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

National federation of associations
Canadian Wood Council

Represents Over 1000 Manufacturers
CWC - Principle Activities

Research
CWC - Principle Activities

Technical Information
CWC - Principle Activities

Technical Information:  www.cwc.ca

The Canadian Wood Council (CWC) is the national association representing manufacturers of Canadian wood products used in construction. The CWC enables the selling of Canadian wood products through programs and services focused on creating market access and demand.
CWC - Principle Activities

Codes & Standards
Proposed Changes for the 2020 NBC: Encapsulated Mass Timber Construction
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
“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.”

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 - ??
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*.”
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
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
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>
<thead>
<tr>
<th>Structural timber elements</th>
<th>Type of Dimension</th>
<th>Minimum Dimensions (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall, floor and roof assemblies</td>
<td>thickness/depth</td>
<td>96</td>
</tr>
<tr>
<td>Beams, columns and arches with 2-sided or 3-sided fire exposure</td>
<td>cross-section</td>
<td>192 x 192</td>
</tr>
<tr>
<td>Beams, columns and arches with 4-sided fire exposure</td>
<td>cross-section</td>
<td>224 x 224</td>
</tr>
</tbody>
</table>
### 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

<table>
<thead>
<tr>
<th>Structural Wood Elements</th>
<th>Minimum Thickness, mm</th>
<th>Minimum Width x Depth, mm x mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall that is a fire separation or exterior wall</td>
<td>96</td>
<td>-</td>
</tr>
<tr>
<td>Wall that requires a fire-resistance rating but is not a fire separation</td>
<td>192</td>
<td>-</td>
</tr>
<tr>
<td>Floors and Roofs</td>
<td>96</td>
<td>-</td>
</tr>
<tr>
<td>Beams, columns and arches (2- or 3-sided fire exposure)</td>
<td>-</td>
<td>192 x 192</td>
</tr>
<tr>
<td>Beams, columns and arches (4-sided fire exposure)</td>
<td>-</td>
<td>224 x 224</td>
</tr>
</tbody>
</table>
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 m²
  • Group D: 7,200 m²
Division B – 2020 NBC: Encapsulated Mass Timber Construction

Permitted – all storeys:
• Group C
• Group D
Division B – 2020 NBC: Encapsulated Mass Timber Construction

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
Division B – 2020 NBC: Encapsulated Mass Timber Construction

Limit height of uppermost floor level to 42 m above 1st floor

≤ 42 m
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Requirements for high building applicable to EMTC buildings over 18 m

≥ 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
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Exterior Cladding:
Division B – 2020 NBC:
Encapsulated Mass Timber Construction

Exterior Cladding:
Division B – 2020 NBC: Encapsulated Mass Timber Construction

Exterior Cladding:
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:

<table>
<thead>
<tr>
<th>Exposed mass timber element</th>
<th>Max percentage of aggregate surface area of the total wall area of the perimeter of the suite or ceiling area</th>
<th>Flame spread rating</th>
<th>Other requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beams, columns and arches</td>
<td>10%</td>
<td>150</td>
<td>Also permitted in a fire compartment</td>
</tr>
<tr>
<td>Walls</td>
<td>35%</td>
<td>150</td>
<td>Surfaces face the same direction</td>
</tr>
<tr>
<td>Combined beams, columns, arches and walls</td>
<td>35%</td>
<td>150</td>
<td>Wall surfaces face the same direction</td>
</tr>
<tr>
<td>Ceilings (option 1)</td>
<td>10%</td>
<td>150</td>
<td>-</td>
</tr>
<tr>
<td>Ceilings (option 2)</td>
<td>25%</td>
<td>75</td>
<td>No exposed walls</td>
</tr>
</tbody>
</table>
Division B – 2020 NBC: Encapsulated Mass Timber Construction

Two major mass timber fire testing done for EMTC

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

FINAL REPORT BY:

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February 2018

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

<table>
<thead>
<tr>
<th>Rough Opening in Wall W2</th>
<th>Compartment Surface</th>
<th>Test</th>
<th>CLT Compartment</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.8 m wide x 2.0 m high</td>
<td>9.1 m x 2.7 m</td>
<td>3GB</td>
<td>1</td>
<td>Feb. 16</td>
</tr>
<tr>
<td></td>
<td>4.6 m x 2.7 m</td>
<td>3GB</td>
<td>1-4*</td>
<td>Mar. 21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>exposed</td>
<td>1*</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9.1 m x 2.7 m</td>
<td>3GB</td>
<td>1-5</td>
<td>Apr. 13</td>
</tr>
<tr>
<td></td>
<td>4.6 m x 2.7 m</td>
<td>3GB</td>
<td>4</td>
<td>Apr. 18</td>
</tr>
<tr>
<td></td>
<td>9.1 m x 4.6 m</td>
<td>3GB</td>
<td>3</td>
<td>Apr. 18</td>
</tr>
<tr>
<td>3.6 m wide x 2.0 m high</td>
<td>9.1 m x 2.7 m</td>
<td>3GB</td>
<td>1-2</td>
<td>Feb. 23</td>
</tr>
<tr>
<td></td>
<td>4.6 m x 2.7 m</td>
<td>3GB</td>
<td>1-3*</td>
<td>Mar. 16</td>
</tr>
<tr>
<td></td>
<td>9.1 m x 4.6 m</td>
<td>3GB</td>
<td>2</td>
<td>Mar. 16</td>
</tr>
</tbody>
</table>

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.

The graph shows the heat release rate (HRR) and total heat release (THR) over time for different tests. The graph includes the following data:

- HRR Test 1-2
- HRR Test 1-1
- THR Test 1-2
- THR Test 1-1

The x-axis represents time (min) and the y-axis represents heat release rate (MW) and total heat release (MJ). The graph illustrates the heat release pattern and total heat release for each test.

Graph showing heat release rate (MW) against time (min). The baseline and test 1-3 curves are compared.

Images of burning structures are included to illustrate the fire tests.

![Graph showing heat release rate over time for wide and narrow openings in different tests.](image)
Standard for Performance-Rated Cross-Laminated Timber
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
Fire Testing of Rooms with Exposed Wood Surfaces in Encapsulated Mass Timber Construction
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<table>
<thead>
<tr>
<th>Test</th>
<th>CLT Wall A (4.5 m x 2.7 m)</th>
<th>CLT Wall B (2.4 m x 2.7 m)</th>
<th>CLT Wall C (4.5 m x 2.7 m)</th>
<th>CLT Wall D (2.4 m x 2.7 m)</th>
<th>CLT Ceiling (4.5 m x 2.4 m)</th>
<th>CLT Floor (4.5 m x 2.4 m)</th>
<th>Glulam Beam (327 mm x 457 mm)</th>
<th>Glulam Column (457 mm x 457 mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3GB</td>
<td>3GB</td>
<td>3GB</td>
<td>3GB</td>
<td>3GB</td>
<td>3GB</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>exposed (= 33% of perimeter)</td>
<td>2GB</td>
<td>2GB</td>
<td>2GB</td>
<td>10% exposed 90% 2GB</td>
<td>2GB</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>2GB</td>
<td>2GB</td>
<td>2GB</td>
<td>2GB</td>
<td>2GB</td>
<td>2GB</td>
<td>exposed (4.54 m² = 11.5% of perimeter)</td>
<td>exposed (9.62 m² = 24.5% of perimeter)</td>
</tr>
<tr>
<td>4</td>
<td>2GB</td>
<td>2GB</td>
<td>2GB</td>
<td>2GB</td>
<td>100% exposed</td>
<td>2GB</td>
<td>exposed (2.46 m² = 6.4% of perimeter)</td>
<td>exposed (4.81 m² = 12.6% of perimeter)</td>
</tr>
<tr>
<td>5</td>
<td>2GB</td>
<td>exposed (= 17.5% of perimeter)</td>
<td>2GB</td>
<td>exposed (=17.5% of perimeter)</td>
<td>100% exposed</td>
<td>2GB</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

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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<td>10%</td>
<td>150</td>
<td>Also permitted in a <em>fire compartment</em></td>
</tr>
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<td>35%</td>
<td>150</td>
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<tr>
<td>Combined beams, columns, arches and walls</td>
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<td>150</td>
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</tr>
<tr>
<td>Ceilings (option 1)</td>
<td>10%</td>
<td>150</td>
<td>-</td>
</tr>
<tr>
<td>Ceilings (option 2)</td>
<td>25%</td>
<td>75</td>
<td>No exposed walls</td>
</tr>
</tbody>
</table>
Divison B – 2020 NBC: Encapsulated Mass Timber Construction
CWC proposed update to exposed mass timber in suites:

<table>
<thead>
<tr>
<th>Exposed mass timber element</th>
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<th>Flame spread rating</th>
<th>Other requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beams, columns and arches</td>
<td>10% → <strong>35%</strong></td>
<td>150</td>
<td>Also permitted in a fire compartment</td>
</tr>
<tr>
<td>Walls</td>
<td>35%</td>
<td>150</td>
<td>Horizontal distance between surfaces is more than 4.5 m</td>
</tr>
<tr>
<td>Combined beams, columns, arches and walls</td>
<td>35%</td>
<td>150</td>
<td>Horizontal distance between wall surfaces is more than 4.5 m</td>
</tr>
<tr>
<td>Ceilings (option 1)</td>
<td>10%</td>
<td>150</td>
<td>-</td>
</tr>
<tr>
<td>Ceilings (option 2)</td>
<td>25% → <strong>150</strong></td>
<td></td>
<td>No exposed walls</td>
</tr>
<tr>
<td><strong>Ceilings (option 3)</strong></td>
<td><strong>100%</strong></td>
<td>75</td>
<td>Decrease to 20% for beams, columns and arches</td>
</tr>
</tbody>
</table>
Thank You