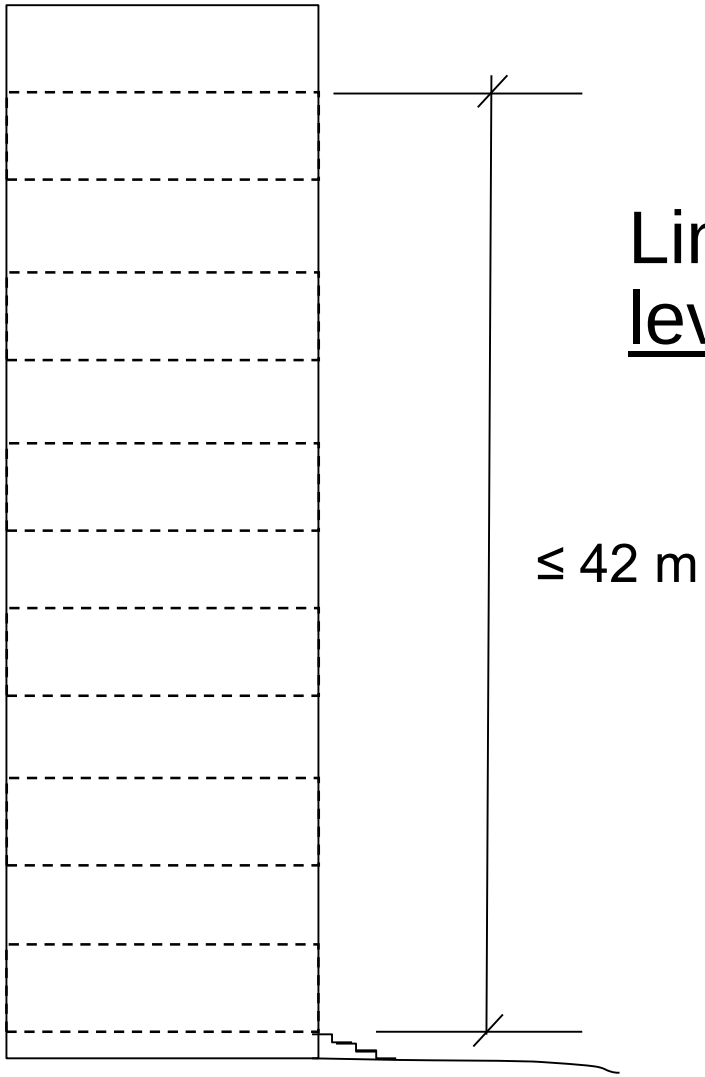

Limit height of <u>uppermost floor level</u> to 42 m above 1st floor

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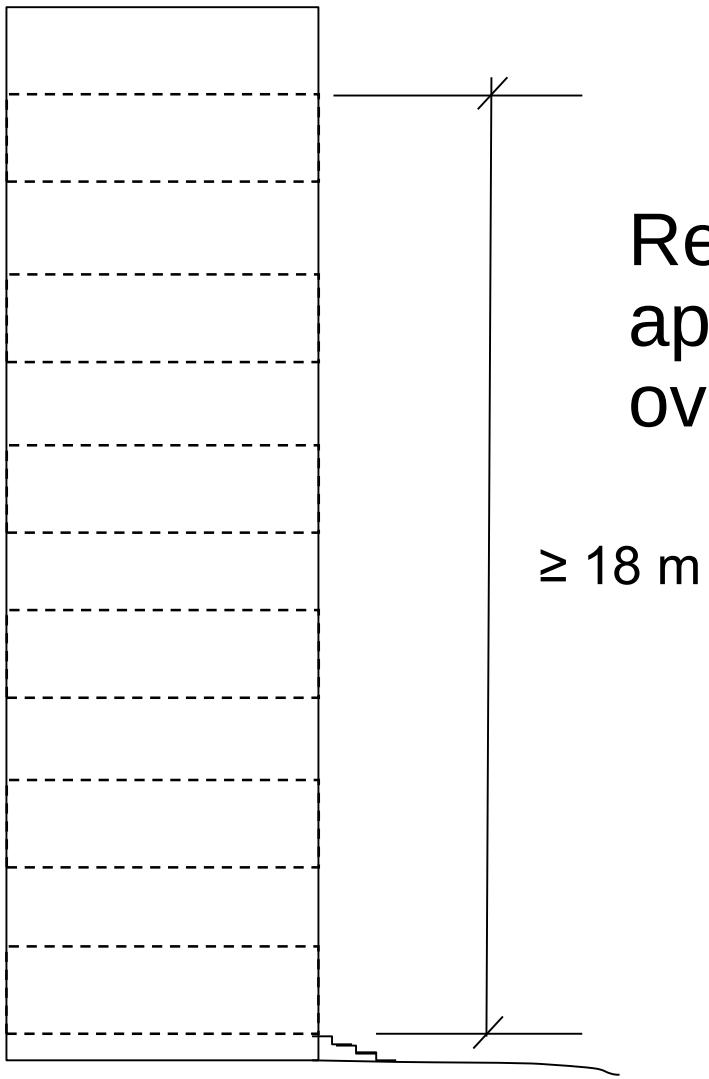


Requirements for high building applicable to EMTC buildings over 18 m

Division B – 2020 NBC: Encapsulated Mass Timber Construction

Additional Requirements:

- **Materials Permitted shall conform to Subsection 3.1.5. or these new requirements for EMTC:**
  - **Combustible Roofing Materials**
  - **Combustible Window Sashes and Frames**
  - **Exterior Cladding**
  - **Combustible Components in Exterior Walls**
  - **Nailing Elements**
  - **Combustible Flooring Elements**
  - **Combustible Stairs**
  - **Combustible Interior Finishes**
  - **Combustible Elements in Partitions**
  - **Concealed Spaces**

Division B – 2020 NBC: Encapsulated Mass Timber Construction

Exterior Cladding:

- **Option 1**
  - **Represents not more 10% on each storey**
  - **Not contiguous over more than 4 storeys**
  - **Not more than 1.2 m in width**
  - **Separated from other portions on the same storey by 1.2 m**
  - **Separated from other portions on adjacent storeys by 2.4 m**
  - **Flame-spread rating not more than 75**

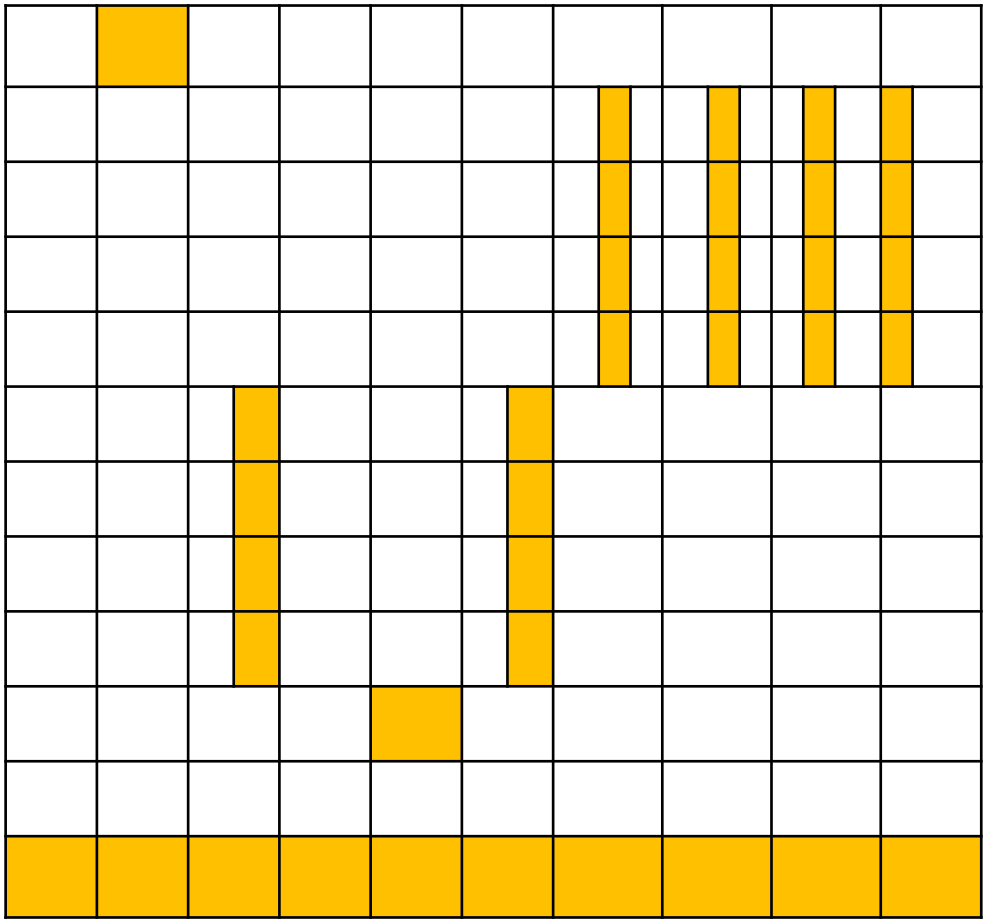
Division B – 2020 NBC: Encapsulated Mass Timber Construction

Exterior Cladding:

- **Option 2**
  - **Represents not more 10% on each storey**
  - **Not contiguous across adjacent storeys**
  - **Separated from other portions on adjacent storeys by 2.4 m**
  - **Flame-spread rating not more than 75**
- **Option 3**
  - **Represents up to 100% of the first storey**
  - **Located not more than 15 m from a street or access route**

Division B – 2020 NBC: Encapsulated Mass Timber Construction

Exterior Cladding:



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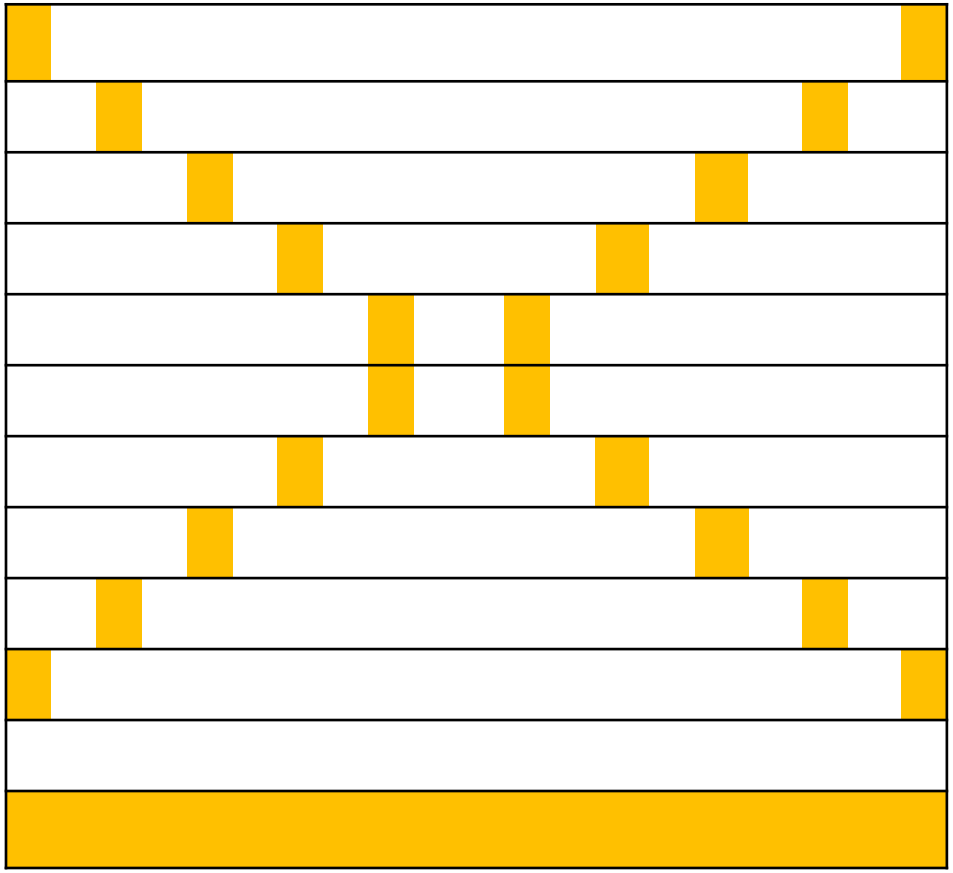
Exterior Cladding:



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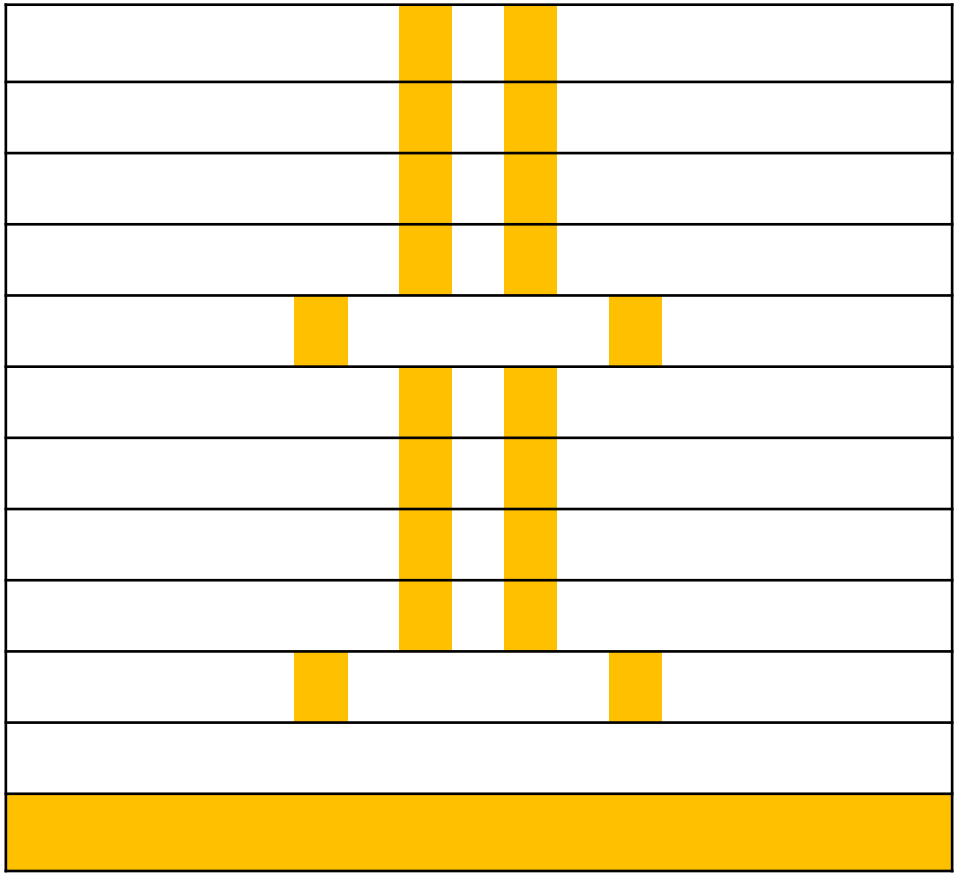
Exterior Cladding:



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Division B – 2020 NFC: Encapsulated Mass Timber Construction

Requirements:

- **Damage or Removed Encapsulation Materials**
  - **They shall be repaired or replaced so that the encapsulation rating of the materials is maintained.**

- **Additional requirements in Subsection 5.6.3. on construction site fire safety to be applied:**
  - **Construction Access**
  - **Standpipe Installation**
  - **Protective Encapsulation**
    - **4 storeys are permitted to be unprotected**
    - **Minimum of 25 min encapsulation rating is needed on (1 layer of 12.7 mm Type X gypsum board):**
      - **80% of the total area of mass timber ceilings**
      - **35% of the total area of mass timber walls**

Division B – 2020 NBC: Encapsulated Mass Timber Construction

Some mass timber surfaces permitted to remain exposed within a suite:

Exposed mass timber element	Max percentage of aggregate surface area of the total wall area of the perimeter of the suite or ceiling area	Flame spread rating	Other requirements
Beams, columns and arches	10%	150	Also permitted in a *fire compartment*
Walls	35%	150	Surfaces face the same direction
Combined beams, columns, arches and walls	35%	150	Wall surfaces face the same direction
Ceilings (option 1)	10%	150	-
Ceilings (option 2)	25%	75	No exposed walls

Division B – 2020 NBC: Encapsulated Mass Timber Construction

Two major mass timber fire testing done for EMTC

- **Fire Safety Challenges of Tall Wood Buildings – Phase 2: Task 2 & 3 – Cross Laminated Timber Compartment Fire Tests**
- **Fire Testing of Rooms with Exposed Wood Surfaces in Encapsulated Mass Timber Construction**

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Fire Safety Challenges of Tall Wood Buildings – Phase 2: Task 2 & 3 – Cross Laminated Timber Compartment Fire Tests

FINAL REPORT BY:

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February 2018

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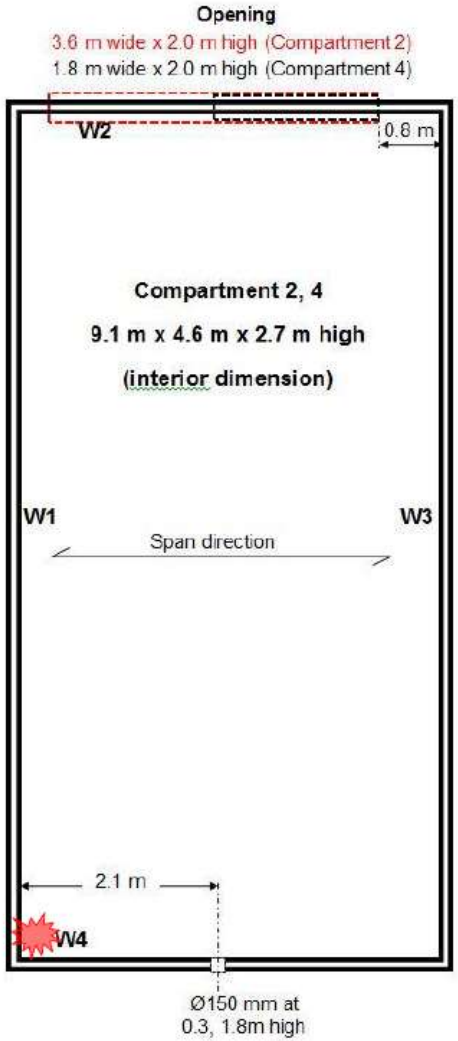
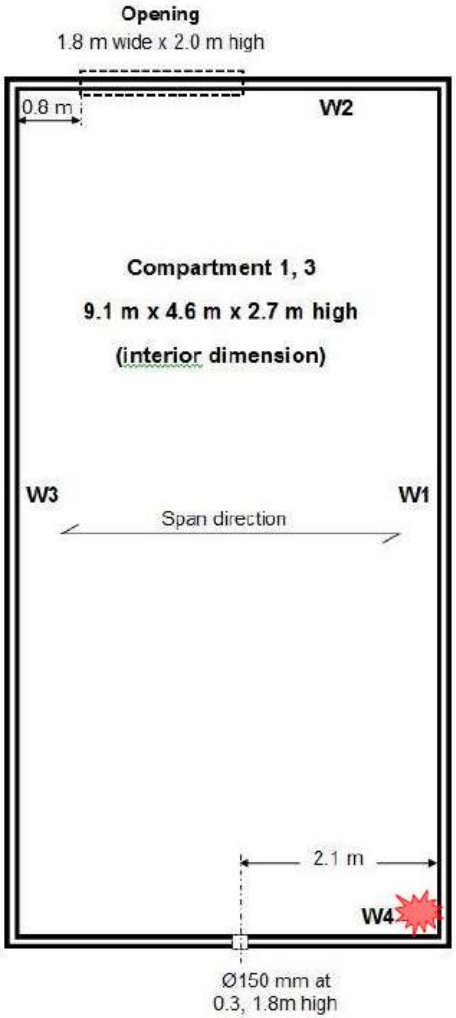
Fire Safety Challenges of Tall Wood Buildings – Phase 2: Task 2 & 3 – Cross Laminated Timber Compartment Fire Tests





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Fire Safety Challenges of Tall Wood Buildings – Phase 2: Task 2 & 3 – Cross Laminated Timber Compartment Fire Tests

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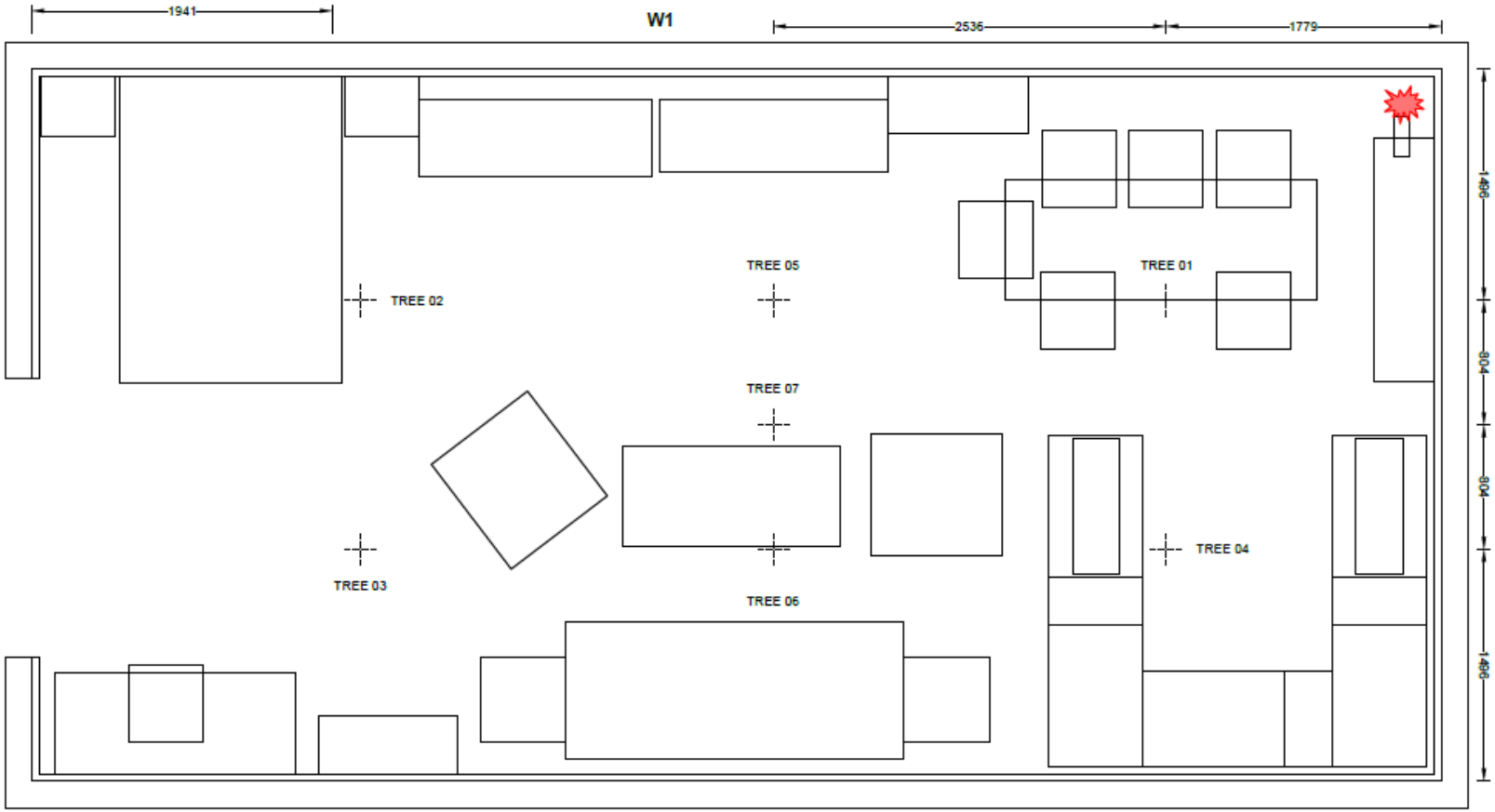

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Fire Safety Challenges of Tall Wood Buildings – Phase 2: Task 2 & 3 – Cross Laminated Timber Compartment Fire Tests

Table 1. Test Matrix of CLT Compartments for Fire Tests.

Rough Opening in Wall W2	Compartment Surface					Test	CLT Compart-ment	Date
	W1 9.1 m x 2.7 m	W2 4.6 m x 2.7 m	W3 9.1 m x 2.7 m	W4 4.6 m x 2.7 m	Ceiling 9.1 m x 4.6 m			
1.8 m wide x 2.0 m high	3GB	3GB	3GB	3GB	3GB	1-1	1	Feb. 16
	3GB	3GB	3GB	3GB	**exposed**	1-4*	1*	Mar. 21
	exposed	3GB	3GB	3GB	3GB	1-5	4	Apr. 13
	exposed	3GB	3GB	3GB	**exposed**	1-6	3	Apr. 18
3.6 m wide x 2.0 m high	2GB	2GB	2GB	2GB	2GB	1-2	2	Feb. 23
	exposed	2GB	2GB	2GB	3GB	1-3*	2*	Mar. 16

GB: 15.9 mm (5/8 in.) thick Type X gypsum board; 2GB: 2 layers of GB; 3GB: 3 layers of GB
** Reused CLT structure.*

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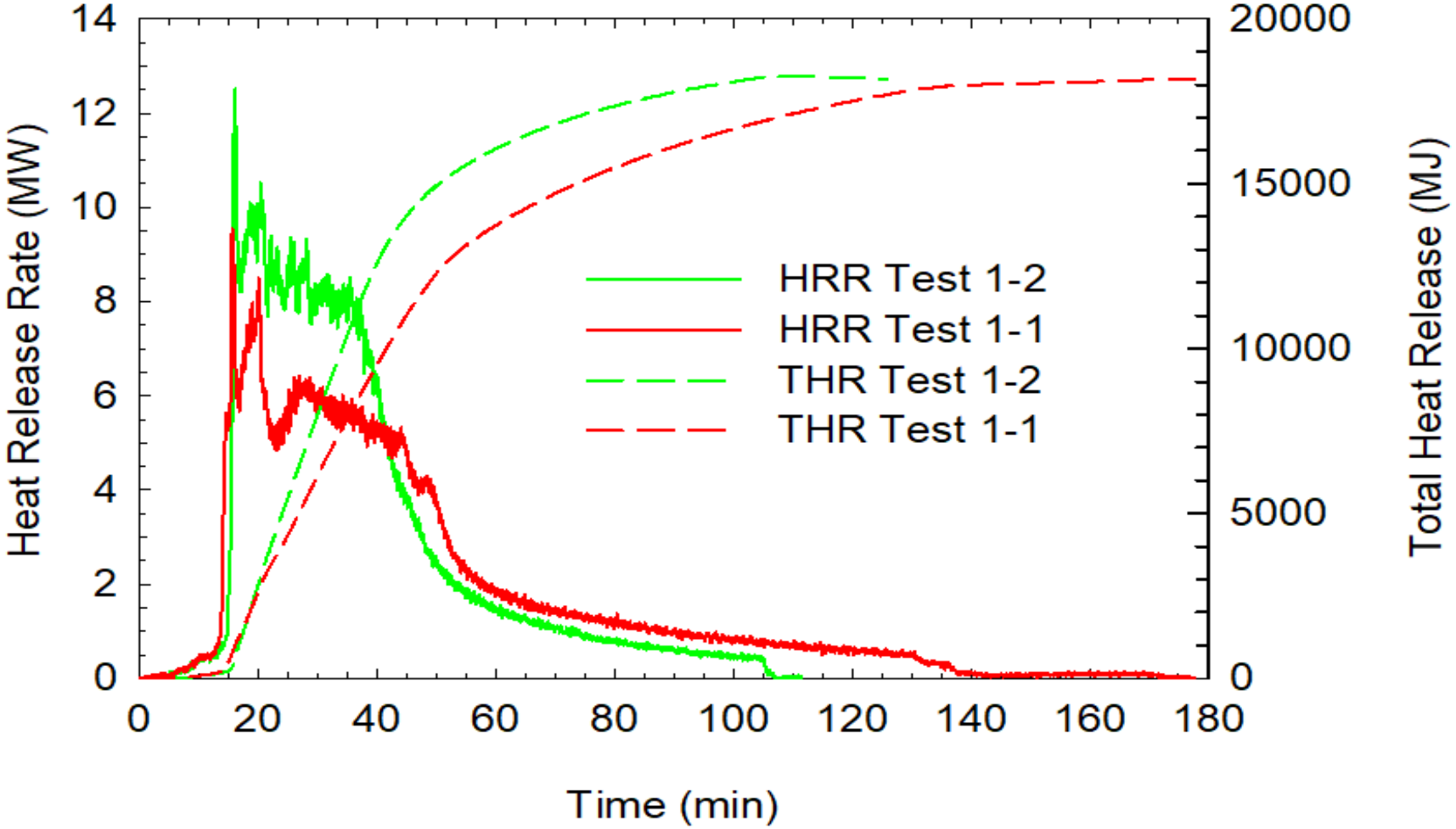
Fire Safety Challenges of Tall Wood Buildings – Phase 2: Task 2 & 3 – Cross Laminated Timber Compartment Fire Tests



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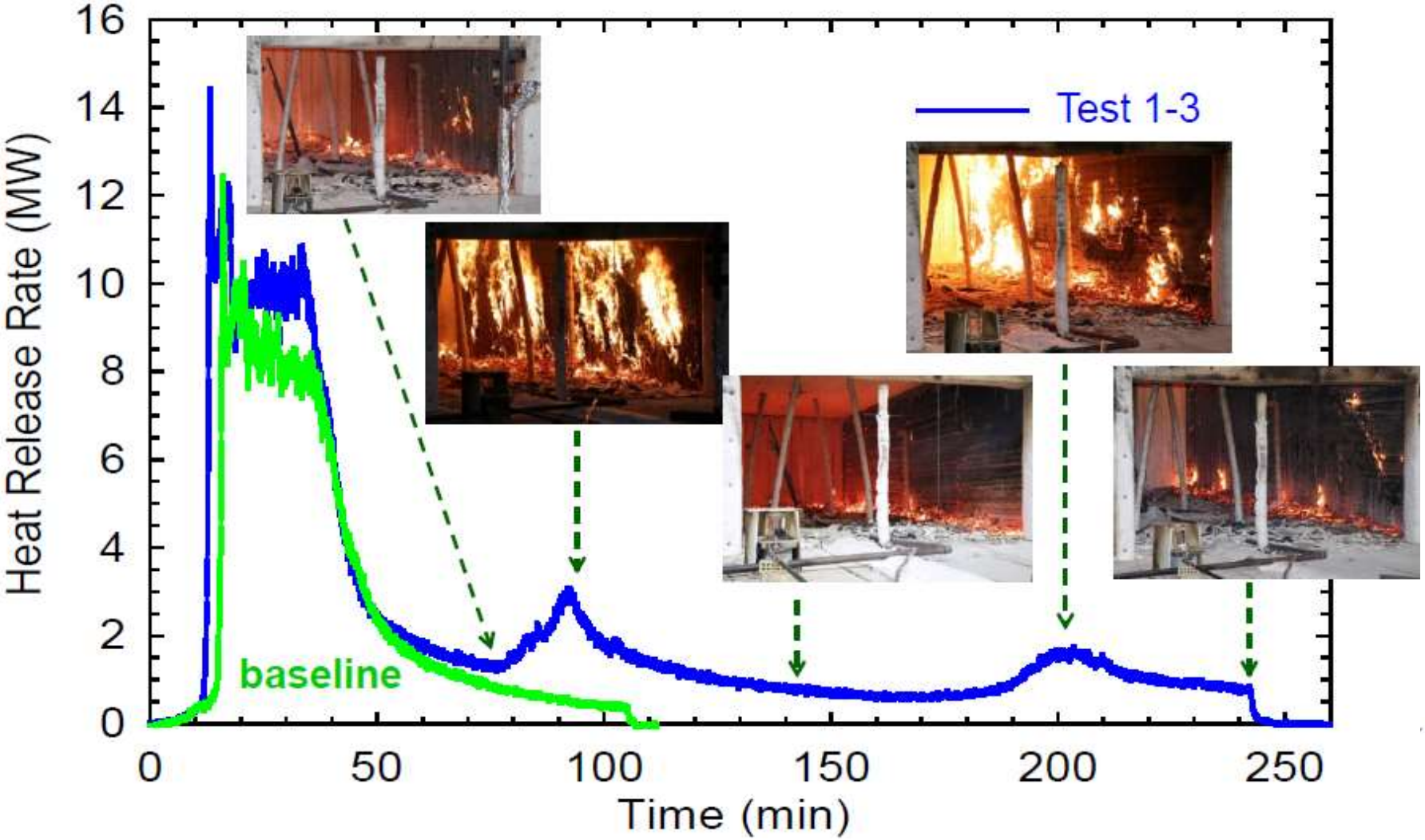

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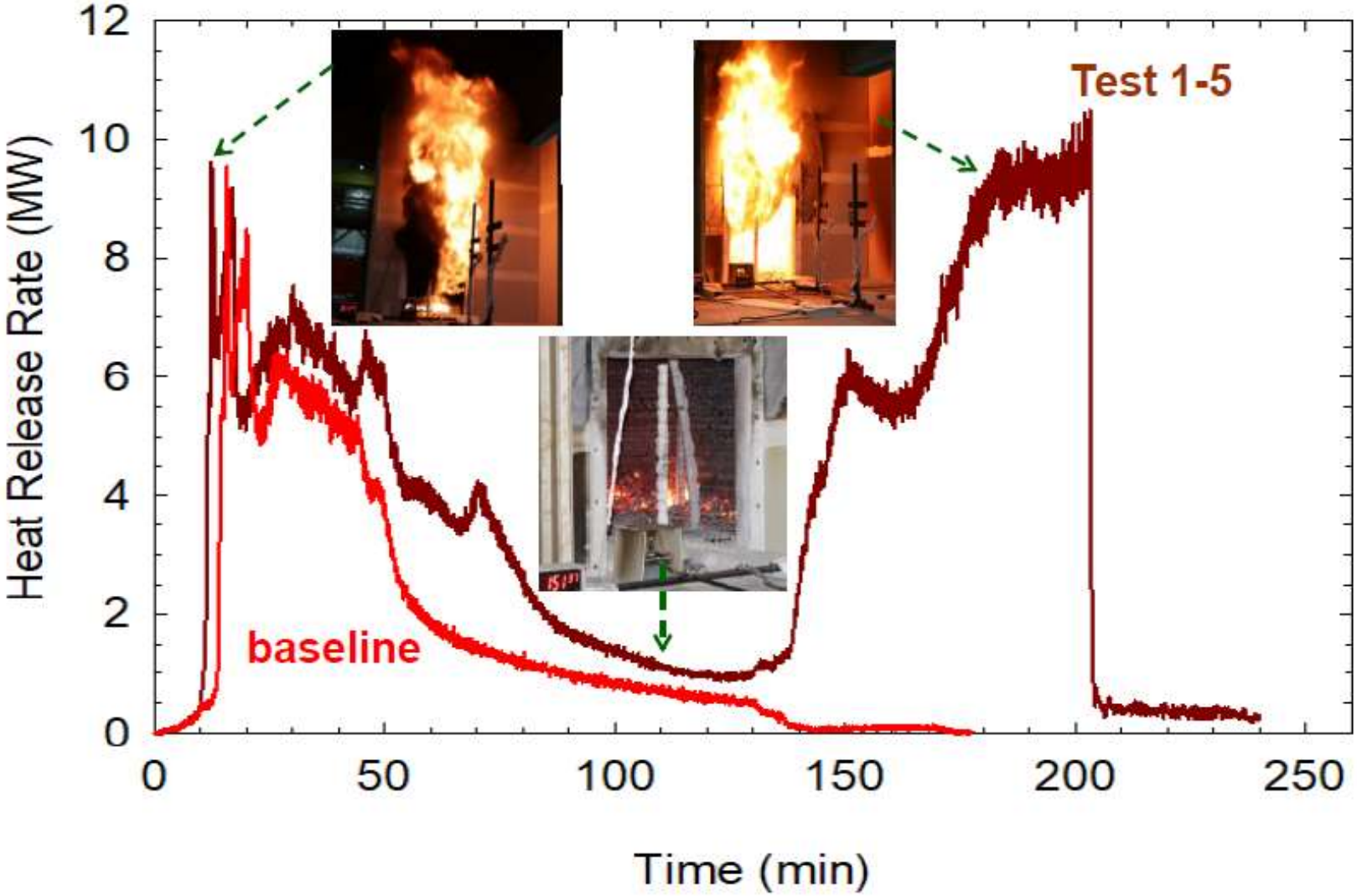

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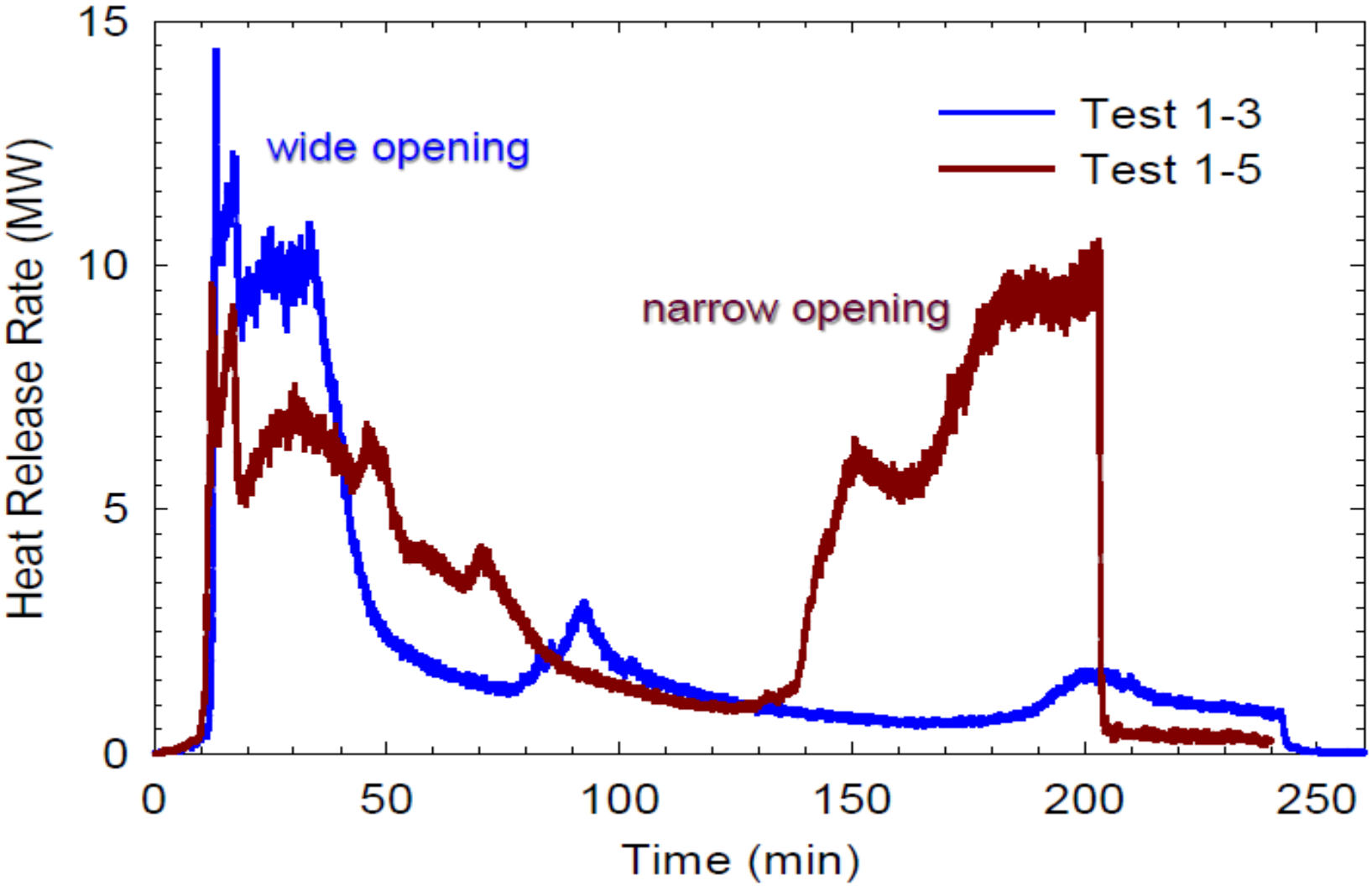

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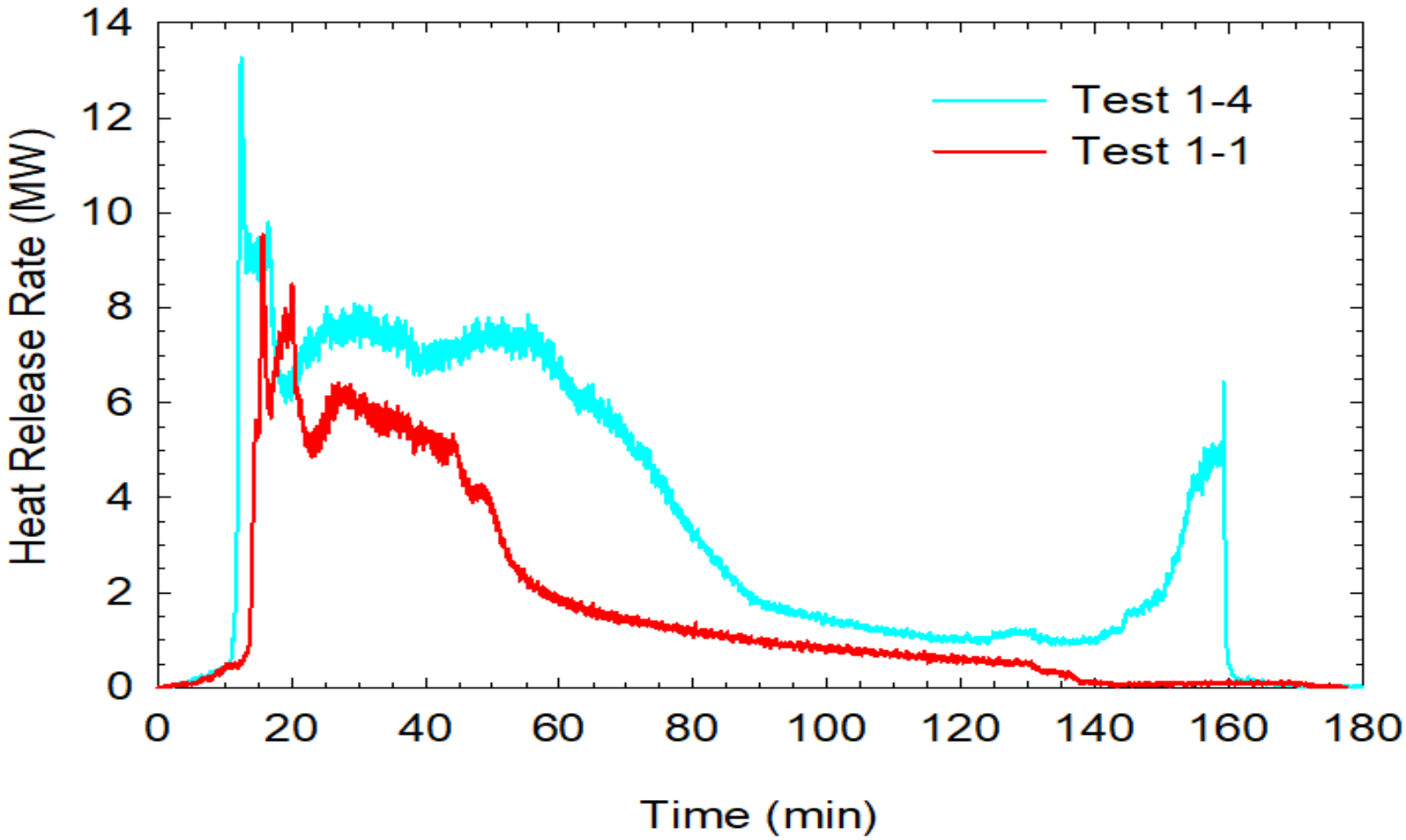

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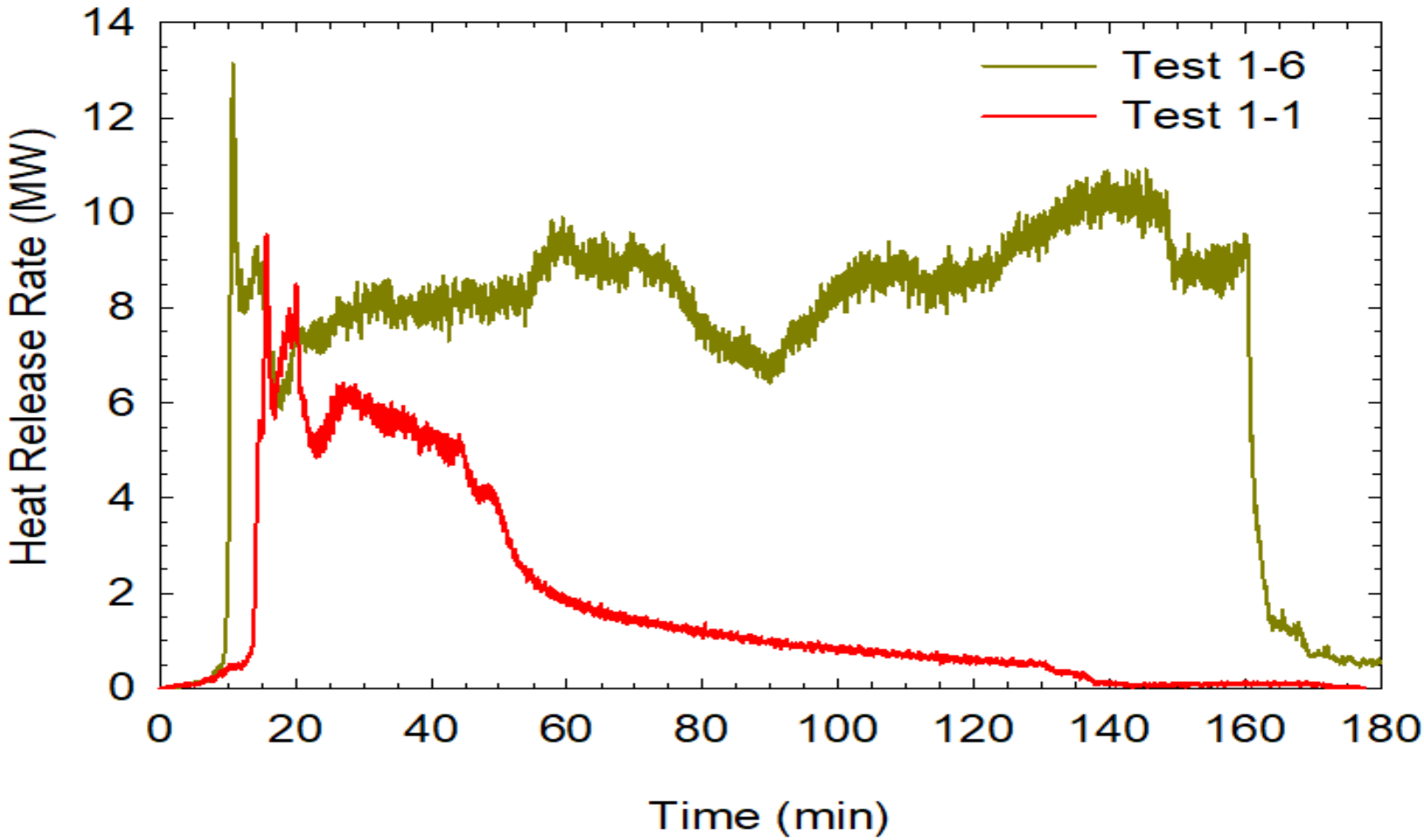

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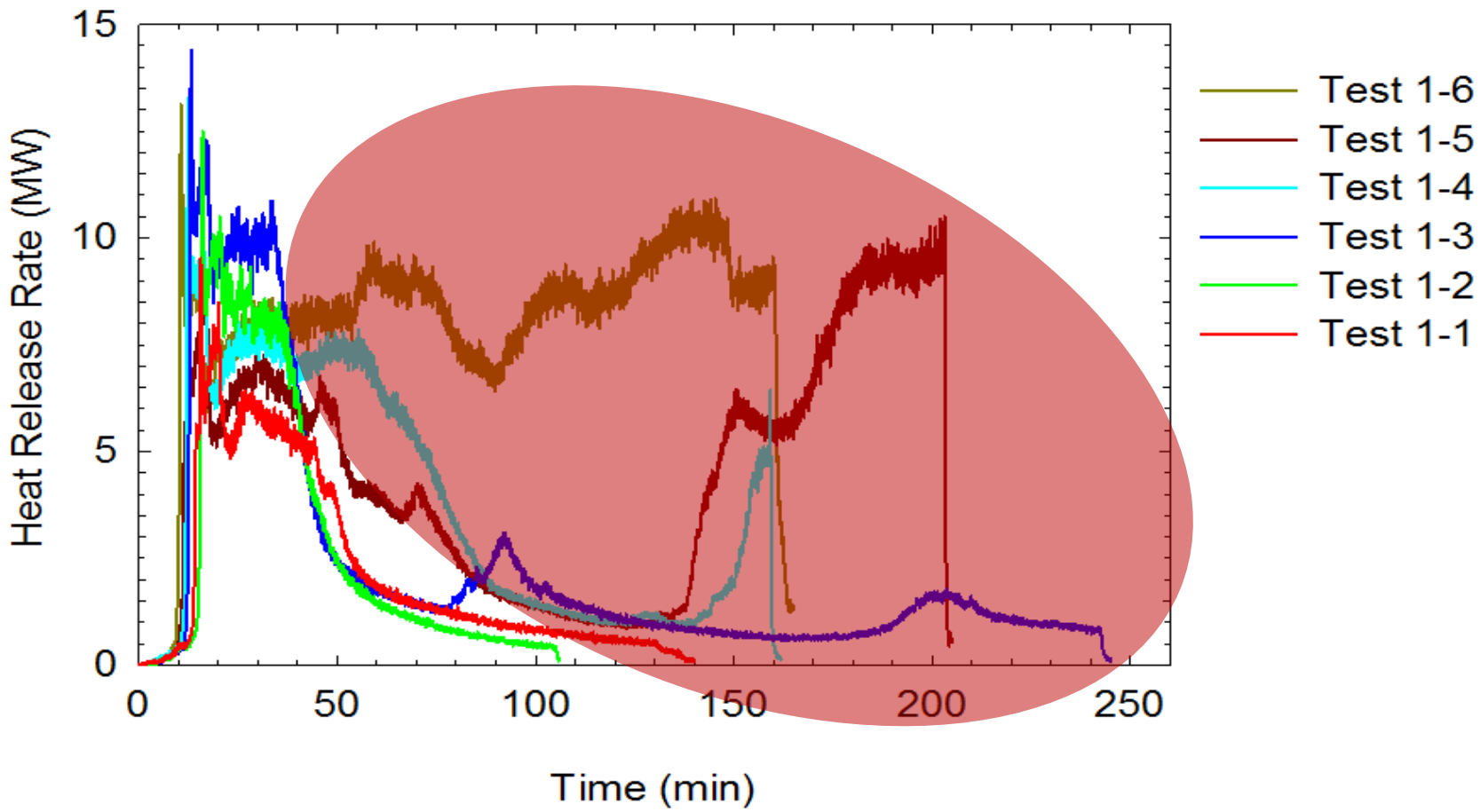

ANSI/APA PRG 320-2018

AMERICAN NATIONAL STANDARD

Standard for Performance-Rated Cross-Laminated Timber

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NRC·CNRC CONSTRUCTION

FIRE TESTING OF ROOMS WITH EXPOSED WOOD SURFACES IN ENCAPSULATED MASS TIMBER CONSTRUCTION

Joseph Su, Patrice Leroux, Pier-Simon Lafrance, Rob Berzins, Karl Gratton, Eric Gibbs, Mark Weinfurter

8 August 2018

National Research Council Canada
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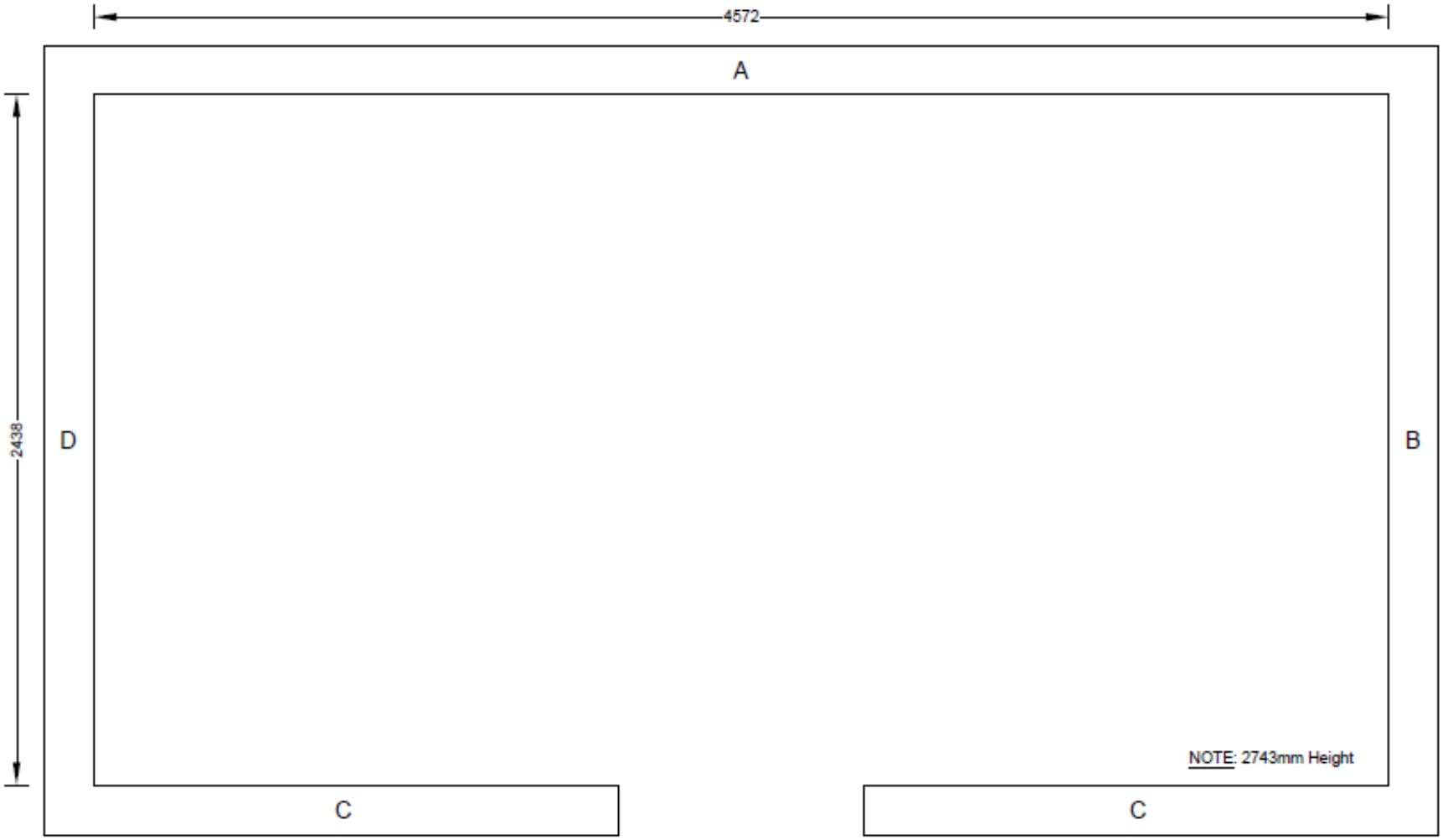
Fire Testing of Rooms with Exposed Wood Surfaces in Encapsulated Mass Timber Construction



Fire Testing of Rooms with Exposed Wood Surfaces in Encapsulated Mass Timber Construction

Fire Testing of Rooms with Exposed Wood Surfaces in Encapsulated Mass Timber Construction

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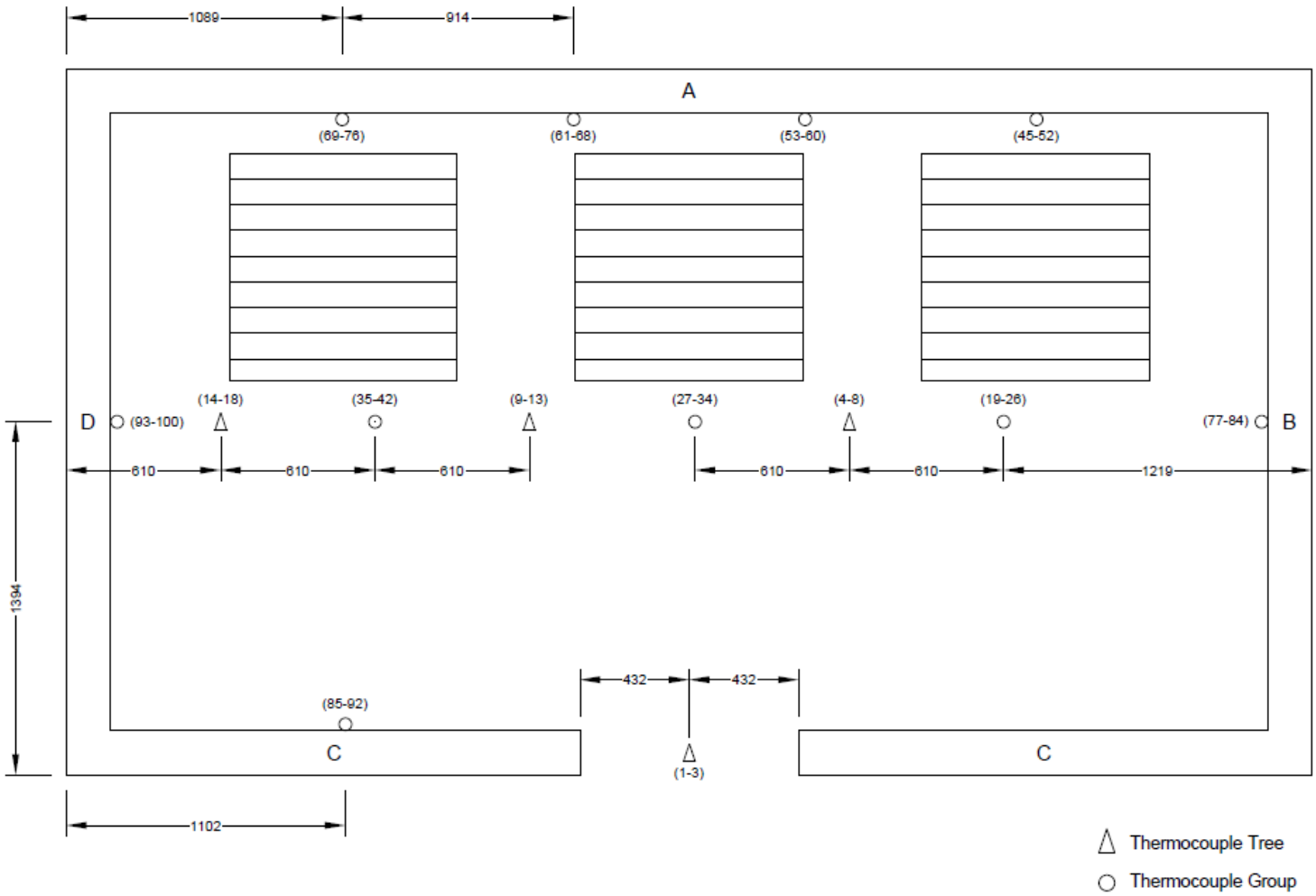
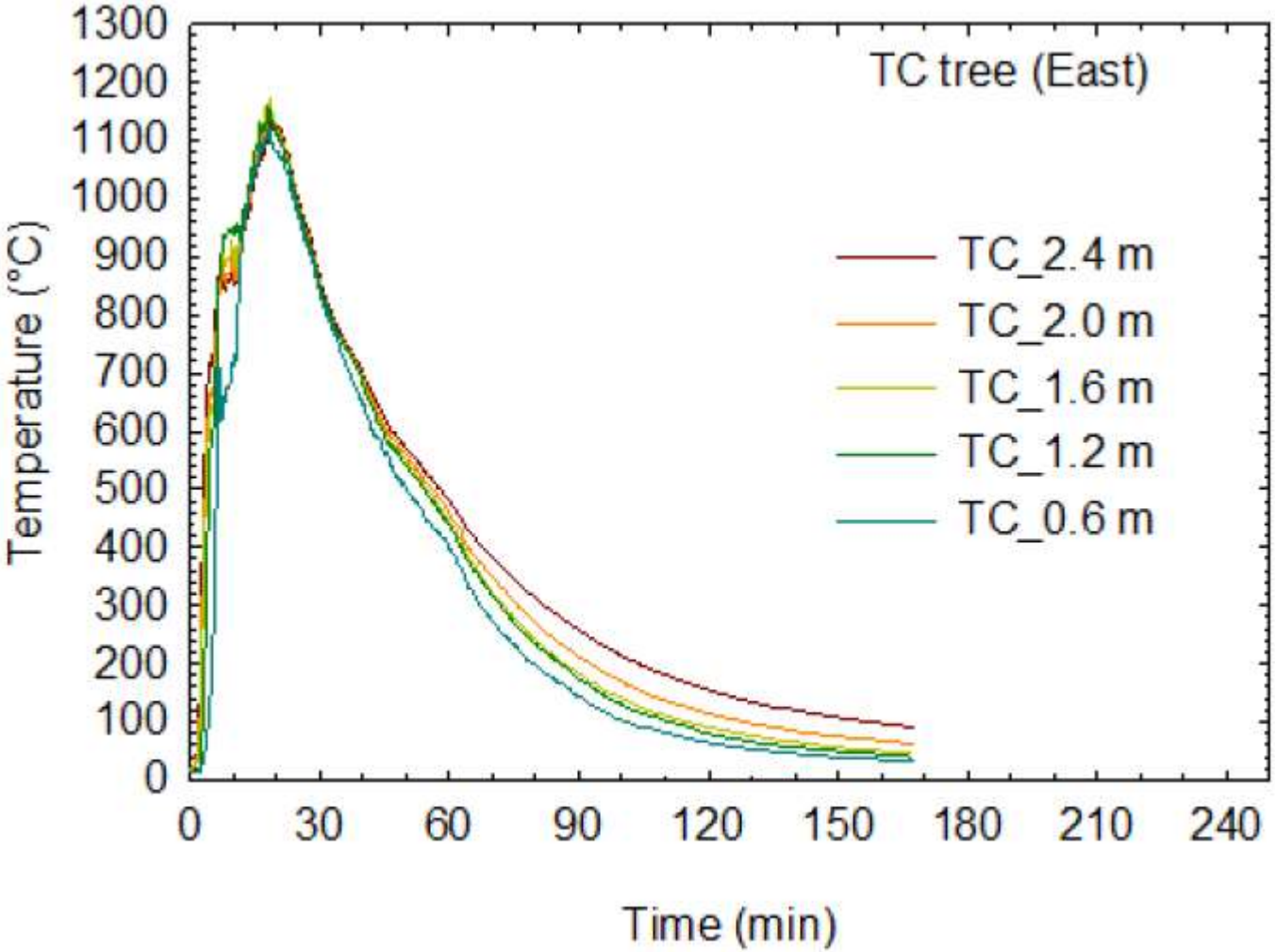


Fire Testing of Rooms with Exposed Wood Surfaces in Encapsulated Mass Timber Construction

Test	Interior Surface Area							
	CLT Wall A 4.5 m x 2.7 m	CLT Wall B 2.4 m x 2.7 m	CLT Wall C 4.5 m x 2.7 m	CLT Wall D 2.4 m x 2.7 m	CLT Ceiling 4.5 m x 2.4 m	CLT Floor 4.5 m x 2.4 m	Glulam Beam 327 mm x 457 mm	Glulam Column 457 mm x 457 mm
1	3GB	3GB	3GB	3GB	3GB	3GB	-	-
2	**exposed** (= 33% of perimeter)	2GB	2GB	2GB	10% **exposed** 90% 2GB	2GB	-	-
3	2GB	2GB	2GB	2GB	2GB	2GB	**exposed** (4.54 m^2 = 11.5% of perimeter)	**exposed** (9.62 m^2 = 24.5% of perimeter)
4	2GB	2GB	2GB	2GB	100% **exposed**	2GB	**exposed** (2.46 m^2 = 6.4% of perimeter)	**exposed** (4.81 m^2 = 12.6% of perimeter)
5	2GB	**exposed** (= 17.5% of perimeter)	2GB	**exposed** (=17.5% of perimeter)	100% **exposed**	2GB	-	-

3GB: 1 layer of 15.9 mm thick Type X gypsum board + 2 layers of 12.7 mm thick Type X gypsum board
2GB: 2 layers of 12.7 mm thick Type X gypsum board

Fire Testing of Rooms with Exposed Wood Surfaces in Encapsulated Mass Timber Construction



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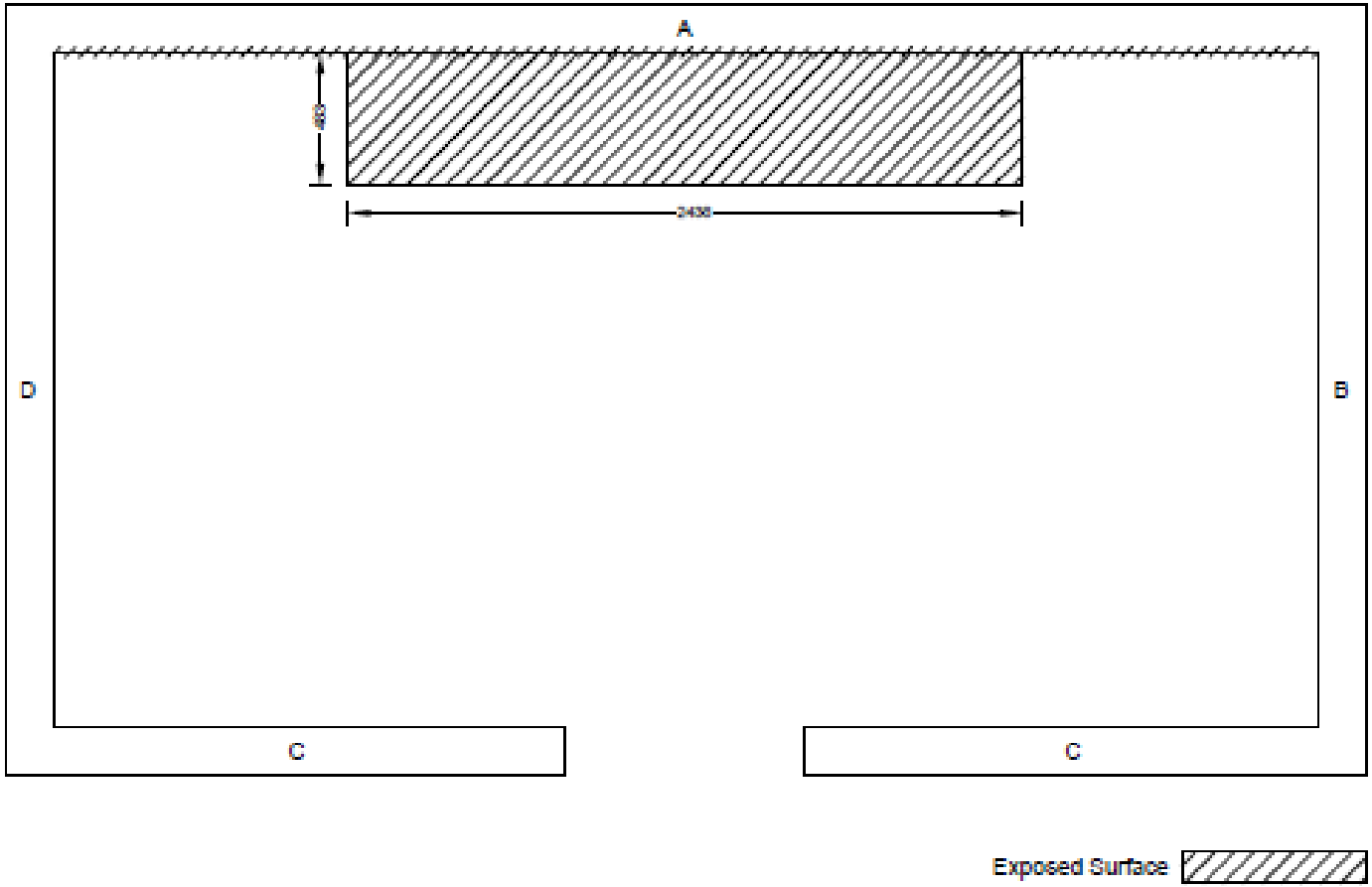

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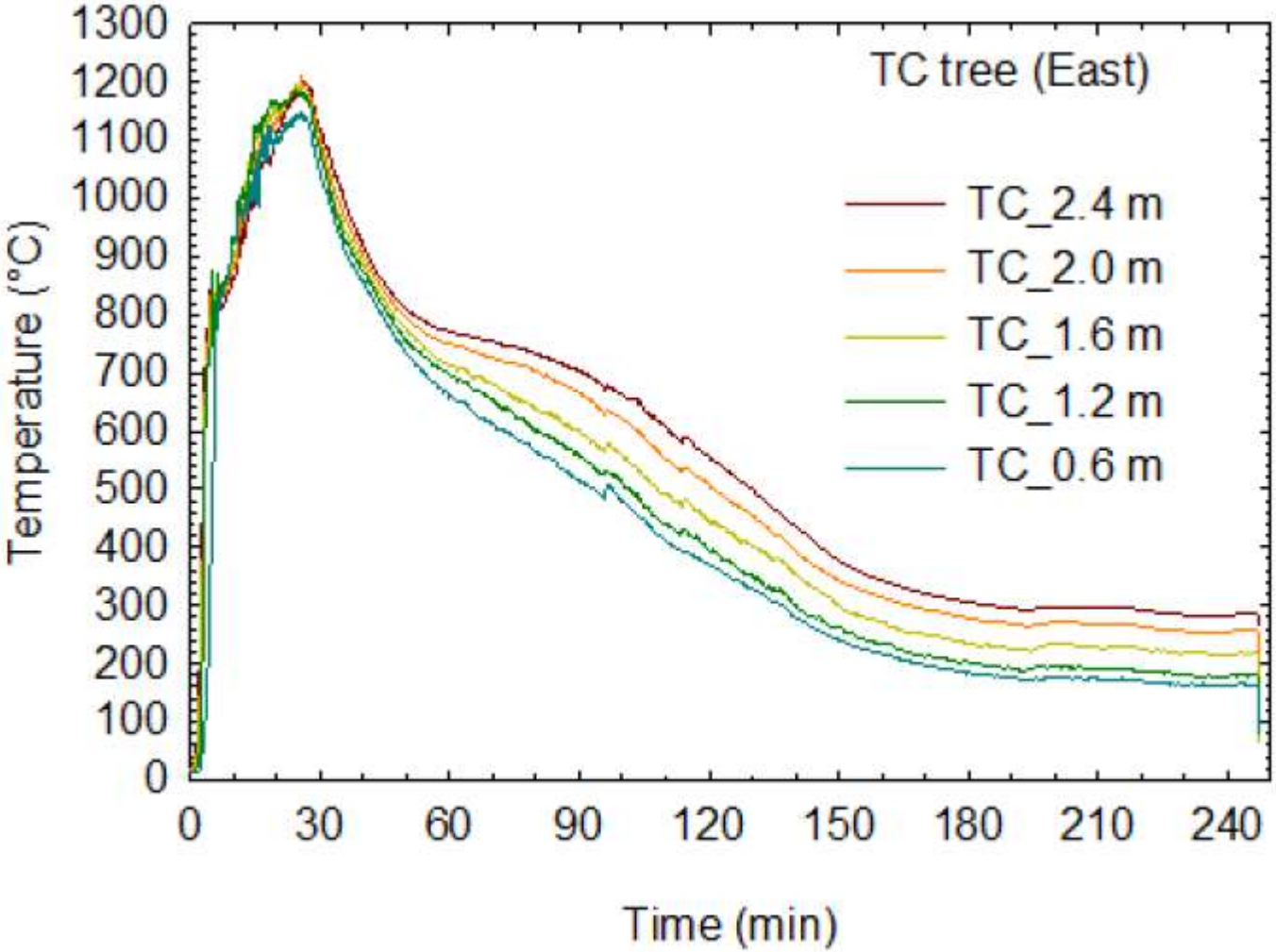

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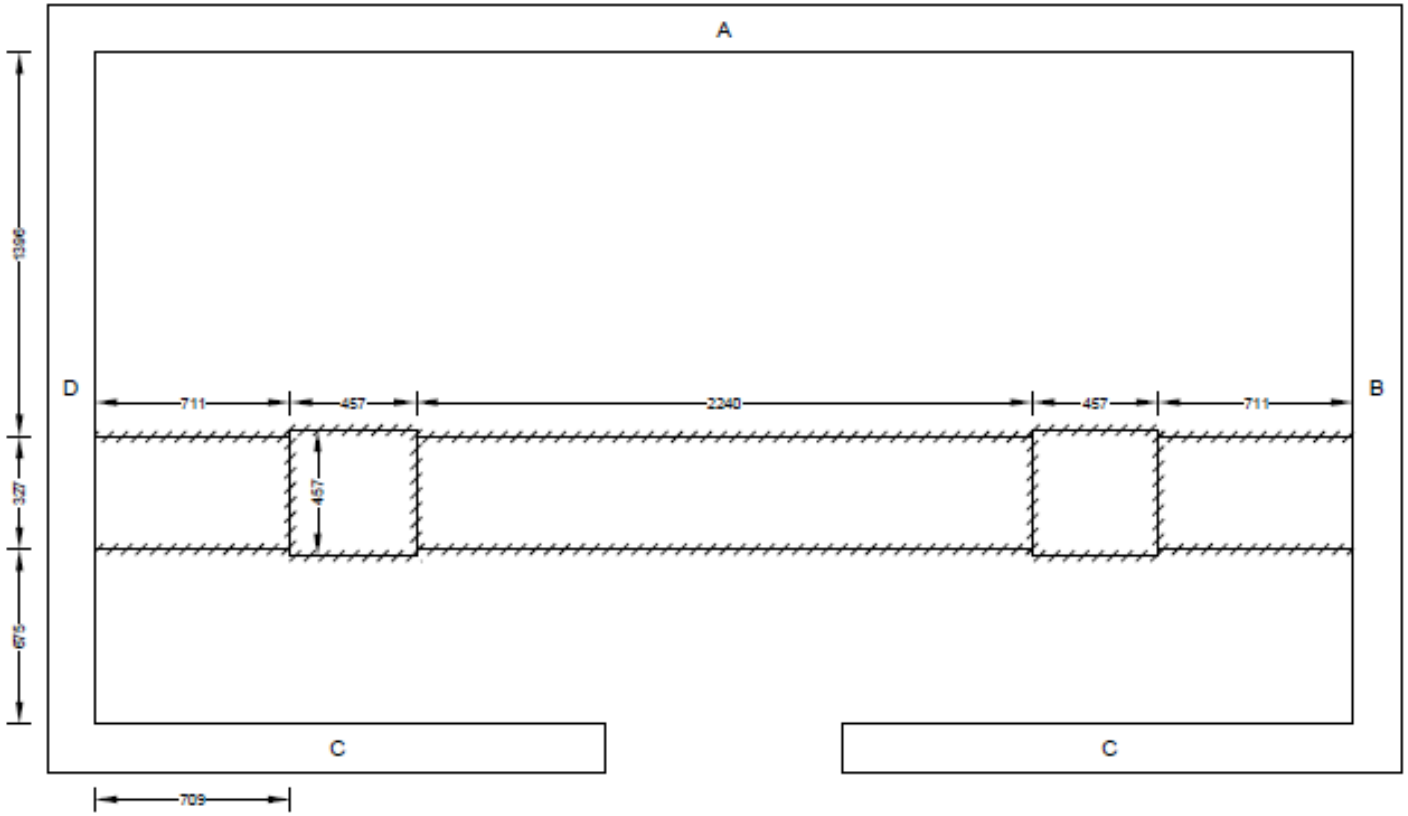

Exposed Surface

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wood WORKS!

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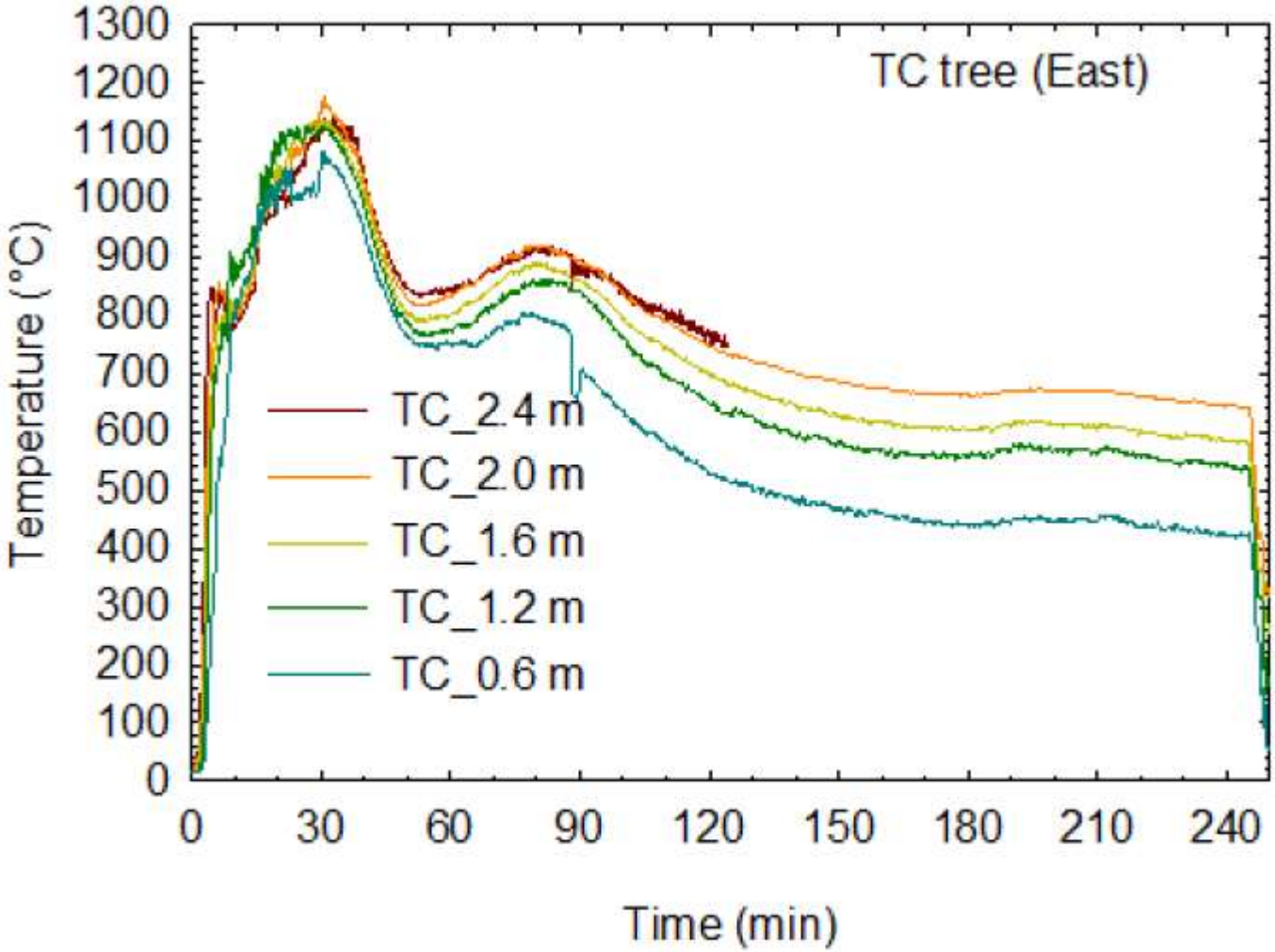

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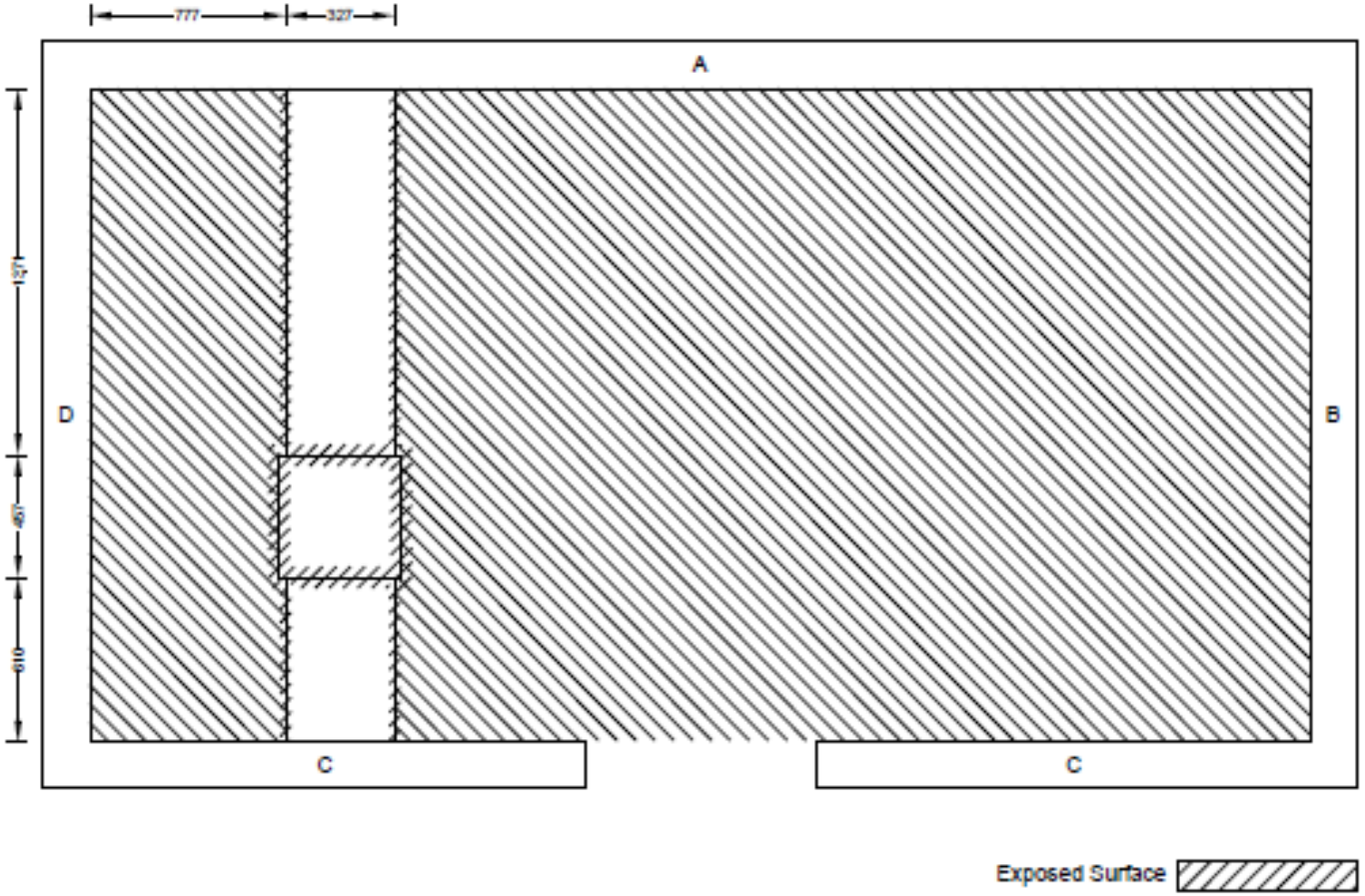

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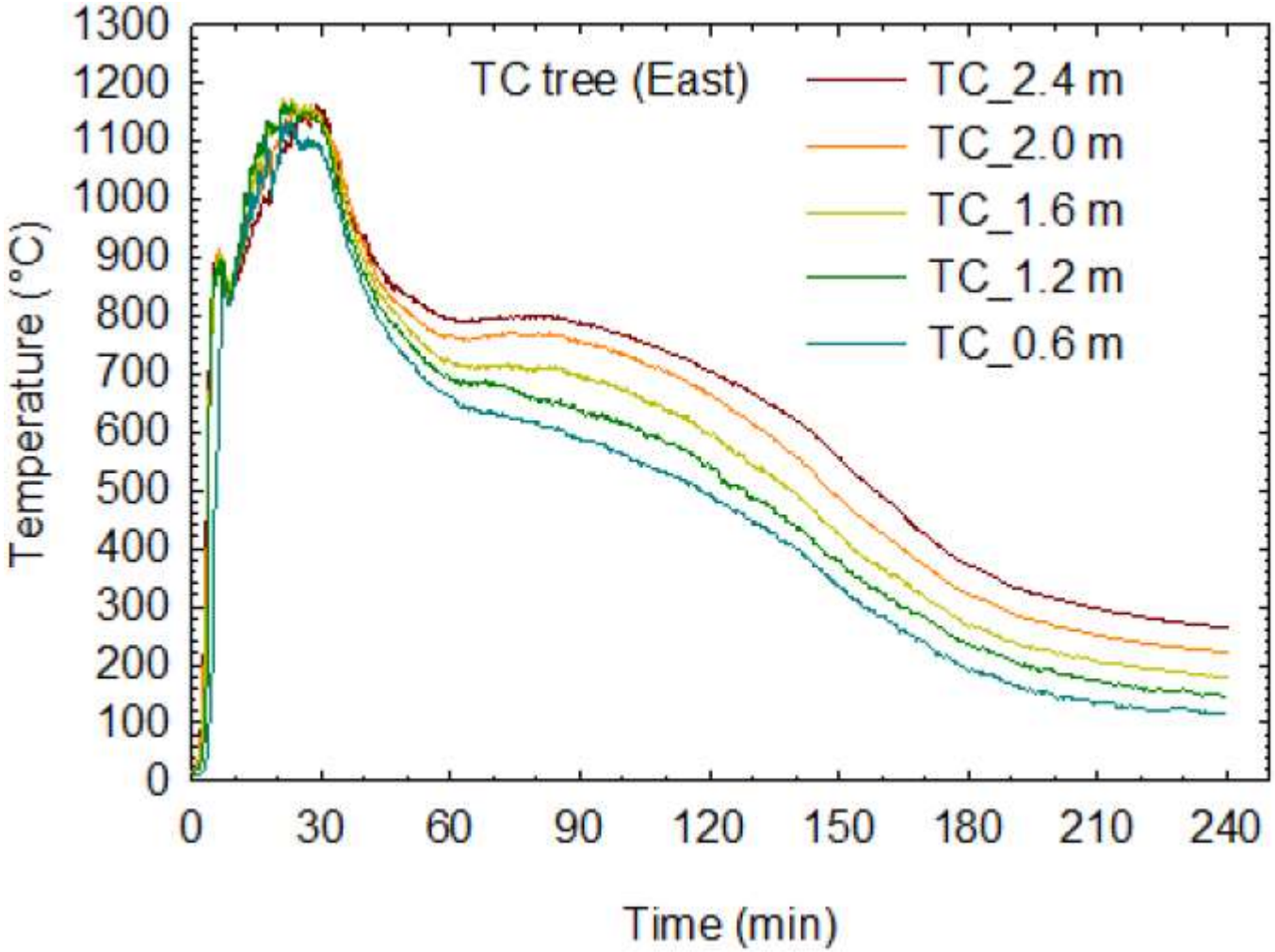

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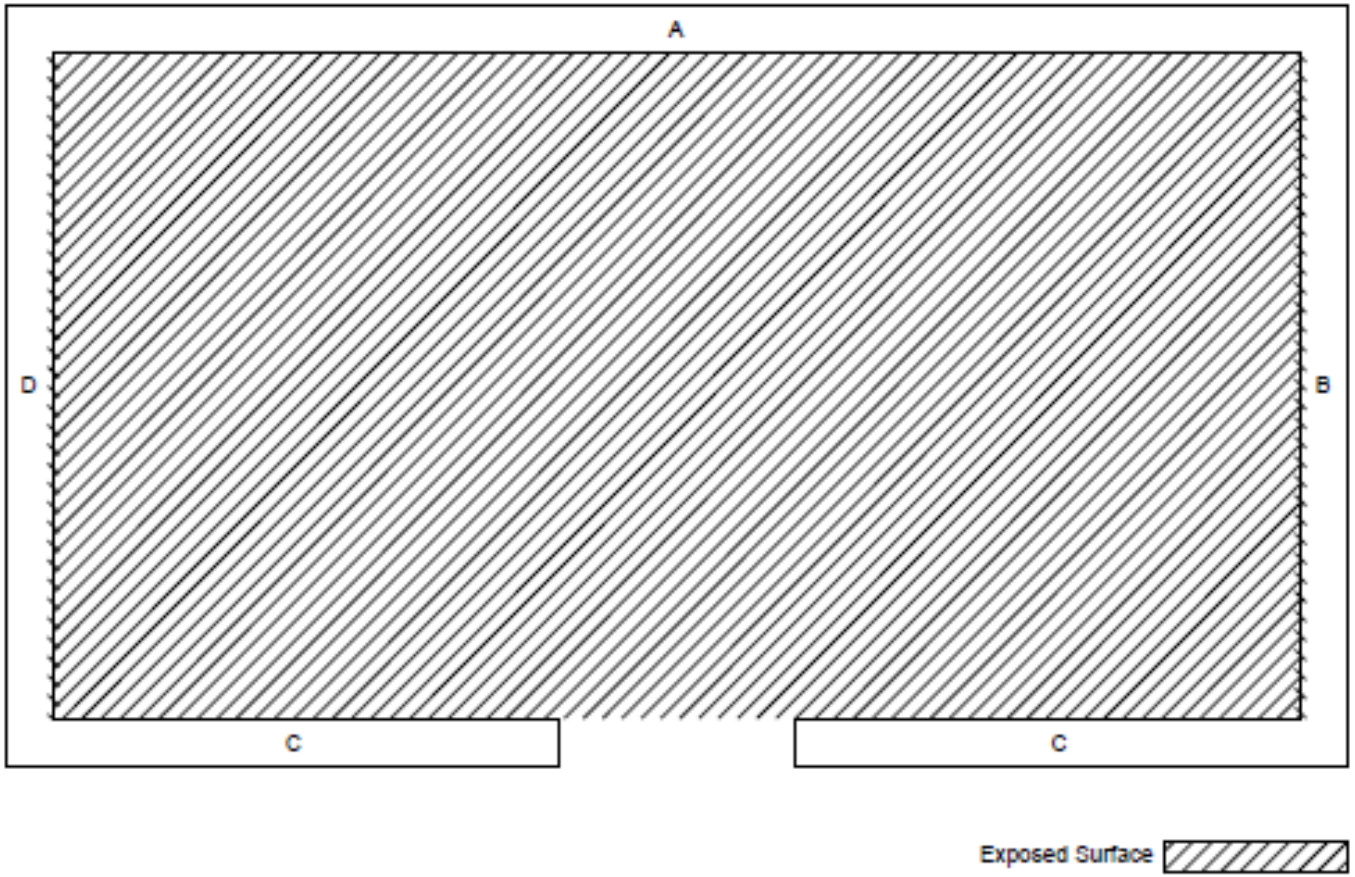

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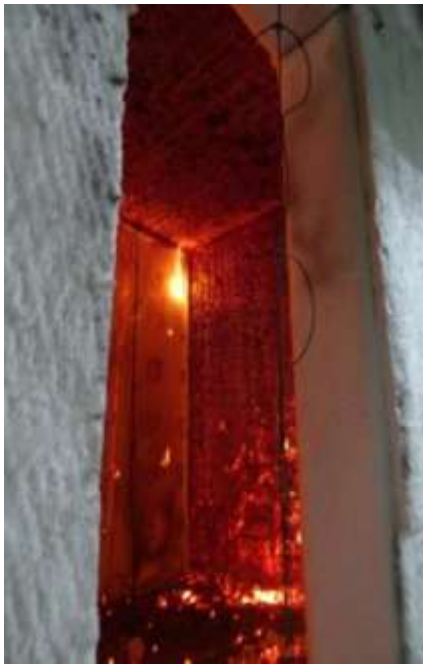

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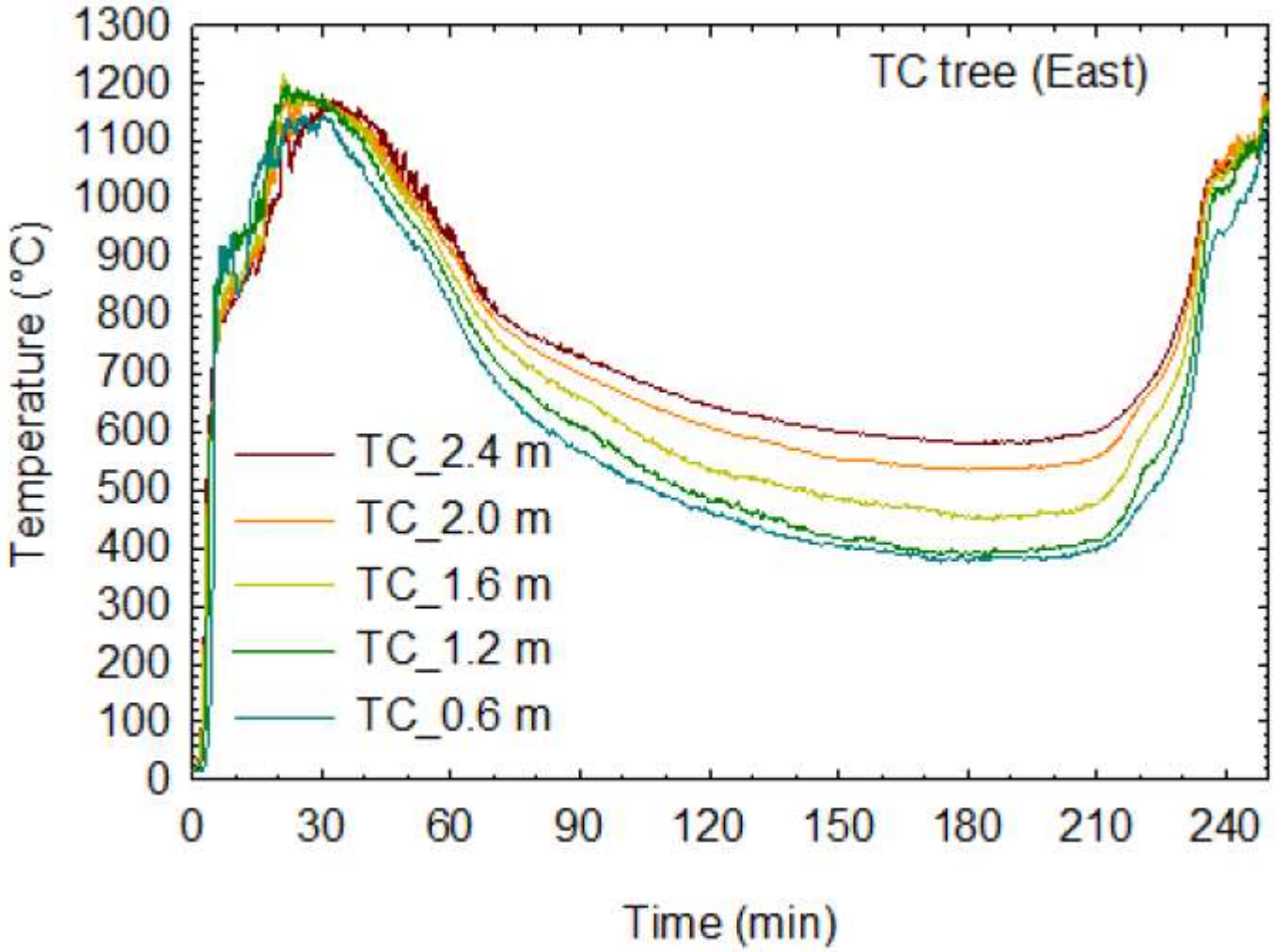

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Division B – 2020 NBC: Encapsulated Mass Timber Construction

Some mass timber surfaces permitted to remain exposed within a suite:

Exposed mass timber element	Max percentage of aggregate surface area of the total wall area of the perimeter of the suite or ceiling area	Flame spread rating	Other requirements
Beams, columns and arches	10%	150	Also permitted in a *fire compartment*
Walls	35%	150	Surfaces face the same direction
Combined beams, columns, arches and walls	35%	150	Wall surfaces face the same direction
Ceilings (option 1)	10%	150	-
Ceilings (option 2)	25%	75	No exposed walls

Division B – 2020 NBC: Encapsulated Mass Timber Construction

CWC proposed update to exposed mass timber in suites:

Exposed mass timber element	Max percentage of aggregate surface area of the total wall area of the perimeter of the suite or ceiling area	Flame spread rating	Other requirements
Beams, columns and arches	10% → 35%	150	Also permitted in a *fire compartment*
Walls	35%	150	Horizontal distance between surfaces is more than 4.5 m
Combined beams, columns, arches and walls	35%	150	Horizontal distance between wall surfaces is more than 4.5 m
Ceilings (option 1)	10%	150	-
Ceilings (option 2)	25%	75 → 150	No exposed walls
Ceilings (option 3)	100%	75	Decrease to 20% for beams, columns and arches

Thank You

wood WORKS!

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