World Conference on Timber Engineering Oslo 2023

TALL WOOD BUILDINGS WITHIN THE 2020 NATIONAL BUILDING CODE OF CANADA

Marc Alam[1], Rodney McPhee[1]

ABSTRACT: In the past decade, many examples have been seen where large and tall buildings of mass timber construction have been built around the world, including here in North America. This paper summarizes the approved provisions within the 2020 National Building Code of Canada (NBC) to allow tall wood buildings up to 12 storeys. The paper will include discussion about the historical precedent of moving away from the NBC prescriptive approach of recognizing only two primary types of construction ─ combustible and noncombustible construction ─ and provide details introducing a new third type of construction called 'encapsulated mass timber construction' (EMTC), which is required to be used for these tall wood buildings. This includes details on current fire research on mass timber construction and the proposed new prescriptive fire protection requirements introducing EMTC within the 2020 NBC.

KEYWORDS: Tall wood buildings, 2020 National Building Code of Canada, Encapsulated mass timber construction

1 INTRODUCTION

The Canadian Commission on Building and Fire Codes (CCBFC), approved changes in the 2020 National Building Code (NBC) to allow construction of tall wood buildings up to 12 storeys in height. This proposal includes a new construction type called 'encapsulated mass timber construction' (EMTC). EMTC is generally defined as a type of construction where a degree of safety is attained through a combination of prescribed minimum sizes of structural mass timber elements and a minimum time for these elements to be protected from fire (encapsulated) using a noncombustible protective membrane.

2 NBC CONSTRUCTION TYPES

2.1 EXISTING CONSTRUCTION TYPES

The 2015 NBC contained two primary construction types: noncombustible and combustible construction. These construction types have been in the NBC since the 1960s. '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*' [1] (e.g., concrete, steel, masonry). 'Combustible construction' means '*that type of construction that does not meet the requirements for noncombustible construction*' [1] (e.g., wood frame, masonry joist, etc.). There is a subset of combustible construction referenced in the NBC known as 'Heavy Timber Construction' that is defined as '*that type of combustible construction in which a degree of fire safety is attained by placing limitations on the sizes of wood structural members and on the thickness and composition of wood floors and roofs and by the avoidance of concealed spaces under floors and roofs*' [1].

Buildings of noncombustible construction can be of unlimited height and unlimited area when they are designed with a 2-hour structural fire-resistance rating and sprinklered throughout. Buildings of combustible construction are limited to a maximum building height of six storeys, with a maximum six storey building area of 1,500 m^2 (16,145 ft^2) for residential occupancies or 3,000 m^2 (32,290 ft^2) for business and personal services occupancies, when they are designed with a 1-hour structural fire-resistance rating and sprinklered throughout.

2.2 NEW CONSTRUCTION TYPE

The Canadian Wood Council submitted a Code Change Request (CCR) package to the CCBFC in 2016 to introduce provisions in the NBC permitting tall wood buildings above six storeys when constructed with a new construction type called 'Encapsulated Mass Timber Construction' (EMTC). The CCR package was reviewed by the CCBFC Standing Committee on Fire Protection (SC-FP). The SC-FP is made up of volunteers chosen for their fire protection expertise to represent all facets of the construction industry from across Canada. Following lengthy discussions and analysis, the SC-FP developed revised wordings for the proposed changes, which were posted for review and comment as part of three public reviews in 2017, 2018, and 2019. In resolving the public comments, the final wording of the changes were

[1]Marc Alam, Canadian Wood Council, Canada, malam@cwc.ca
[1]Rodney McPhee, Canadian Wood Council, Canada, rmcphee@cwc.ca

https://doi.org/10.52202/069179-0392

approved by the SC-FP and recommended to the CCBFC to be included in the 2020 NBC.

EMTC 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*' [2]. In simple terms, EMTC is defined as the combination of two components: encapsulation rating and minimum dimensions of structural mass timber members.

2.2.1 Encapsulation Rating

The first component of EMTC, the 'encapsulation rating', is defined as '*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*' [2]. The encapsulation rating is determined using a new standard fire test method, CAN/ULC-S146 "*Standard Method of Test for the Evaluation of Encapsulation Materials and Assemblies of Materials for the Protection of Mass Timber Structural Members and Assemblies*" [3]. The fire exposure conditions used in this new test method is the same as the standard time-temperature curve (see Figure 1) from CAN/ULC-S101, "*Standard Methods of Fire Endurance Tests of Building Construction and Materials*" [4]. This is the same time-temperature curve from ASTM E119, "*Standard Test Methods for Fire Tests of Building Construction and Materials*" [5], and similar to time-temperature curve from ISO 834, "*Fire-Resistance Tests*" [6] (see Figure 1).

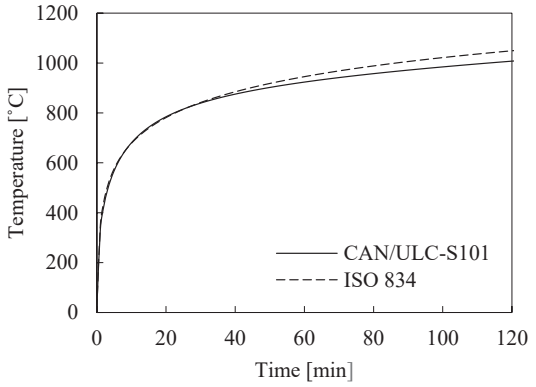

Figure 1: *CAN/ULC-S101 and ISO 834 standard time-temperature curves*

In CAN/ULC-S146, the encapsulation material or assembly of materials are applied to a timber substate and tested within a horizontal furnace with a minimum specimen size of 3.66 m (12 ft) x 3.66 m (12 ft). Unless otherwise prescribed, the encapsulation material or assembly of materials must be noncombustible and is assigned an encapsulation rating that relates to the lesser of the times at which an average temperature rise of 250°C (482°F) or a maximum temperature rise of 270°C (518°F) is recorded at the interface (see Figure 2) of the encapsulation material(s) and the wood substrate that is part of the test specimen.

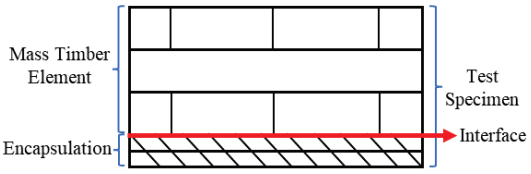

Figure 2: *Temperature interface location in the test specimen*

The minimum encapsulation rating prescribed by the NBC for EMTC is 50 minutes, but in some special cases, a 25-minute rating is permitted. The 2020 NBC provisions also include specifications that describe generic materials that are otherwise deemed to meet the 50-minute encapsulation rating: 2 layers of not less than 12.7 mm (1/2 in) thick Type X gypsum board and not less than 38 mm (1-1/2 in) thick gypsum-concrete or concrete topping. Type X gypsum board, conforming to ASTM C1396 "*Standard Specification for Gypsum Board*" [5], is a fire-resistant board that is manufactured with glass fibre reinforcements and other additives to help limit thermal degradation due to fire exposure [8].

2.2.2 Minimum Dimensions for Timber Members

The second component of EMTC, the minimum dimensions required for the structural mass timber members are shown in Table 1:

Table 1: *Minimum dimensions of mass timber elements*

Structural Wood Elements	Minimum Thickness, mm	Minimum Width × Depth, mm × mm
Wall that is a fire separation or exterior wall (1-sided exposure)	96	-
Wall that requires a fire-resistance rating but is not a fire separation (2-sided exposure)	192	-
Floors and Roofs (1-sided exposure)	96	-
Beams, columns and arches (2- or 3-sided fire exposure)	-	192 × 192
Beams, columns and arches (4-sided fire exposure)	-	224 × 224

Note: Fire separation means a construction assembly that acts as a barrier against the spread of fire [2].

These minimum dimensions are prescribed to increase the likelihood that the timber elements, once they are burning, will exhibit the fire performance characteristics of mass timber rather than of lightweight, small-dimensioned wood elements. This means that after initiation of charring, the timber elements will still be thermally thick for the required fire-resistance rating period [7].

3 CODE REQUIREMENTS

3.1 HEIGHTS AND AREA

The 2020 NBC provisions prescribe the height and area limits for buildings constructed of EMTC. Building height (in storeys) is defined as '*the number of storeys contained*

https://doi.org/10.52202/069179-0392

between the roof and the floor of the first storey.' [1] The building height limit is 12 storeys, with a 42-meter (138-foot) physical height limit (see Figure 3) that is also mandated for the building, which is measured between the floor of the first storey and the uppermost floor level. The first storey is defined as '*the uppermost storey having its floor level not more than 2 m (6.5 ft) above the lowest of the average levels of finished ground adjoining each exterior wall of the building.*'

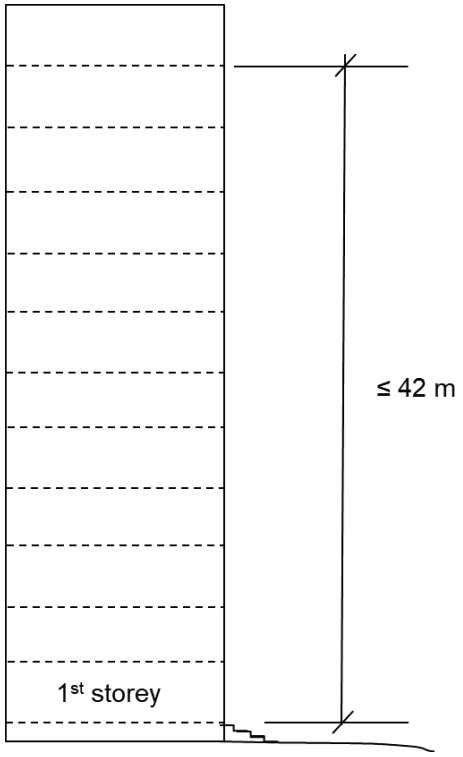

Figure 3: *Physical height limit of EMTC buildings*

Building area means '*the greatest horizontal area of a building above grade within the outside surface of exterior walls or within the outside surface of exterior walls and the centre line of firewalls'* [1]. For buildings constructed of EMTC, the maximum building area for any building height is 6,000 m^2 (64,585 ft^2) for a residential occupancy and 7,200 m^2 (77,500 ft^2) for a business and personal services occupancy.

3.2 FIRE-RESISTANCE AND SPRINKLERING

Fire-resistance ratings within the NBC are determined on the basis of results of standard fire tests conducted in conformance with CAN/ULC-S101 [4]. Within buildings constructed of EMTC, floor assemblies are required to be fire separations, with a fire-resistance rating of not less than 2 hours, and mezzanines shall have a fire-resistance rating of at least 1 hour. Loadbearing walls, columns and arches shall have a fire-resistance rating not less than that required for the supported assembly.

Buildings constructed of EMTC are required to be sprinklered throughout, with the automatic sprinkler system designed in accordance with NFPA 13, "*Standard for the Installation of Sprinkler Systems*" [8].

3.3 OCCUPANCY TYPES

The NBC classifies occupancy (building use) types within 6 different Groups. The main occupancy types permitted on all storeys in buildings constructed of EMTC are Group C, residential and Group D, business and personal services occupancies. Other occupancy types are permitted on the lower storeys as follows: Group E, mercantile occupancy, on the first and second storey, Group A2, assembly occupancy, up to the third storey, and storage garages up to the fourth storey. In addition, Group F2 and F3, medium- and low-hazard industrial occupancies are permitted on the first and second storeys of buildings with a Group D occupancy (See Figure 4).

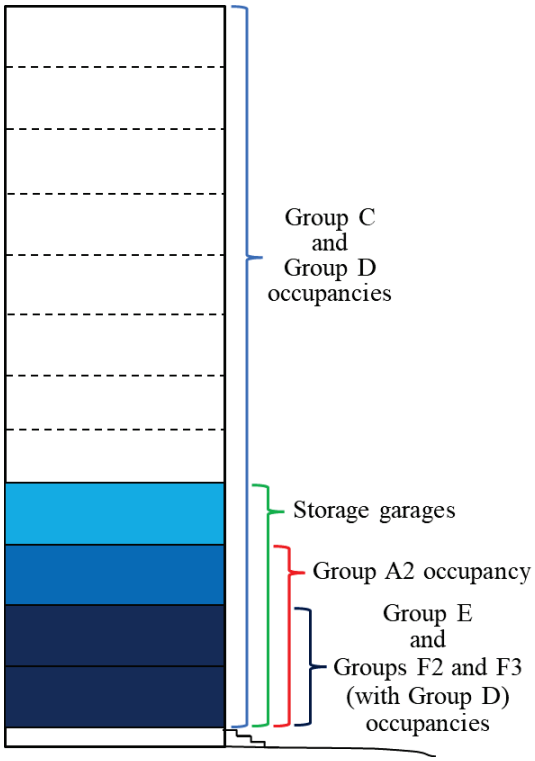

Figure 4: *Allowable occupancy type locations*

3.4 COMBUSTIBLE MATERIALS PERMITTED

Combustible materials are permitted within buildings of EMTC. These include combustible roofing materials, window sashes and frames, exterior cladding, components in exterior walls, nailing elements, stairs, interior finishes, elements in partitions, raised wood floors, concealed spaces, and non-loadbearing wood frame partitions. The provisions regarding combustible components that require more detail are explained below.

3.4.1 Exterior Cladding

Generally, exterior walls and cladding on a building constructed of EMTC shall be noncombustible. Cladding on wall assemblies tested in accordance with CAN/ULC-

https://doi.org/10.52202/069179-0392

S134, "*Fire Test of Exterior Wall Assemblies*" [11] is also permitted, along with some very limited amounts of combustible cladding that are arranged in accordance with three specific design approaches.

CAN/ULC-S134

The CAN/ULC-S134 methodology is a full-scale standard fire test for exterior walls. This fire test evaluates fire spread on the exterior of buildings that have combustible cladding or other combustible components within the exterior wall.

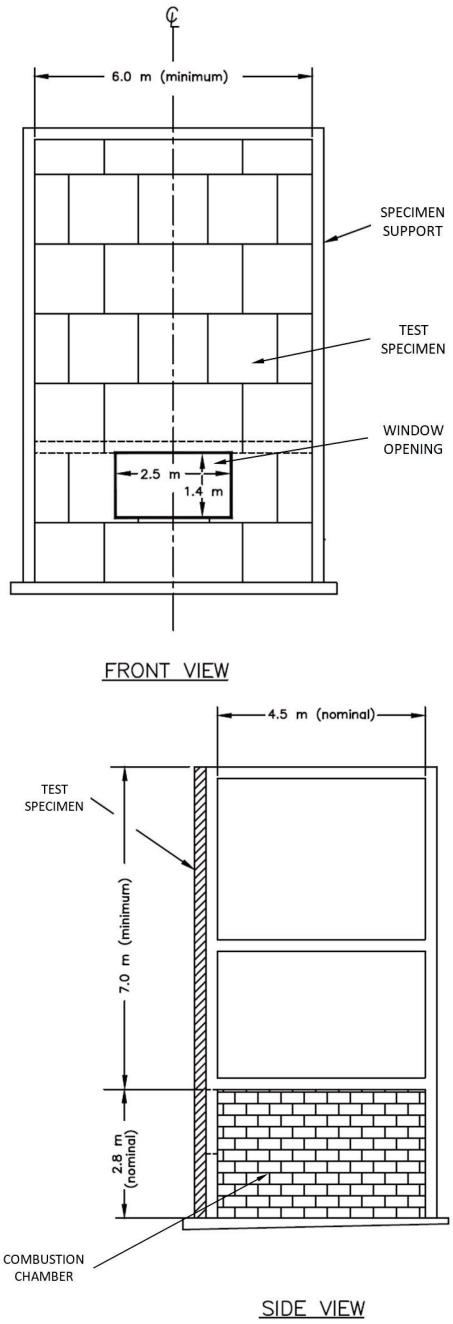

Figure 5: *Typical CAN/ULC-S134 test facility* [11]

The test facility (see Figures 5 and 7) consists of a façade with a minimum 6 m (19.7 ft) width and 9.5 m (31.2 ft) height. The burn room located on the lowest level is 6 m (19.7 ft) wide by 4.5 m (14.8 ft) deep by 2.8 m (9.2 ft) high with a 2.5 m (8.2 ft) wide by 1.4 m (4.6 ft) high window opening. The mass flow rate of gas (shown in Figure 6) shall be adjusted throughout a period of 25 min followed by an observation period of 35 min. From the start of the test (ignition), the gas flow is increased linearly for 5 min, followed by a 15 min steady state period, followed by another 5 min period of linear decrease to zero.

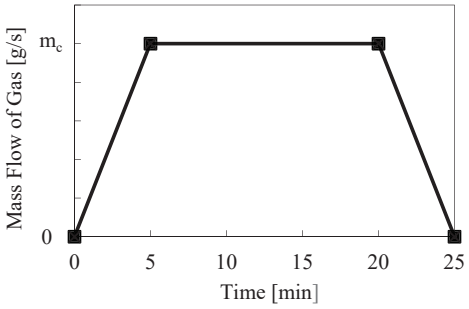

Figure 6: *Mass flow of gas vs time* [11]

The steady mass flow rate of gas, m_c, consists of flames emerging from the opening exposing the outer face of the wall to a heat flux density of 45 ± 3 kW/m^2 at 0.5 m above the top of the opening and 27 ± 2 kW/m^2 at 1.5 m above the top of the opening.

Figure 7: *Example CAN/ULC-S134 test*

Exterior combustible cladding and combustible exterior wall assemblies tested in accordance with CAN/ULC-S134 shall be permitted in buildings constructed of EMTC if they satisfy the following criteria: flaming on or in the

https://doi.org/10.52202/069179-0392

wall assembly does not spread more than 5 m (16.4 ft) above the opening and the heat flux during the flame exposure on the wall assembly is not more than 35 kW/m^2 measure at 3.5 m (11.5 ft) above the opening [1]. The 2020 NBC will include descriptions of generic exterior wall assemblies deemed to satisfy the criteria. These assemblies are shown in Table 2.

Table 2: *Generic CAN/ULC-S134 exterior wall assemblies* [2]

Structural Members	Absorptive Material	Sheathing	Cladding
38 mm × 89 mm wood studs spaced at 400 mm o.c.	89 mm thick rock or slag fibre in cavities formed by studs	-	12.7 mm thick fire-retardant-treated plywood siding
140 mm thick rock or slag fibre in cavities formed by studs	140 mm thick rock or slag fibre in cavities formed by studs	Gypsum sheathing ≥ 12.7 mm thick	Noncombustible exterior cladding
38 mm × 140 mm wood studs spaced at 400 mm o.c.	140 mm thick rock or slag fibre in cavities formed by studs	15.9 mm thick fire-retardant-treated plywood	Noncombustible exterior cladding
38 mm × 140 mm wood studs spaced at 600 mm o.c. attached CLT wall panels ≥ 38 mm thick	140 mm thick glass, rock or slag fibre in cavities formed by studs	Gypsum sheathing ≥ 12.7 mm thick	Noncombustible exterior cladding
89 mm horizontal Z-bars spaced at 600 mm o.c. attached to CLT wall panels ≥ 105 mm thick	89 mm thick rock or slag fibre in cavities formed by Z-bars	-	Noncombustible exterior cladding attached to 19 mm vertical hat channels spaced at 600 mm o.c.

Combustible Cladding

As noted earlier, along with noncombustible cladding and cladding on walls tested in accordance with CAN/ULC-S134, the 2020 NBC will permit three approaches to allow the use of combustible cladding on exterior walls of buildings constructed of EMTC.

The first approach allows for not more than a 10% portion of the exterior cladding on each storey to be combustible and any such portion shall not be contiguous over more than 4 storeys. With this approach, each contiguous combustible cladding portion shall have a maximum width of 1.2 m (3.9 ft). They must also be separated from other portions on the same storey by a horizontal distance of not less than 1.2 m (3.9 ft) and from other portions on the adjacent storeys by a horizontal distance of not less than 2.4 m (7.9 ft). The combustible cladding shall have a flame-spread rating of 75 when tested to CAN/ULC-S102, "*Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies*" [12]. Flame-spread rating means '*an index or classification indicating the extent of spread-of-flame on the surface of a material or an assembly of materials as determined in the standard fire test*' [1].

The second approach also allows for not more than a 10% portion of the exterior cladding on each storey to be combustible, and does not impose the 1.2 m width limit, but any such portion shall not be contiguous across adjacent storeys. As such, the maximum total width of any portion (aggregate width for multiple portions on the same storey) is limited to 10% of the storey width. For portions on adjacent storeys, they shall be separated by a distance of not less than 2.4 m (7.9 ft). Similarly, the combustible cladding shall have a flame-spread rating of 75 when tested to CAN/ULC-S102.

The third approach allows for up to 100% of the cladding on exterior walls of the first storey, provided all of the combustible cladding can be directly accessed and are located not more than 15 m (49.2 ft) from a street or access route, measured horizontally from the face of the building [2].

These approaches can be applied individually or in combination as shown in Figure 8. All other portions of cladding that are not combustible are required to be noncombustible or tested in accordance with CAN/ULC-S134.

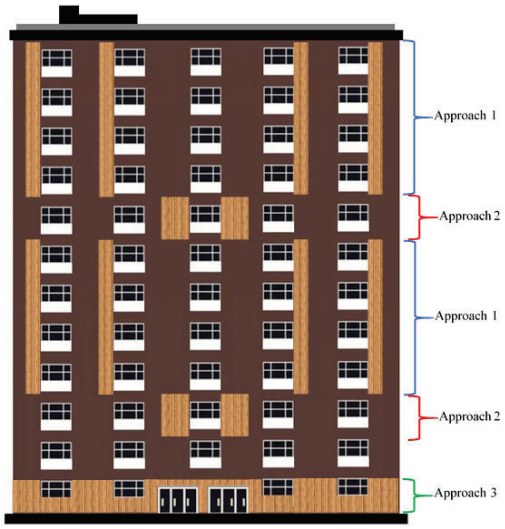

Figure 8: *Example of combustible cladding approaches on buildings constructed of EMTC*

3.4.2 Concealed Spaces

Concealed spaces within structural mass timber elements are permitted in buildings constructed of EMTC. For one example, see Figure 9, where the two mass timber floor slabs are separated by mass timber beams creating a concealed space.

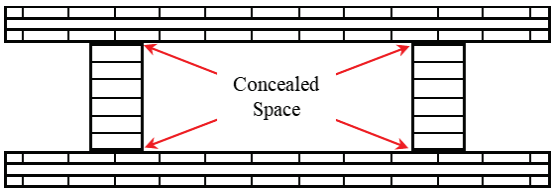

Figure 9: *Example of concealed space in mass timber elements*

These concealed spaces shall be provided with one of the following protective measures set out in the 2020 NBC [2]:

https://doi.org/10.52202/069179-0392

1. Sprinklered and divided into compartments by fire blocks.
2. Completely filled with rock or slag fibre insulation conforming to CAN/ULC-S702, "*Mineral Fibre Thermal Insulation for Buildings*," [13] and having a density of not less than 32 kg/m^3.
3. If horizontal (e.g., floor element), lined with not less than one layer of 12.7 mm (1/2 in) Type X gypsum board or noncombustible material providing an encapsulation rating of not less than 25 min.
4. If vertical (e.g., wall element), lined with not less than one layer of 12.7 mm (1/2 in) Type X gypsum board or noncombustible material providing an encapsulation rating of not less than 25 min and vertically divided into compartments by fire blocks.

Concealed spaces are also permitted where wood nailing elements are used for the attachment of a material or assembly of materials to provide an encapsulation rating in a building constructed of EMTC, provided the concealed space created by the wood nailing elements is not more than 25 mm (1 in) deep as shown in Figure 10.

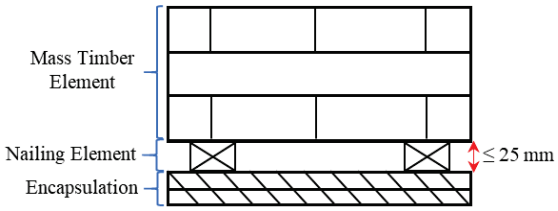

Figure 10: *Maximum depth of concealed space created by wood nailing elements*

Unlike any concealed spaces found within mass timber elements, these concealed spaces will not need to be protected.

3.4.3 Combustible Elements in Partitions

Combustible partitions, which do not enclose exits or vertical service spaces, are permitted in buildings constructed of EMTC. The partitions shall consist of solid lumber not less than 38 mm (1.5 in) thick or wood framing. Protection shall be provided on each face of the partitions. The protection shall consist of one layer of 12.7 mm (1/2 in) thick Type X gypsum board, with all joints either backed or taped and filled, or one layer of 19 mm (3/4 in) thick fire-retardant-treated wood. If fire-retardant-treated wood is used on partitions containing wood framing, the wood stud cavities shall be filled with noncombustible insulation.

3.5 DAMAGE OR REMOVED ENCAPSULATION MATERIAL

In the 2020 National Fire Code of Canada (NFC) [14], there is a new requirement for buildings constructed of EMTC for encapsulation material or assembly of materials if they are damaged or removed such that their integrity is compromised. The 2020 NFC requires that these damaged or removed encapsulation materials or assembly of materials be repaired or replaced in conformance with the 2020 NBC to restore their encapsulation rating.

3.6 PROTECTION DURING CONSTRUCTION

To address safety during construction, the 2020 NFC requires that protective encapsulation be installed in different locations within buildings constructed of EMTC. The encapsulation material or assembly or materials will need to provide an encapsulation rating of not less than 25 min. This rating can be met with one layer of not less than 12.7 mm (1/2 in) thick Type X gypsum board.

The encapsulation will be required to be installed on 100% of the interior side of mass timber stairways and vertical service spaces, and on each face of solid lumber, mass timber or wood framing partitions. In addition, 80% of the area of the underside of the mass timber floor assembly on each storey and 65% of the total area of structural mass timber within the storey will need to be encapsulated during construction [14].

To allow for quick construction of buildings of EMTC, the NFC permits that not more than the four uppermost contiguous storeys to be unprotected during construction. For example, for a 7 storey EMTC building under construction, the first 3 storeys would need to be encapsulated and top 4 storeys can be unprotected. To be able to construct the 8th storey, the first 4 storeys would be protected.

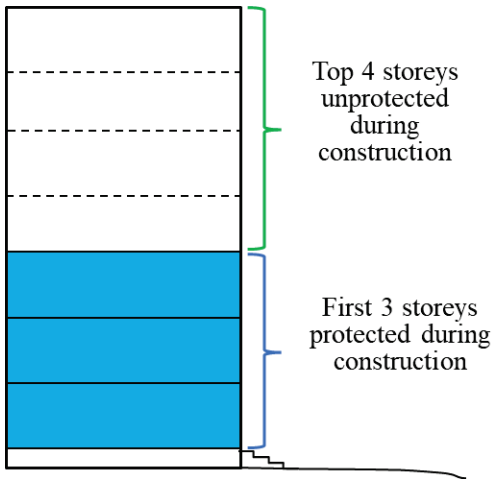

Figure 11: *Example of protection during construction*

3.7 EXPOSED MASS TIMBER

Exposed mass timber elements are permitted in buildings constructed of EMTC. There are limits to the percentage of exposed mass timber walls, beams, columns, arches, and ceilings that may be within either suites or fire compartments within the buildings. A suite means "*a single room or series of rooms of complementary use, operated under a single tenancy, and includes dwelling units, individual guest rooms in motels, hotels, boarding houses, rooming houses and dormitories as well as individual stores and individual or complementary rooms*

https://doi.org/10.52202/069179-0392

for business and personal services occupancies" and a fire compartment means "*an enclosed space in a building that is separated from all other parts of the building by enclosing construction providing a fire separation having a required fire-resistance rating*" [1].

For exposed surfaces of mass timber walls within a suite, they need not be protected if their aggregate surface area does not exceed 35% of the total wall area of the perimeter of the suite in which they are located and each exposed surface faces the same direction [2]. An example of a residential suite with exposed mass timber walls is shown in Figure 12. The surrounding blue rectangle is considered the perimeter of the suite and the total wall area around the perimeter would be used to find the percent of exposed mass timber permitted within the suite. The green lines are the location of the exposed walls within the suite. They represent less than 35% of the total wall area of the perimeter of the suite. Also, the exposed surfaces all face the same direction, as represented in Figure 12 where the green lines are drawn on the right side of each wall.

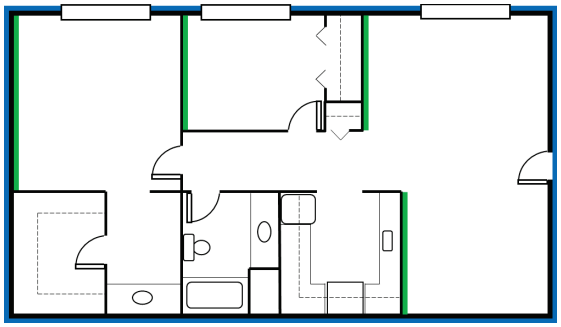

Figure 12: *Example of residential suite with exposed mass timber walls*

The exposed mass timber walls will also be required to have a flame-spread rating not more than 150.

Similarly, exposed surfaces of mass timber beams, columns, and arches within either a suite or fire compartment can be unprotected if their combined aggregate surface area does not exceed 10% of the total wall area of the perimeter of the suite or fire compartment [2]. They also will be required to have a flame-spread rating not more than 150.

The combined exposed surfaces of mass timber walls, beams, columns, and arches within a suite shall not exceed 35% of the total wall area of the perimeter of the suite. For example, if the suite has exposed mass timber beams, columns, and arches that represent the maximum 10% of the total wall area of the perimeter of the suite, then exposed mass timber walls are only permitted to have the remaining 25% of the total wall area of the perimeter of the suite be exposed, for a total of 35%.

Exposed surfaces of mass timber ceilings will have two options to allow for them to be unprotected within suites. The first option for exposed surfaces of mass timber ceilings is where the aggregate area does not exceed 10% of the total ceiling area of the suite and the exposed surfaces have a flame-spread rating not more than 150. In this case, mass timber walls, beams, columns, and arches within the suite are permitted to be exposed as described. The second option for exposed surfaces of mass timber ceilings is where the aggregate area does not exceed 25% of the total ceiling area of the suite and the exposed surfaces have a flame-spread rating not more than 75. With the higher percent of exposed ceilings, no mass timber walls are permitted to be exposed, but exposed beams, columns, and arches are still permitted [2].

A summary of exposed mass timber requirements for buildings constructed of EMTC is shown in Table 3.

Table 3: *Summary of exposed mass timber elements* [2]

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

The exceptions to allow surfaces of mass timber elements to be exposed within buildings constructed of EMTC is, in part, based on cross-laminated timber (CLT) room burn research conducted at Carleton University in 2013 [13] and 2014 [14]. In the CLT room burn tests, without automatic sprinkler protection, the fire duration was influenced by the amount of exposed mass timber, the re-radiation between opposing/facing walls, and the char fall-off of CLT. This research limited the percent of exposed mass timber and required all exposed wall surfaces to face the same direction in buildings constructed of EMTC.

In 2018, after the 2020 NBC EMTC exposed mass timber percentages were initially accepted by the SC-FP of the CCBFC, the National Research Council Canada (NRC) undertook two research projects on fire testing of mass timber compartments without sprinkler systems and with exposed mass timber surfaces:

1. Fire Testing of Rooms with Exposed Wood Surfaces in Encapsulated Mass Timber Construction [15]
2. Nail Laminated Timber Compartment Fire Tests [16]

In the first NRC research project, the walls and roof of the test compartment were built from second generation CLT, which meets the 2018 version of ANSI/APA PRG 320, "*Standard for Performance-Rated Cross-Laminated Timber*" [17]. The adhesives used in the CLT conform to

https://doi.org/10.52202/069179-0392

the elevated temperature performance requirements in the standard, which exclude the use of adhesives that permit premature CLT char layer fall-off resulting in fire regrowth during the cooling phase of fully developed fire [17]. In the second NRC research project, the walls and roof of the test compartment were built from nail laminated timber (NLT) made on site at NRC. Several of the compartments in both research projects also included some percentage of exposed glued laminated timber beams and columns.

In most cases, the exposed surfaces of mass timber walls, beams, columns, and ceilings within the compartments exceeded the maximum allowances that have been chosen and approved for buildings constructed of EMTC in the 2020 NBC. These research projects show that the percentages of the acceptable exposed mass timber within EMTC buildings are conservative and can be increased. A new CCR has been submitted to increase these percentages in the 2025 edition of the NBC and is under review by the SC-FP.

4 CONCLUSIONS

This paper summarizes the code changes that were proposed to allow for the construction of tall wood buildings up to 12 storeys within the 2020 National Building Code of Canada. A description of the new construction type used for these tall wood buildings called encapsulated mass timber construction (EMTC) was also introduced. Details of the two main components of EMTC, encapsulation rating and minimum dimensions for timber members were explained. Detailed information about the code requirements on the different components of these tall wood buildings within the 2020 National Building and Fire Codes were shown. Specifics on current research projects on fire testing of mass timber compartments with exposed mass timber surfaces are included.

REFERENCES

[1] National Research Council of Canada, National Building Code of Canada 2015, Ottawa, 2015.

[2] National Research Council of Canada, National Building Code of Canada 2020, Ottawa, 2022.

[3] Underwriters Laboratories of Canada, "CAN/ULC-S146 Standard Method of Test for the Evaluation of Encapsulation Materials and Assemblies of Materials for the Protection of Mass Timber Structural Members and Assemblies," Standards Council of Canada, Ottawa, 2019.

[4] Underwriters Laboratories of Canada, "CAN/ULC-S101 Standard Methods of Fire Endurance Tests of Building Construction and Materials," Standards Council of Canada, Ottawa, 2014.

[5] ASTM International, "E119 Standard Test Methods for Fire Tests of Building Construction and Materials," ASTM International, West Conshocken, 2022.

[6] International Organization for Standardization, "ISO 834 Fire-Resistance Tests," ISO/TC 92/SC 2 Fire containment, Geneva, 2021.

[7] ASTM International, "ASTM C1396 Standard Specification for Gypsum Board," ASTM International, West Conshohocken, 2017.

[8] CertainTeed, "What is fire rated gypsum?" https://www.certainteed.com/drywall/what-fire-rated-gypsum/. [Accessed 4 February 2022].

[9] CHM Fire Consultants Ltd., "Defining Mass Timber for Tall Buildings," Canadian Wood Council, Ottawa, 2016.

[10] National Fire Protection Association, "NFPA 13 Standard for the Installation of Sprinkler Systems," NFPA, Quincy, 2019.

[11] Underwriters Laboratories of Canada, "CAN/ULC-S134 Standard Method of Fire Test of Exterior Wall Assemblies," Standards Council of Canada, Ottawa, 2018.

[12] Underwriters Laboratories of Canada, "CAN/ULC-S102 Standard Method of Test for Surface Burning Characteristics of Building Materials and Assemblies," Standards Council of Canada, Ottawa, 2018.

[13] Underwriters Laboratories of Canada, "CAN/ULC-S702 Mineral Fibre Thermal Insulation for Buildings," Standards Council of Canada, Ottawa, 2021.

[14] National Research Council of Canada, "National Fire Code of Canada," Ottawa, 2022.

[15] C. J. McGregor, "Contribution of Cross Laminated Timber Panels to Room Fires. Masters Thesis," Carleton University, Ottawa, 2013.

[16] A. R. M. Hevia, "Fire Resistance of Partially Protected Cross-Laminated Timber Rooms. Masters Thesis," Carleton University, Ottawa, 2014.

[17] Joseph Su et al, "Fire Testing of Rooms with Exposed Wood Surfaces in Encapsulated Mass Timber Construction," National Research Council Canada, Ottawa, 2018.

[18] Joseph Su et al, "Nail Laminated Timber Compartment Fire Tests," National Research Council Canada, Ottawa, 2019.

[19] American National Standards Institute, "Standard for Performance-Rated Cross-Laminated Timber," APA - The Engineered Wood Association, Tacoma, 2018.