Submit a comment

# Proposed Change 1870

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| **Code Reference(s):** | **NBC20 Div.B 3.1.6.4. (first printing)** |
| Subject: | Encapsulated Mass Timber Construction |
| Title: | Exposure of Mass Timber Elements |
| Description: | This proposed change revises the encapsulation requirements for mass timber elements based on recent research. |
| Related Code Change Request(s): | CCR 1381 |
| Related Proposed Change(s): | PCF 1872, PCF 1963 |

This change could potentially affect the following topic areas:

- [ ] Division A
- [ ] Division C
- [ ] Building operations
- [ ] Small Buildings
- [x] Fire Protection
- [ ] Accessibility
- [ ] Building Envelope
- [ ] Heating, Ventilating and Air Conditioning
- [x] Division B
- [x] Design and Construction
- [ ] Housing
- [x] Large Buildings
- [x] Occupant safety in use
- [ ] Structural Requirements
- [ ] Energy Efficiency
- [ ] Plumbing
- [ ] Construction and Demolition Sites

## Problem

Over the past decade, fire research on mass timber structures, specifically those constructed using cross-laminated timber (CLT), has shown that in certain fire scenarios (i.e., no automatic sprinkler activation and no fire department intervention), a secondary fire growth and even a secondary flashover can occur, due to the delamination of the CLT elements. As a result of the concerns arising from these fire phenomena, the encapsulation requirements and special exceptions for encapsulated mass timber construction (EMTC) were introduced in the National Building Code of Canada (NBC) 2020, which include restrictions on exposed mass timber surfaces as well as exposed surface flammability (via flame-spread ratings) for the different elements in Article 3.1.6.4.

The exceptions were based on the research conducted up to that point using CLT product that was manufactured in conformance with ANSI/APA PRG 320-2014, "Standard for Performance-Rated Cross-Laminated Timber." Since that time, additional fire research was performed that resulted in the 2018 edition of the standard, which was referenced in the NBC 2020, and includes additional fire-performance requirements for the adhesives used in CLT product to eliminate delamination in a fire.

Also, research testing was recently performed by the National Fire Laboratory of the National Research Council of Canada (NRC) using CLT product conforming to ANSI/APA PRG 320-2018, as well as nail-laminated timber (NLT) elements, and additional mass timber elements, such as glued-laminated timber (glulam) beams and columns. Furthermore, research on real-scale fire tests was conducted by the Research Institutes of Sweden (RISE) on compartments constructed of CLT product that is also compliant with ANSI/APA PRG 320-2018. These tests have demonstrated that the existing provisions in the NBC 2020 are now conservative in nature and can be safely expanded to provide additional options to designers and builders.

The current provisions for small areas of exposed ceilings are restrictive in that they are only allowed within suites, not in fire compartments. This can be confusing and restrictive, especially in cases where the entire storey is a single occupancy/tenant or in the case of classrooms where the concept of suites is not always clear. Research has shown that allowing for increased use of exposed ceilings would not result in an undue fire risk. As such, the requirements in Article 3.1.6.4. on the encapsulation of mass timber elements do not reflect the latest research and need to be revised to reflect the performance of the materials that are now available in the market.

## Justification

This proposed change revises the exceptions to encapsulation of structural mass timber elements for EMTC in Article 3.1.6.4. of Division B of the NBC, based on new research performed by the Fire Laboratory at the NRC and RISE, as well as the recent changes made to ANSI/APA PRG 320 in 2018 that require the use of adhesives with additional fire performance characteristics in the manufacture of CLT.

In most cases, an automatic sprinkler system will ensure that, if a fire starts in a building, the fire never grows large enough to challenge the structure. This is equally true in a high-rise mass timber building with exposed mass timber. In the case that the sprinklers are unable to control the fire, the fire department is expected to arrive and extinguish the fire long before the structure is compromised, given that a two-hour fire-resistance-rated structure is required for buildings over six storeys in accordance with Articles 3.2.2.48. and 3.2.2.57. The primary concern regarding exposed mass timber in a high-rise building is what happens in the event the fire is not controlled by either the sprinkler system or the fire department, even though the probability of such an event occurring is acceptably low. Therefore, the question becomes: what happens when the fire continues to burn and the room’s combustible contents are consumed? More specifically, the question is whether the mass timber structure provides enough fuel for the fire to continue to burn at a level that will eventually lead to structural failure or the

fire will decay as would be expected in a noncombustible building. The concern for this low-probability scenario is the primary reason the EMTC provisions in the NBC 2020 have taken steps to limit the amount of exposed mass timber in Article 3.1.6.4.

As a result of the perceived fire hazard concerns arising from the potential for delamination in CLT (assuming no sprinkler activation or fire department intervention), recent changes were developed and adopted in ANSI/APA PRG 320-2018. The new requirements mandate the use of adhesives that must be pre-qualified through large-scale fire testing that is intended to evaluate the propensity for delamination of the CLT wood laminations.

Between 2018 and 2021, additional fire research was conducted by the NRC and RISE using CLT products manufactured using the "new generation" adhesives (qualified under the ANSI/APA PRG 320-2018 protocol) and other mass timber products such as NLT and glulam. Primarily, this research was initiated to specifically evaluate the Code provisions for EMTC that were introduced in the NBC 2020 as well as the limits prescribed in American codes, which relate to the percentages of permitted exposed mass timber surfaces using the CLT product with new generation adhesives. This research also explored other mass timber element scenarios with different amounts of mass timber elements exposed.

The NRC and RISE reports are listed below:

- "Fire Testing of Rooms with Exposed Wood Surfaces in Encapsulated Mass Timber Construction" (NRC CLT Report)[1]
- "Nail Laminated Timber Compartment Fire Tests" (NRC NLT Report)[2]
- "Fire Safe implementation of visible mass timber in tall buildings – compartment fire testing" (RISE Report)[3]

The NRC CLT Report describes a total of five CLT compartment fire tests (2018 NRC CLT compartment tests) that included varying amounts of exposed CLT wall and ceiling surfaces; two of the tests also incorporated glulam columns and beams.

The test rooms were relatively small (4.5 m × 2.4 m × 2.7 m tall) due to the test laboratory constraints. This test room size represents a severe scenario from the point of view of re-radiation of heat between surfaces, which is critical for the mass timber surfaces to continue to burn once the movable fuel load is consumed. The test room also had a door opening that provided a ventilation condition similar to the more severe one used in earlier tests performed by the NRC for the Fire Protection Research Foundation at the National Institute for Science and Technology (NIST) laboratory.[4] The smaller ventilation condition resulted in a longer duration and, therefore, more severe fire exposure to the compartment boundaries (walls and ceiling), as well as any beams and columns included. Table 1 provides a summary of the tests.

**Table 1. Summary of the 2018 NRC CLT compartment test results by configuration**[1]

| Test No. | Compartment Configuration | Protected and Exposed Mass Timber Surfaces | Comparison to 2020 EMTC Provisions | Results |
|---|---|---|---|---|
| 1 | CLT walls and ceiling | All walls and ceiling protected | Baseline scenario: replication of fire in noncombustible construction with none of the permitted combustible interior finishes | Fire burned out, leading to self-extinguishment |
| 2 | CLT walls and ceiling | One long wall (representing 33% of perimeter wall area) and 10% of ceiling exposed, remainder protected | Compliant | Fire eventually burned out, leading to self-extinguishment |
| 3 | CLT walls and ceiling + 2 glulam columns + 3 glulam beams | Beams and columns fully exposed (representing 36% of the perimeter wall area); walls and ceiling protected | Exceeds current 10% max. exposed surface area for beams and columns | Fire reached the decay phase |
| 4 | CLT walls and ceiling + 1 glulam column + 2 glulam beams | Beams and column fully exposed (representing 19% of the perimeter wall area); ceiling 100% exposed; walls protected | Exceeds current 10% max. exposed surface area for beams and columns; exceeds current 25% for exposed ceiling with no walls exposed | Fire eventually burned out, leading to self-extinguishment |
| 5 | CLT walls and ceiling | Two short walls exposed facing each other (representing 35% of the perimeter wall area, 4.5 m apart); ceiling 100% exposed; remaining two walls protected | Exceeds current 10% max. for exposed ceiling with any exposed walls; exposed walls facing each other currently not permitted | Fire reached the decay phase; only after approximately 3.5 h, the fire began to regrow |

With respect to the overall results of the various degrees and configurations of exposed mass timber surfaces, the NRC CLT Report states that "[i]n all tests with exposed mass timber, the peak room temperatures were similar to the baseline (fully encapsulated)."

With respect to the performance of the CLT, which used an adhesive compliant with ANSI/APA PRG 320-2018, the NRC CLT Report concludes that "[a]ll tests in this series showed that the second generation CLT with the thermal resistant adhesive improved significantly in fire performance to resist the char layer fall-off." This means that the changes made to ANSI/APA PRG 320 in early 2018 do ensure that adhesives that are approved for use in CLT (because they are compliant with that edition of the standard) will not delaminate, thereby significantly increasing the fire performance of the CLT panels. This increased performance was demonstrated in particular in Test 4 of the

recent NRC tests, where a fire in a compartment that had an exposed glulam beam and column and an exposed CLT ceiling still experienced the decay phase once the moveable fire load was consumed. This result is significant since the test set-up was rather challenging (i.e., severe). The room was small, thereby increasing the radiation feedback between burning surfaces, and the ventilation opening was a single doorway, resulting in a longer and more severe fire exposure than typically occurs in actual construction.

These results are for CLT products that conform to ANSI/APA PRG 320-2018, which is the latest version of the standard and is referenced in NBC Sentence 3.1.6.3.(3). The results are equally applicable to other mass timber products that are known not to delaminate, such as glulam, when exposed to fire temperatures.

The NRC NLT Report describes a total of four NLT compartment fire tests (2019 NRC NLT compartment tests) that included varying amounts of exposed NLT wall and ceiling surfaces; two of the tests also incorporated glulam columns and beams.

The same set-up was used for the test rooms as in the NRC CLT Report in terms of the size of the compartments and door ventilation openings. The compartment configurations were also similar to Tests 4 and 5 of the CLT compartment tests. Table 2 provides a summary of the NLT compartment tests.

**Table 2. Summary of the 2019 NRC NLT compartment test results by configuration**[2]

| Test No. | Compartment Configuration | Protected and Exposed Mass Timber Surfaces | Comparison to 2020 EMTC Provisions | Differences Between Tests | Results |
|---|---|---|---|---|---|
| 1 (Similar to CLT Test 4) | NLT walls and ceiling + 1 glulam column + 2 glulam beams | Beams and column fully exposed (representing 19% of the perimeter wall area); ceiling 100% exposed; walls protected | Exceeds current 10% max. exposed surface area for beams and columns; exceeds current 25% max. for exposed ceiling with no walls exposed | Test 1 ceiling had flat/smooth surface made by 2 × 8 lumber, while Test 2 ceiling had an uneven surface made with 2 × 8 and 2 × 10 lumber | Fire reached the decay phase |

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| 2<br>(Similar to CLT Test 4) | NLT walls and ceiling + 1 glulam column + 2 glulam beams | Beams and column fully exposed (representing 19% of the perimeter wall area); ceiling 100% exposed; walls protected | Exceeds current 10% max. exposed surface area for beams and columns; exceeds current 25% max. for exposed ceiling with no walls exposed | | Fire reached the decay phase |
| 3<br>(Similar to CLT Test 5) | NLT walls and ceiling | Two short walls exposed facing each other (representing 35% of the perimeter wall area, 4.5 m apart); ceiling 100% exposed; remaining two walls protected | Exceeds current 10% max. for exposed ceiling with any exposed walls; exposed walls facing each other currently not permitted | Test 3 used 2 layers of 12.7 mm thick Type X gypsum board to encapsulate the protected walls, while Test 4 used 3 layers of 12.7 mm thick Type X gypsum board to encapsulate the protected walls | Fire did not reach the decay phase |
| 4<br>(Similar to CLT Test 5) | NLT walls and ceiling | Two short walls exposed facing each other (representing 35% of the perimeter wall area, 4.5 m apart); ceiling 100% exposed; remaining two walls protected | Exceeds current 10% max. for exposed ceiling with any exposed walls; exposed walls facing each other currently not permitted | | Fire burned out, leading to self-extinguishment |

Again, with respect to the overall results of the various degrees and configurations of exposed mass timber surfaces, the results of the NRC NLT Report show that the peak room temperatures were similar to the CLT baseline (fully encapsulated).

With respect to the performance of the NLT, the NRC NLT Report concludes that "NLT panels typically have some small gaps between laminations … These small gaps provided passages for the flame and hot pyrolysis gas to travel in the NLT panels. Test NLT-3 and Test NLT-4 demonstrated that, in the absence of operationally effective sprinklers, to reach full decay of the fire three layers of 12.7 mm thick Type X gypsum board were necessary for NLT rooms with partially encapsulated walls and fully exposed ceilings to limit undue contributions of the protected NLT elements to the compartment fires, while still keeping the same total area of exposed surfaces as in the two test configurations." It was also stated that, based on the test results from both NRC reports, "second generation CLT generally performed better than NLT in these compartment fire tests to limit contributions of timber to the fire."

The NRC NLT Report also notes, "it is reasonable to expect that, had the three-layer gypsum board protection been used on Wall A and Wall C in Test CLT-5, the recurrent fire at 2020 minutes would not have occurred in that CLT test." This would mean that if a third layer of 12.7 mm thick Type X gypsum board were added to CLT Test 5 the additional regrowth in that test would not occur and the fire would reach full decay.

The RISE Report describes another five CLT compartment fire tests (2021 RISE CLT compartment tests) that included varying amounts of exposed CLT wall and ceiling surfaces and glulam columns and beams.

The test compartments were larger outdoor structures (7.0 m × 6.85 m × 2.73 m tall) with two ventilation opening factors (0.062 $m^{1/2}$ or 0.25 $m^{1/2}$) representative of typical openings in tall residential and office buildings respectively. The CLT used in these tests were also products manufactured using the *new generation* adhesives that was qualified under ANSI/APA PRG 320-2018 protocol. Table 3 provides a summary of the tests.

**Table 3. Summary of the 2021 RISE CLT compartment test results by configuration**[3]

| Test No. | Compartment Configuration | Protected and Exposed Mass Timber Surfaces | Comparison to 2020 EMTC Provisions | Results |
|---|---|---|---|---|
| 1 | CLT walls and ceiling + 1 glulam column + 1 glulam beam;<br>ventilation opening factors 0.062 $m^{1/2}$ | All mass timber elements protected | Baseline scenario: replication of fire in noncombustible construction with none of the permitted combustible interior finishes | Fire burned out, leading to self-extinguishment |

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| 2 | CLT walls and ceiling + 1 glulam column + 1 glulam beam;<br>ventilation opening factors 0.062 $m^{1/2}$ | - Two side walls facing each other (representing 55% of the perimeter wall area, 7.0 m apart);<br>- ceiling 100% exposed;<br>- beam (representing 13% of the perimeter wall area);<br>- remaining two walls protected | - Exceeds current 35% max. exposed surface area for walls;<br>- exceeds current 10% max. exposed surface area for beams;<br>- exceeds current 35% maximum exposed surface area for combined walls and beams;<br>- exceeds current 10% max. for exposed ceiling with any exposed walls;<br>- exposed walls facing each other currently not permitted | Fire eventually burned out, leading to self-extinguishment |

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| 3 | CLT walls and ceiling + 1 glulam column + 1 glulam beam;<br>ventilation opening factors 0.062 $m^{1/2}$ | - Left wall and front wall fully exposed and partial right wall exposed (representing 66% of the perimeter wall area, walls adjacent/opposing);<br>- ceiling 100% exposed;<br>- beam and column (representing 19% of the perimeter wall area);<br>- back wall protected | | Fire reached the decay phase; only after approximately 3 h, the fire began to regrow |
| 4 | CLT walls and ceiling + 1 glulam column + 1 glulam beam;<br>ventilation opening factors 0.25 $m^{1/2}$ | - side walls and front wall fully exposed (representing 50% of the perimeter wall area, walls adjacent/opposing);<br>- ceiling 100% exposed;<br>- beam and column (representing 28% of the perimeter wall area);<br>- back wall protected | | Fire eventually burned out, leading to self-extinguishment |
| 5 | CLT walls and ceiling + 1 glulam column + 1 glulam beam;<br>ventilation opening factors 0.062 $m^{1/2}$ | - Left wall and right wall fully exposed and partial front wall exposed (representing 59% of the perimeter wall area, walls adjacent/opposing);<br>- ceiling 100% exposed;<br>- beam and column (representing 19% of the perimeter wall area);<br>- back wall and partial front wall protected | | Fire eventually burned out, leading to self-extinguishment |

Again, with respect to the overall results of the various degrees and configurations of exposed mass timber surfaces, the results of the RISE Report show that the peak room temperatures were similar to the baseline (fully encapsulated).

With respect to the performance of the CLT that used an adhesive compliant with ANSI/APA PRG 320-2018, the RISE Report showed similar performance to the NRC CLT Report where thermal resistant adhesive improved significantly in fire performance to resist the char layer fall-off. This result means that the changes made

to ANSI/APA PRG 320 in early 2018 do ensure that the adhesives approved for use in CLT (because they are compliant with that edition of the standard) will not delaminate, thereby significantly increasing the fire performance of the panels.

Therefore, the findings of the NRC and RISE research would suggest that the current requirements are too restrictive and can be relaxed, while continuing to maintain a sufficient level of fire safety.

Table 4 provides a comparison of the NBC 2020 requirements and proposed changes for the NBC 2025 based on the most recent fire research.

**Table 4. Comparison of NBC 2020 EMTC provisions and the proposed changes for the NBC 2025**

| Code Reference | | Exposed beams, columns, arches | Exposed Walls | Exposed Ceiling | Flame-Spread Rating (FSR) | Suite (S) or Fire Compart-ment (FC) | Special Details |
|---|---|---|---|---|---|---|---|
| | | % of total area of suite perimeter walls | | % of total suite ceiling area | | | |
| 3.1.6.4.(3) | NBC 2020 | X ≤ 10% | – | – | ≤150 | S or FC | – |
| | Proposed | X ≤ 35% | – | – | ≤150 | S or FC | – |
| 3.1.6.4.(4) | NBC 2020 | – | Y ≤ 35% | – | ≤150 | S | Exposed wall surfaces face same direction |
| | Proposed | – | Y ≤ 35% | – | ≤150 | S | Exposed wall surfaces face same direction<br>OR<br>Exposed wall surfaces separated by 4.5 m |
| 3.1.6.4.(5) | NBC 2020 | X ≤ 10% | Y ≤ 35%–X% | – | ≤150 | S | Exposed wall surfaces face same direction |
| | Proposed | X ≤ 35% | – | – | ≤150 | S | – |

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|---|---|---|---|---|---|---|---|
| | | – | Y ≤ 35% | | | | Exposed wall surfaces face same direction<br>OR<br>Exposed wall surfaces separated by 4.5 m |
| | | X ≤ 35% | Y ≤ 35%–X% | | | | Exposed wall surfaces face same direction<br>OR<br>Exposed wall surfaces separated by 4.5 m |
| 3.1.6.4.(6) | NBC 2020 | X ≤ 10% | – | 10% | ≤150 | S | – |
| | | – | Y ≤ 35% | | | S | Exposed wall surfaces face same direction |
| | | X ≤ 10% | Y ≤ 35%–X% | | | S | Exposed wall surfaces face same direction |
| | | X ≤ 10% | NP | 25% | CL ≤ 75 | S | – |
| | | | | | B/C/A ≤150 | S | |
| | Proposed | X ≤ 35% | – | 10% | ≤150 | S or FC | Except exits/public corridors |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | – | Y ≤ 35% | | | S | Exposed wall surfaces face same direction<br>OR<br>Exposed wall surfaces separated by 4.5 m |
| | | X ≤ 35% | Y ≤ 35%–X% | | | S | Exposed wall surfaces face same direction<br>OR<br>Exposed wall surfaces separated by 4.5 m |
| | | X ≤ 35% | – | 25% | CL/W ≤ 75<br>B/C/A ≤150 | S or FC | Except exits/public corridors |
| | | – | Y ≤ 35% | | | S | Exposed wall surfaces face same direction<br>OR<br>Exposed wall surfaces separated by 4.5 m |
| | | X ≤ 35% | Y ≤ 35%–X% | | | S | Exposed wall surfaces face same direction<br>OR<br>Exposed wall surfaces separated by 4.5 m |
| 3.1.6.4.(7) | NBC 2020 | NP | NP | NP | NP | – | – |

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|---|---|---|---|---|---|---|---|
| | Proposed | X ≤ 20% | – | ≤100% | CL ≤ 75<br>B/C/A ≤150 | S | Unexposed walls will be protected with an encapsulation rating of 50 min |
| | | – | Y ≤ 35% | ≤100% | CL ≤ 75<br>W ≤ 75 | S | Exposed wall surfaces face same direction<br>OR<br>Exposed wall surfaces separated by 4.5 m and all unexposed walls will be protected with an encapsulation rating of either 50 min or 80 min (see also proposed revisions to Article 3.1.6.6) |

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| | | X ≤ 20% | Y ≤ 35%–X% | ≤100% | CL ≤ 75<br>W ≤ 75<br>B/C/A ≤150 | | Exposed wall surfaces face same direction<br>OR<br>Exposed wall surfaces separated by 4.5 m and all unexposed walls will be protected with an encapsulation rating of either 50 min or 80 min (see also proposed revisions to Article 3.1.6.6.) |

**Notes to Table 4:** CL = ceiling; W = walls; B/C/A = beams/columns/arches; S = suite; FC = fire compartment; FSR = flame-spread rating; NP = not permitted

Sentence 3.1.6.4.(3) on Beams, Columns and Arches

The proposed change to Clause 3.1.6.4.(3)(a) is based on Test 3 of the NRC CLT Report, which included three beams and two columns that were fully exposed, representing 36% of the perimeter wall area. Therefore, this proposed change increases the maximum permitted exposed surface area for beams, columns and arches from 10% to 35% of the perimeter wall area.

Sentence 3.1.6.4.(4) on Walls

This proposed change revises Clause 3.1.6.4.(4)(a). Instead of requiring all exposed surface areas for mass timber walls to face one direction, the proposed change aligns with the research that shows it also suffices to ensure that facing or adjacent surfaces are a minimum distance apart, so re-radiation between exposing surfaces is sufficiently minimized.

A distance of 4.5 m between the two facing or adjacent walls with exposed surface areas was used in the NRC CLT and NLT Reports. Specifying a minimum distance requirement between facing exposing surfaces is also a change made in the US building code regarding tall mass timber buildings.

Note A-3.1.6.4.(4) on Exposed Surfaces of Mass Timber Walls

As a result of the proposed revision to Sentence 3.1.6.4.(4), this proposed change also revises the explanatory Note to that Sentence for consistency.

Sentence 3.1.6.4.(6) on Ceilings

This proposed change revises Sentence 3.1.6.4.(6) to add "or *fire compartment*, other than an *exit* or *corridor*," which would also allow limited percentages of the total ceiling area (10% and 25%) of exposed mass timber outside a suite as specified.

This proposed change also removes the restriction on exposed mass timber walls within a suite where the exposed ceiling area is limited to 25% without permitting exposed mass timber walls outside a suite.

In the early stages of the development of the original EMTC changes, the limits imposed on exposed ceilings were established with the view that no exposed mass timber ceilings should be permitted within fire compartments such as exits, corridors and lobbies. Also, it was agreed that when the area of the exposed ceiling exceeded 10% of the suite, no exposed walls should be allowed. These restrictions were felt necessary, in part, due to the early generation fire research on mass timber elements that was available at the time (primarily CLT), which showed that in some cases fully developed fires would not decay or, with some decay, could result in regrowth (due to delamination of the CLT) to a fully developed fire.

A significant amount of fire research was conducted of greater scale and complexity since the original Code changes were developed in 2014 and 2015. This research has shown, among other things, that having a ceiling area of 100% exposed mass timber can still result in a fully developed fire reaching the decay phase and eventually burning out. (See proposed Sentence 3.1.6.4.(7)-2025.)

This proposed change maintains the NBC provisions permitting a maximum flame-spread rating (FSR) of 150 for any exposed mass timber surface in the case of only 10% of the ceiling being exposed. However, where the exposed ceiling area is increased to 25%, a maximum FSR of 75 is imposed, which includes any surface of exposed mass timber walls that might be present within the suite, which would otherwise be permitted to have a maximum FSR of 150 with no exposed ceiling.

The 10% and 25% upper limits on the total ceiling area of exposed mass timber (and the maximum FSR of 75 for the latter case) are expected to allow for a fully developed fire to enter the decay phase without any regrowth occurring.

Proposed Sentence 3.1.6.4.(7)-2025 on Additional Exceptions for Ceilings

The test results reported in NRC and RISE research demonstrate that having exposed beams and columns with a surface area that is 19% of the perimeter wall area in addition to a fully (100%) exposed ceiling with an FSR lower than 75 (black spruce lumber) resulted in the fire decaying on its own. This is an important finding since many tall mass timber buildings are of post-and-beam construction; therefore, a fully exposed structure results in exposed mass timber beams, columns and ceiling. As a result, designers are seeking permission to use this option.

Additionally, the NRC Reports (CLT Test 5 and NLT Test 3) demonstrated that having opposing exposed walls with a surface area that is 35% of the perimeter wall area in addition to a fully (100%) exposed ceiling resulted in a fire regrowth or no decay when the remaining unexposed walls were protected with two layers of 12.7 mm Type X gypsum board. By contrast, in NLT Test 4, with three layers of 12.7 mm Type X gypsum board protection on the unexposed walls, the compartment fire burned out and self-extinguished. Proposed Subclause 3.1.6.4.(7)(b)(ii)-2025 would require not less

than three layers of 12.7 mm Type X gypsum board protection on unexposed walls, which represents an encapsulation rating of 80 min, based on the NRC test report, "Intermediate Scale Encapsulation Tests"[5].

References

[1] Su, J.; Leroux, P.; Lafrance, P.-S.; Berzins, R.; Gratton, K.; Gibbs, E.; and, Weinfurter, M.; "Fire Testing of Rooms with Exposed Wood Surfaces in Encapsulated Mass Timber Construction"; National Research Council of Canada; Report No: A1-012710.1; Ottawa, Canada; August 2018.

[2] Su, J.; Leroux, P.; Lafrance, P.-S.; Berzins, R.; Gratton, K.; Gibbs, E.; and, Weinfurter, M.; "Nail Laminated Timber Compartment Fire Tests"; National Research Council of Canada; Report No: A1-014149.1; Ottawa, Canada; May 2019.

[3] Brandon, D.; Sjöström, L.; Temple, A.; Hallberg, E.; and, Kahl, F.; "Fire Safe implementation of visible mass timber in tall buildings – compartment fire testing"; Research Institutes of Sweden; Report No: 2021:40; Borås, Sweden; February 2021.

[4] Su, J.; Lafrance, P.; Hoehler, M.; Bundy, M.; "Fire Safety Challenges of Tall Wood Buildings Phase 2: Tasks 2 & 3 – Development and Implementation of Cross Laminated Timber (CLT) Compartment Fire Tests"; Fire Protection Research Foundation; 2018.

[5] Su, J.; Leroux, P.; Lafrance, P.-S.; Berzins, R.; Gratton, K.; Gibbs, E.; and, Frade, A.; "Intermediate Scale Encapsulation Tests"; National Research Council of Canada; Report No: A1-015805.1; Ottawa, Canada; December 2019.

# PROPOSED CHANGE

**NBC20 Div.B 3.1.6.4. (first printing)**

**[3.1.6.4.] 3.1.6.4. Encapsulation of Mass Timber Elements**

**(See also Note A-3.1.6.3.)**

**[1] 1)** Except as provided in Sentences (3) ~~to (6)~~to (7), 3.1.6.3.(4), 3.1.6.16.(2) and 3.1.6.17.(2), and Articles 3.1.6.7. and 3.1.6.12., the exposed surfaces of structural mass timber elements conforming to Article 3.1.6.3. shall be protected from adjacent spaces in the *building*, including adjacent concealed spaces within wall, floor and roof assemblies, by a material or assembly of materials conforming to Sentence (2) that provides an *encapsulation rating* of not less than 50 min. (See Note A-3.1.6.4.(1).)

**[2] 2)** Except as provided in Sentence 3.1.6.11.(1), the material or assembly of materials referred to in Sentence (1) shall consist of

[a] a) gypsum board,

[b] b) gypsum concrete,

[c] c) *noncombustible* materials,

[d] d) materials that conform to Sentences 3.1.5.1.(2) to (4), or

[e] e) any combination of the materials listed in Clauses (a) to (d).

**[3] 3)** Except as provided in Sentences (5) and (7), the exposed surfaces of

mass timber beams, columns and arches within a *suite* or *fire compartment* need not be protected in accordance with Sentence (1), provided

[a] a) their aggregate exposed surface area does not exceed ~~10~~35% of the total wall area of the perimeter of the *suite* or *fire compartment* in which they are located, and

[b] b) the *flame-spread rating* on any exposed surface is not more than 150.

(See ~~Note A-3.1.6.4.(3) to (6)~~Note A-3.1.6.4.(3) to (7).)

**[4] 4)** Except as provided in Sentences (5) ~~and (6)~~ and (7), the exposed surfaces of mass timber walls within a *suite* need not be protected in accordance with Sentence (1), provided

[a] a) ~~each exposed surface faces the same direction, and~~all portions of the exposed surfaces

[i] --) face the same direction, or

[ii] --) are separated by a horizontal distance of not less than 4.5 m, and

[b] b) the *flame-spread rating* on any exposed surface is not more than 150.

(See Notes A-3.1.6.4.(4) ~~and A-3.1.6.4.(3) to (6)~~and A-3.1.6.4.(3) to (7).)

**[5] 5)** Except as provided in Subclause (7)(b)(ii), ~~T~~the aggregate exposed surface area of mass timber elements within a *suite* permitted in Sentences (3) and (4) shall not exceed 35% of the total wall area of the perimeter of the *suite*. (See ~~Note A-3.1.6.4.(3) to (6)~~Note A-3.1.6.4.(3) to (7).)

**[6] 6)** Except as provided in Sentence (7), ~~T~~the exposed surfaces of mass timber ceilings within a *suite* or *fire compartment*, other than an *exit* or *public corridor*, need not be protected in accordance with Sentence (1), provided their aggregate surface area does not exceed

[a] a) 10% of the total ceiling area of the *suite* or *fire compartment*, where the *flame-spread rating* on any exposed surface~~s~~ is ~~have a *flame-spread rating*~~ not more than 150, or

[b] b) 25% of the total ceiling area of the *suite* or *fire compartment*, where the *flame-spread rating* on any exposed surface of a mass timber wall or ceiling is not more than 75.

[i] i) ~~the *suite* contains no mass timber walls with exposed surfaces, and~~

[ii] ii) ~~the exposed surfaces of the mass timber ceiling have a *flame-spread rating* not more than 75.~~

(See ~~Note A-3.1.6.4.(3) to (6)~~Note A-3.1.6.4.(3) to (7).)

**[7] --)** The exposed surfaces of mass timber ceilings within a *suite* need not be protected in accordance with Sentence (1) or (6), provided

[a] --) the aggregate surface area of any exposed mass timber beams, columns and arches does not exceed 20% of the total wall area of

the perimeter of the *suite* in which they are located,

[b] --) all surfaces of mass timber walls are

[i] --) protected in accordance with Sentence (1), or

[ii] --) where the aggregate exposed surface area of mass timber elements exceeds the limit specified in Sentence (5), protected by a material or assembly of materials conforming to Sentence (2) that provides an *encapsulation rating* of not less than 80 min, and

[c] --) the *flame-spread rating* on any exposed surface of a mass timber wall or ceiling is not more than 75.

(See Note A-3.1.6.4.(3) to (7).)

**Note A-3.1.6.4.(3) to (7~~6~~) Fire-Resistance Rating of Mass Timber with Exposed Surfaces.**

Portions of mass timber elements required to have a fire-resistance rating are permitted to be exposed in accordance with the permissions stated in Sentences 3.1.6.4.(3) ~~to (6)~~to (7); however, it is important to note that applying those permissions does not waive the requirement for these elements to have a fire-resistance rating.

**Note A-3.1.6.4.(4) Exposed Surfaces of Mass Timber Walls.**

The primary objective of encapsulating mass timber elements is to limit the probability that these elements will significantly contribute to fire spread and fire duration in the event of a fire. Since thick wood members require a source of imposed heat flux to burn, ~~the stipulation in~~ Clause 3.1.6.4.(4)(a) stipulates that any portions of the exposed surfaces of different mass timber walls within a suite either face the same direction ~~within a suite~~ or have a minimum horizontal distance between one other. If the sprinkler system fails to operate or to control the fire, this directional orientation or minimum distance is intended to avoid or reduce the potential ~~of~~for re-radiation between portions of burning mass timber surfaces on different walls, and particularly those that either face or are in close proximity to ~~each~~one another, which could sustain flaming combustion into the decay phase of a fire. ~~if the sprinkler system failed to operate or to control the fire.~~ Additionally, if the sprinkler system fails to operate or to control the fire, the maximum percentages of exposed surface areas and maximum flame-spread ratings stated in Article 3.1.6.4. ~~is low~~ are intended to be ~~so that it is not~~ insufficient to sustain a ventilation-controlled fire that might provide the radiation required to sustain flaming combustion into the decay phase of a fire. ~~if the sprinkler system failed to operate or to control the fire.~~

## Impact analysis

**Cost**

This proposed change is not likely to entail significant costs because it would not increase the stringency of the requirements for encapsulating mass timber elements. The proposed change would permit more timber elements to be left exposed, without requiring more of them to be left exposed. Not being required to install encapsulation materials reduces costs; however, the thickness and size of the exposed mass timber elements might need to increase, which could add cost.

A design complying with the NBC 2020 would remain in compliance with this proposed change.

**Benefit**

This proposed change would allow designers to leave exposed more of the mass timber construction elements of a building, an interest in which has been expressed by several regions of Ontario and British Columbia that have requested more biophilic construction (i.e., the use of natural finishes). Not being required to install encapsulation materials also provides benefits during the construction process, which can be challenging as relates to managing moisture effects.

Many Code users, including developers, architects, engineers and builders, across Canada are seeking additional options for the use of products such as wood that have demonstrable environmental benefits (e.g., low embodied carbon) in buildings of a greater variety of heights and sizes.

## Enforcement implications

This proposed change can be enforced by the current Code enforcement infrastructure. This proposed change would not introduce conflict or create enforcement issues since it is generally a relaxation of the existing NBC 2020 provisions.

## Who is affected

Architects, designers, developers, owners and engineers would benefit from the increased flexibility provided by this proposed change.

Authorities having jurisdiction, including fire departments, would need to continue to evaluate their operating procedures in accordance with the Code requirements for EMTC.

## OBJECTIVE-BASED ANALYSIS OF NEW OR CHANGED PROVISIONS

**NBC20 Div.B 3.1.6.4. (first printing)**

**[3.1.6.4.] 3.1.6.4. ([1] 1) [F02-OS1.2]**

**[3.1.6.4.] 3.1.6.4. ([1] 1) [F02-OP1.2]**

**[3.1.6.4.] 3.1.6.4. ([2] 2) [F02-OS1.2]**

**[3.1.6.4.] 3.1.6.4. ([2] 2) [F02-OP1.2]**

**[3.1.6.4.] 3.1.6.4. ([3] 3) no attributions**

**[3.1.6.4.] 3.1.6.4. ([4] 4) no attributions**

**[3.1.6.4.] 3.1.6.4. ([5] 5) no attributions**

**[3.1.6.4.] 3.1.6.4. ([6] 6) no attributions**

**[3.1.6.4.] -- ([7] --) no attributions**