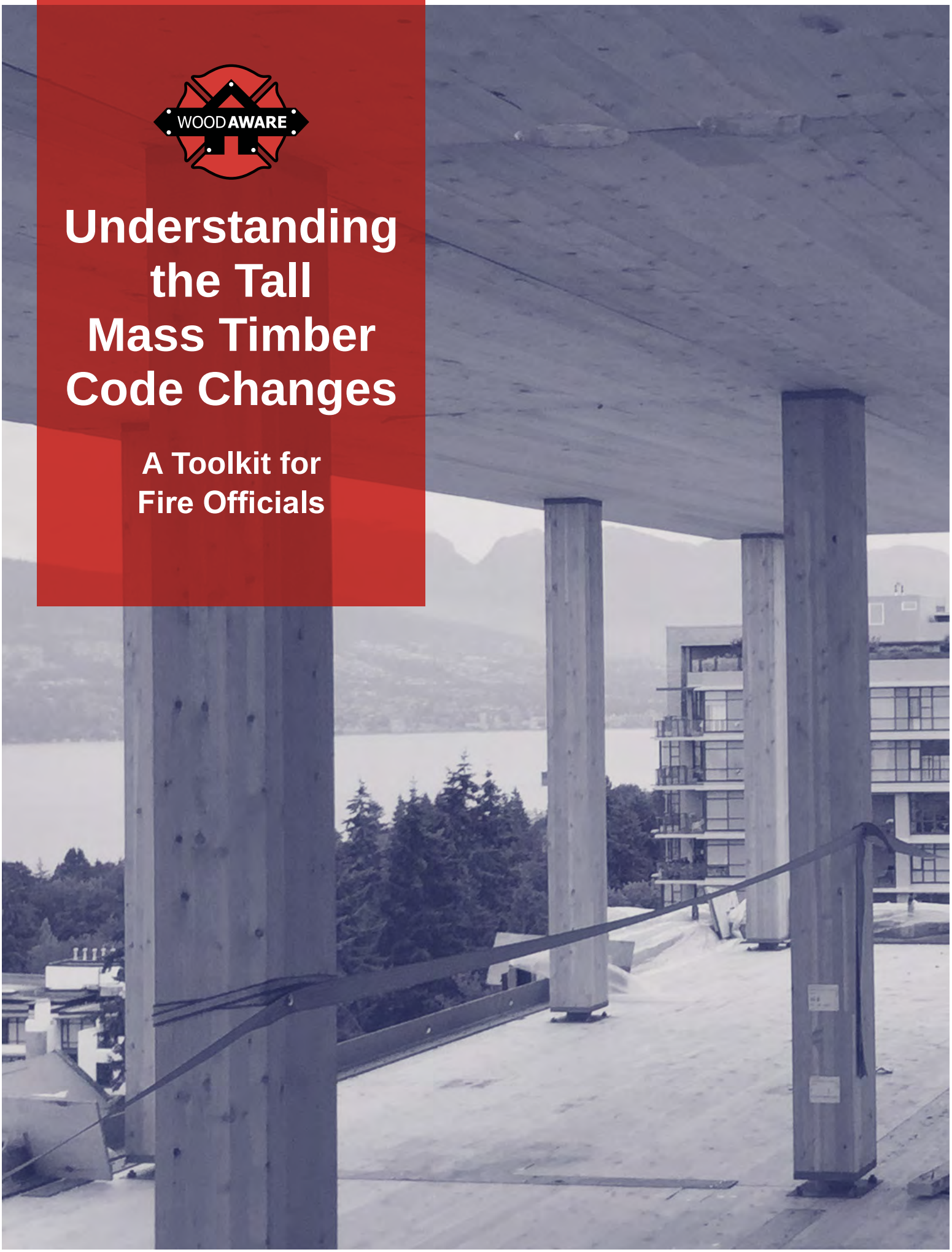
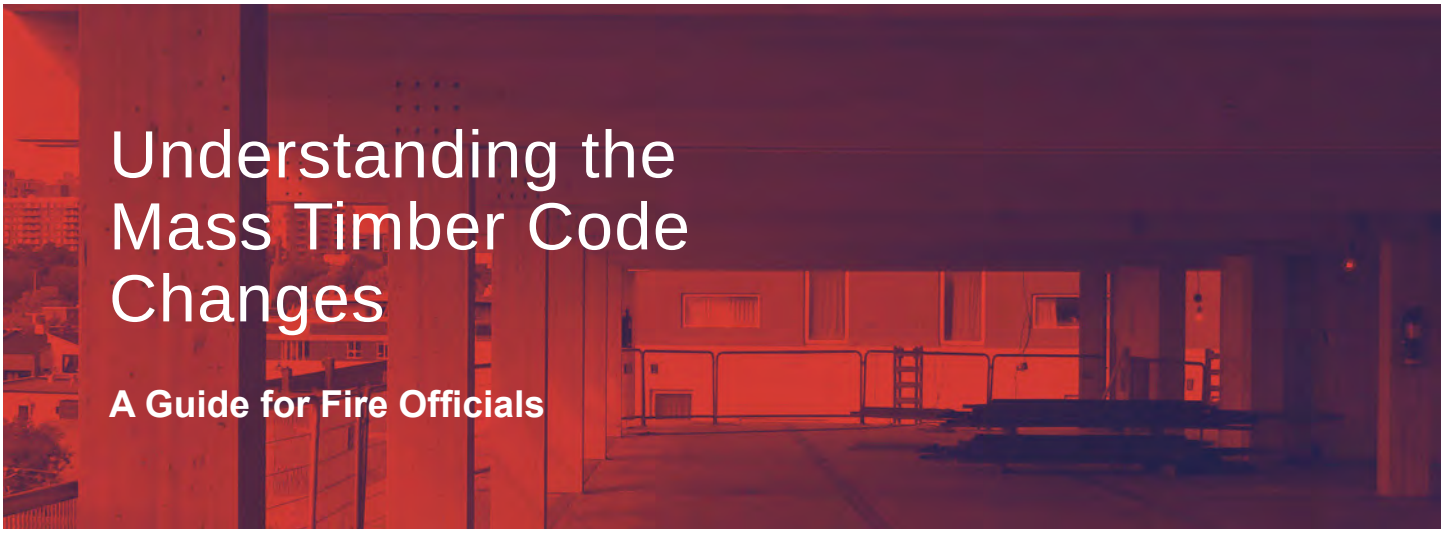


Understanding the Tall Mass Timber Code Changes

A Toolkit for Fire Officials

Table of Contents



Understanding the Mass Timber Code Changes

A Guide for Fire Officials

During the 2018 International Code Council (ICC) code development cycle, the ICC membership approved 14 code changes proposed by its Ad Hoc Committee on Tall Wood Buildings (TWB). The approved code changes were based on the results of several years of studying the science of tall wood buildings by the Committee. The TWB membership included subject matter experts from the fire service, building materials, building design and building regulatory communities.

For those interested in the specific code changes approved, this document provides a recommended sequence for review that should give a comprehensive understanding in an efficient and most-easily understood manner.

As an ICC Committee, the TWB collectively introduced three new types of mass timber construction for the 2021 *International Building Code* (IBC): Types IV-A, IV-B and IV-C. Existing heavy timber (Type IV-HT) remains unchanged by the TWB code changes, although there were significant proposals from other stakeholders pertaining to this type of construction that were approved. Additionally, it is important to distinguish the newly-approved types of construction from traditional lightweight wood-frame construction, as although both are wood based, they each have unique performance characteristics that are important for the fire service to recognize. At a minimum, and without exception, mass timber building elements, used in the new types of construction, must meet heavy timber dimensions assigned in the 2018 IBC.

Code Changes by Category

It is recommended that the code changes be reviewed in the following order, starting with the basic requirements for the new types of construction: Section 602.4 – Type of Construction **(G108-18)**; Section 703.8 – Performance Method **(FS5-18)**; Section 722.7 – Fire Resistance from Noncombustible Protection **(FS81-18)**; Section 703.9 – Sealants at Edges **(FS6018)**; Chapter 7 – Section 718.2.1 – Fire and Smoke Protection **(FS73-18)**; Section 403.3.2 – High Rise Sprinkler Water Supply **(G28-18)**; Section 701.6 – Owners Responsibility **(F88-18)**; Section 3308.4 of the International Fire Code – Fire Safety During Construction **(F266-18)**.

The three code changes addressing allowable heights, areas, and number of stories, Table 504.3 **(G75-18)**; Table 504.4 **(G80-18)**; and Table 506.2 **(G84-18)**, only should be reviewed after a familiarity with the types of construction and the safeguards associated with fire and life safety noted above has been developed. Allowable building heights and areas have long been a subject of debate in the IBC and considerable science-based judgment was applied by the TWB after fully considering the proposed type of construction features, fire resistance, noncombustible protection, and fire sprinkler systems, and then only after full scale fire testing had been conducted with and without sprinklers.

It is recommended that these changes be reviewed last, as follows: Chapter 31 – Section 3102 – Special Construction **(G146-18)**; IBC Appendix D – Fire Districts **(G152-18)**; and Sections 508.4 and 509.4 – Fire Barriers **(G89-18)**.

Tall Mass Timber Code Change Review Guide

Recommended order of review for interested Fire Officials

BACKGROUND ON ICC AD HOC COMMITTEE ON TALL WOOD BUILDINGS

In 2015, the Board of Directors of the International Code Council (ICC), developer of the *International Building Code* (IBC) and other model building codes, created the Ad Hoc Committee on Tall Wood Buildings (TWB). The scope of the TWB was to explore the science of tall wood buildings, its feasibility, and, as appropriate, to develop code change proposals through the ICC process. Priority was given to ensure the safety of tall mass timber buildings for its occupants and first responders. The TWB included subject matter experts from the building materials, building design, building regulatory, and fire service communities. The effort resulted in 17 code change proposals being submitted by the TWB for consideration, as specified by the ICC Code Development process. The entire package of approved code changes will be included in the 2021 IBC and IFC. The approved code changes create three new types of construction: Types IV-A, IV-B and IV-C. Existing Type IV code requirements are unchanged by these code changes, but it will now be designated Type IV-HT in the 2021 IBC. Importantly, **none of these new types of construction allow use of combustible light frame construction in any manner.** Further, mass timber used in the new types of construction must meet the minimum dimensions assigned in the 2018 IBC for all heavy timber construction. To understand the complete package of code changes, they should always be reviewed in their entirety.

The effort resulted in 17 code change proposals being submitted by the TWB for consideration, **as specified by the ICC Code** Development process. The entire package of approved code changes will be included in the **2021 IBC and IFC.**

FIRE TESTING COMPLETED BY THE TWB

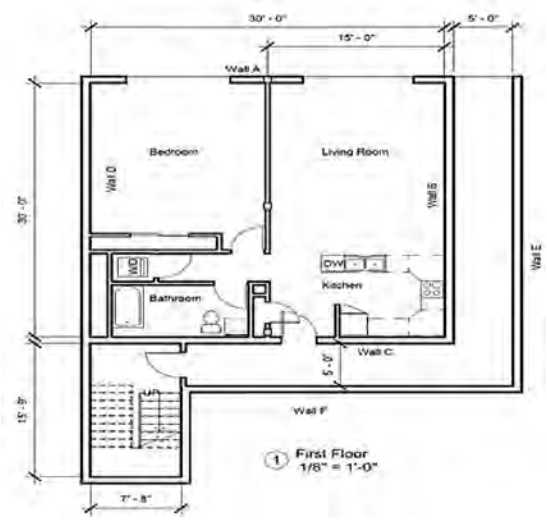
Though individual mass timber building elements and assemblies have undergone significant standardized fire testing, the TWB, as part of its mandate to explore the science of tall wood, conducted fire tests on a large scale to confirm that the fire protection performance intended by the *International Building Code* was achieved. This testing was performed at the U.S. Government's Bureau of Alcohol, Tobacco, Firearms and Explosives (ATF) National Fire Research Laboratory and included a series of five full-scale apartment unit tests verifying that the TWB code change proposals were conservative, and in most cases more conservative than the present performance level required by code.

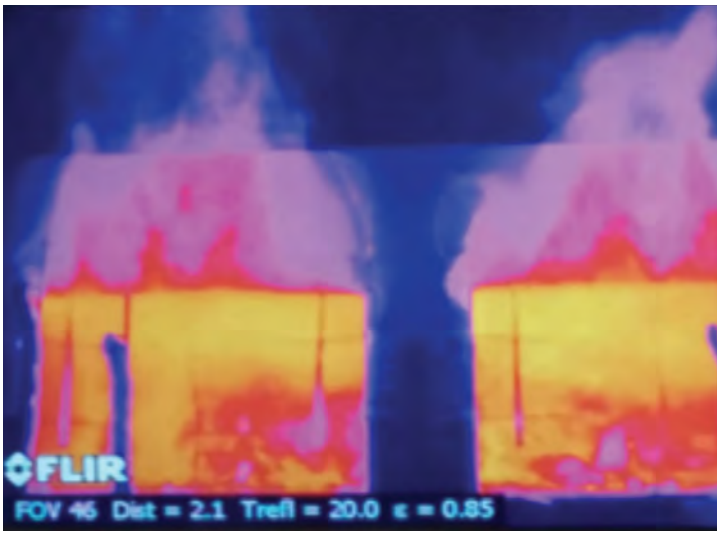
Fire tests performed at the ATF National Fire Research Laboratory verified that the TWB code change proposals were conservative, and in most cases more conservative than the present performance level required by code.

The five fire tests simulated aspects of each new construction type proposed were conducted in a multi-story structure. The following scenarios were evaluated as part of these tests.

- Contribution of mass timber to a fire
- Integrity of structural members
- Performance of connections
- Performance of through-penetration protection
- Conditions for responding fire personnel

Each test was conducted in one of two, one-bedroom apartments on two levels, with both apartments having a corridor leading to a stairway. The results, as well as testing for structural performance in accordance with ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials,* and additional testing by others, helped establish the basis upon which the TWB developed its code change proposals.





Overall, the Committee's package of tall wood building code changes, which are described below, recognize the emergence of a new class of mass timber products, a number of recent technological improvements, and provides a level of protection more conservative than presently recognized by code. However, the code changes are interdependent and all are needed to provide the holistic approach intended for taller mass timber buildings.

The following list provides an overview of the primary fire protection features which will now be required for mass timber buildings and which substantiate the overall conservative approach. Notably, the primary structural frame in Type IV-A construction is required to have a three-hour fire resistance rating, with no reduction permitted for sprinkler protection. Types IV-B and IV-C construction are required to have at least a two-hour fire resistance rating for the primary structural frame.

- Noncombustible materials are required on the exterior of all mass timber buildings, which is more restrictive than what is allowed on Type I or II (noncombustible) buildings.
- All mass timber forming concealed spaces must be protected with noncombustible materials.
- The use of lightweight wood products is not permitted for interior framing, including fire retardant treated wood.
- Type IV-A requires all mass timber to be fully protected by noncombustible material inside and outside (no exposed surfaces).
- Type IV-B allows limited exposed mass timber members on the interior, but they must be spatially separated.
- Type IV-C is limited to the same height in feet as existing HT and only allows an increased number of stories in lower hazard occupancies.
- Dual water supplies and fire pumps are required for mass timber buildings exceeding 120 feet in height, which provides a more robust fire protection package. By comparison, this is not required for Type I-A building until exceeding 420 feet in height.
- Stringent protections are required for mass timber buildings during construction.
- Full-scale fire testing confirmed that Types IV-A and IV-B construction will withstand a complete burnout of an above average residential fuel load without the aid of sprinklers.
- Annual inspections are required to ensure passive protection remains in place.
- Joints and penetrations are still required to be tested, installed and inspected as presently outlined in the IBC.

More information on the fire testing of mass timber construction is available at WoodAware.org/Tall-Mass-Timber.

Mass Timber does not permit the use of light-frame construction

BECOMING FAMILIAR WITH TALL WOOD CODE CHANGES

The code changes should be reviewed in the following order, starting with basic requirements for new types of construction:

Section 602.4 - Type of Construction **(G108-18);**

Section 703.8 - Performance Method **(FS5-18);**

Section 722.7 – Fire Resistance from Noncombustible Protection **(FS81-18);**

Section 703.9 – Sealants at Edges **(FS6-18);**

Chapter 7 – Section 718.2.1 – Fire and Smoke Protection **(FS73-18);**

Section 403.3.2 – High Rise Sprinkler Water Supply **(G28-18);**

Section 701.6 – Owners Responsibility **(F88-18);** and

Section 3308.4 of the IFC - Fire Safety During Construction **(F266-18).**

The three code changes dealing with height, number of stories and allowable area, Table 504.3 **(G75-18);** Table 504.4 **(G80-18)**; and Table 506.2 **(G84-18)**, should be reviewed only after a reader becomes familiar with types of construction and the safeguards for each associated with fire and life safety. Allowable building height and area has long been a subject of debate in the IBC. Considerable science-based judgment was applied by the TWB after fully describing the proposed construction features, fire resistance, noncombustible protection, active fire sprinkler systems, and then only after full scale fire testing with and without sprinklers.

Additionally, three more code changes proposed by the TWB have less relevance to the overall performance of the new types of construction. It is recommended these changes be reviewed last: Chapter 31 – Section 3102 – Special Construction **(G146-18);** IBC Appendix D – Fire Districts (G152-18); and Sections 508.4 and 509.4 – Fire Barriers **(G89-18)**.

During the 2019 code development cycle, three additional changes were submitted by the TWB. These approved changes include: IBC Chapter 1 - Section 110.3 - Inspections (ADM35-19); IBC Chapter 17 - Special Inspections (S100-19) and Chapter 23 - Wood Connections (S170-19).

Review of Individual Code Changes

Requirements in other regions of the world generally place tall mass timber buildings into three categories:

- The mass timber is fully protected with noncombustible insulating materials.
- A limited amount of exposed mass timber elements is allowed.
- The mass timber is permitted to be exposed.

CODE CHANGE G108-18 – TYPES OF CONSTRUCTION

Section 602.4 Type of Construction

Type IV-A: Mass timber construction that is fully protected with noncombustible materials is designated Type IV-A. Additional protection times from use of noncombustible material is described in a new section (722.7). Testing has shown that mass timber construction protected with multiple layers of 5/8-inch Type X gypsum board can endure a complete burnout of a residential fuel load without involving the mass timber. The fire protection specified applies to all building elements. As such, protection of all wall and ceiling surfaces, the underside of the roof surface, the top and bottom of all floor surfaces, as well as all shafts and exterior surfaces are required to be fully protected. In addition, Type IV-A construction has the same fire-resistance rating as Type I-A construction. However, the fire-resistance rating for Type IV-A construction is conservative since the structural elements are intended to resist the fuel loads associated with the various occupancies without the benefit of automatic sprinklers, and without involving the structural members. Type IV-A also requires dual water supplies for buildings exceeding 120 feet in height. This provides redundancy to ensure water is available for automatic and manual suppression systems. A Type I noncombustible building would not have to meet this requirement until it exceeds 420 feet in height.

Type IV-B: Some exposed wood surfaces of ceilings, walls, columns and beams are allowed in Type IV-B. The area of exposed surfaces allowed, as well as the required spatial separation between unprotected areas, is specified to limit contribution of the structure in an interior fire. In areas where mass timber is permitted to be exposed, it must be designed or calculated to provide the required fire resistance rating. Like the other two new construction types, mass timber exterior walls must have the exterior surface protected with noncombustible materials. Concealed spaces, shafts and other specified areas are required to be fully protected with noncombustible protection. Type IV-B must meet the same fire-resistance requirements as Type I-B construction. However, the present allowance in IBC Section 403.2.1.1, to reduce I-B construction to one-hour structural elements has not been included for Type IV-B construction. As such, two-hour structural elements are still required for Type IV-B construction.

As with Type IV-A construction, Type IV-B also requires dual water supplies for buildings exceeding 120 feet in height. This redundant water supply, coupled with the two-hour passively protected structural frame, provides a conservative approach to fire protection.

Type IV-C: Since noncombustible protection is not required for interior elements of Type IV-C, it relies on the inherent fire-resistance of the mass timber itself. Type IV-C construction is more conservative than traditional heavy timber construction (IV-HT) in that Type IV-C is required to provide a two-hour fire-resistance rating. Although Type IV-C construction permits interior mass timber elements to be fully exposed, concealed spaces, shafts, elevator hoistways, and interior exit stairway enclosures are required to be fully protected with noncombustible materials. Like the other two new construction types, exterior faces of Type IV-C are required to be protected by noncombustible materials. Due to the increased fire resistance of Type IV-C construction, additional stories for lower hazard occupancy groups have been allowed, but height (in feet) beyond that already recognized for Type IV-HT has not. This is reflected in reduced allowable height, in both feet and stories, compared to the other TWB proposals to Table 504.3 and 504.4.

Revisions to Tables 601 and 602 to recognize the fire performance requirements of these new types of construction. In summary:

- Type IV-A has a three-hour fire resistance rating, as presently required for Type I-A buildings.
- Type IV-B has a two-hour fire resistance rating, as presently required for Type I-B buildings.
- Type IV-C has a two-hour fire resistance rating, as presently required for Type I-B buildings and newly-approved Type IV-B. No increased height or area beyond IV-HT.

Table 1. Required Fire Resistance of Building Elements in Hours – Current and New

CURRENT OR EXISTING

Construction Types	Exterior Walls	Structural Frame	Floor Protection	Roof Protection
Type I-A — Protected Noncombustible[1]	3 Hrs	3 Hrs	2 Hrs	1 ½ Hrs
Type I-B — Protected Noncombustible[2]	2 Hrs	2 Hrs	2 Hrs	1 Hr
Type II-A — Protected Noncombustible	1 Hr	1 Hr	1 Hr	1 Hr
Type II-B — Unprotected Noncombustible	Noncombustible materials, but no fire resistance required.			
Type III-A — Protected Combustible (protected light wood frame or masonry exterior walls)	2 Hrs	1 Hr	1 Hr	1 Hr
Type III-B — Unprotected Combustible (protected light wood frame or masonry exterior walls)	2 Hrs	None	None	None

NEW MASS TIMBER

Construction Types	Exterior Walls	Structural Frame	Floor Protection	Roof Protection
Type IV-A — Fully Protected, exterior and interior[3]	3 Hrs	3 Hrs	2 Hrs	1 ½ Hrs
Type IV-B — Mass timber protected exterior, limited exposed timber interior[3]	2 Hrs	2 Hrs	2 Hrs	1 Hr
Type IV-C — Mass timber protected exterior, exposed timber interior[4]	2 Hrs	2 Hrs	2 Hrs	1 Hr

CURRENT OR EXISTING

Construction	Exterior Walls	Structural Frame	Floor Protection	Roof Protection
Type IV — Heavy Timber	2 Hrs	Heavy Timber or 1 Hr	Heavy Timber	Heavy Timber
Type V-A — Protected Wood Frame	1 Hr	1 Hr	1 Hr	1 Hr
Type V-B — Unprotected Wood Frame	No Fire Resistance			

[1] **Note:** Dual water supply for fire suppression systems required at 420 feet elevation and above. Permitted to be reduced by 1 Hr. with certain fire sprinkler controls for buildings less than 420 feet high.

[2] **Note:** Permitted to be reduced by 1 Hr. with certain fire sprinkler controls for less hazardous,uses, smaller fuel loads.

[3] **Note:** Dual water supply for fire suppression systems required at 120 feet elevation and above. No reductions in protection permitted.

[4] **Note:** No reductions in protection permitted.

CODE CHANGE FS5-18 - PERFORMANCE METHOD

Section 703.8 - Performance Method

This new code section provides a performance path to determine the contribution to the fire resistance rating provided by noncombustible protection. The fire resistance rating of mass timber structural members consists of the inherent fire resistance rating of the mass timber and the additional fire resistance provided by any noncombustible protection, as described in new definitions.

This change allows any noncombustible material to be tested to determine the time assigned for its contribution to the overall fire resistance rating of the element. This procedure is neither new nor ambiguous. It was used to determine protection times for various membranes. Recent testing has confirmed the values derived from historic testing and have been included in the American Wood Council's Technical Report 10 (TR10), *Calculating the Fire Resistance of Exposed Wood Members,* available as a free download at www.awc.org/codes-standards/publications/tr10.

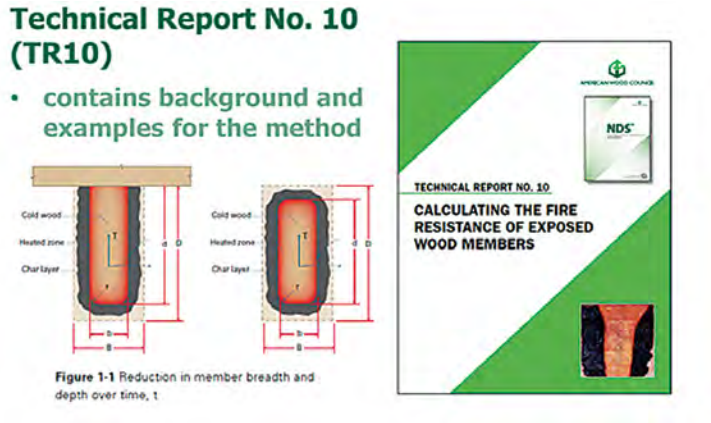


Figure 1-1 Reduction in member breadth and depth over time, t

CODE CHANGE FS81-18 – FIRE RESISTANCE FROM NONCOMBUSTIBLE PROTECTION

Section 722.7 – Fire Resistance Rating of Mass Timber

This TWB change included a prescriptive approach to achieve improved fire resistance for mass timber structures where the designer is allowed to calculate the fire resistance rating of a protected wood element by adding the fire resistance rating of the unprotected wood member to the protection provided by noncombustible materials applied to the wood.

As a prescriptive solution, the conditions of use, such as attachment, finishing and edge treatment when bordering exposed mass timber areas, are also detailed in this section. Fire testing of beams, columns, walls and ceiling panels was conducted to establish the values in Table 722.7.1(b).

To support imposed structural loads, mass timber elements typically have large cross-sections. In addition, cross-laminated timber (CLT) typically incorporate odd numbered laminations. Each lamination of CLT contributes to the fire resistance rating of assembly. Where noncombustible protection is required, 2/3 of the required fire resistance rating must be provided by noncombustible materials. The other 1/3 of the required FRR can be from the mass timber. Additionally, at least two-thirds of the fire-resistance rating is required to be provided by the noncombustible protection, which also achieves conservative results.

Under this new section, the contribution of noncombustible materials to fire resistance is determined by measuring the fire resistance time to structural failure of an exposed mass timber building element in a fire test and then conducting a second test with noncombustible protection applied. Each test is conducted with identical mass timber elements, identical loading, construction and conditions, but one of the tests includes the additional noncombustible protection (as defined in Section 703.5). The difference in results between the two samples tested is the contribution of the noncombustible protection. This testing procedure should not be confused with testing for "finish rating," which is only based on temperature rise on the unexposed side of an attached membrane.

CODE CHANGE FS6-18

Section 703.9 – Sealants at Edges

Mass timber has inherent fire-resistance properties, which provide both structural fire resistance and limit the spread of fire and smoke through building assemblies (walls and floors). Where a wall or horizontal assembly serves as the separation between fire compartments, a fire in one compartment can create sufficient pressure to force heated gases into uninvolved portions of the structure. As such, abutting edges and intersections of walls and floors are required to be sealed. Where mass timber panels are connected, fire tests have demonstrated the importance of sealing abutting edges and intersections. The abutting edges and intersections of the fire tested assemblies were sealed, which provided the rationale for this code change.

For this, the U.S. Edition of the *CLT Handbook* recommends a bead of construction adhesive. Other sealants can also prevent air flow. A newly referenced standard, ASTM Standard D3498—03 (2011) *Standard Specification for Adhesives for Field-Gluing Plywood to Lumber Framing for Floor Systems* provides direction. Where a sealant or adhesive is applied to mass timber building elements (as designated in the construction documents approved by the Authority Having Jurisdiction), special inspections are required during construction to ensure an appropriate sealant or adhesive is used and to provide quality control. An exception is provided for panels manufactured under a proprietary process and tested accordingly to ensure there are no spaces or gaps at abutting edges. Even if a sealant is not required, but not specifically excluded, special inspection is still considered good practice.

This code change does not apply to "joints" as defined in Section 202 of the IBC. Joints have an opening designed to accommodate construction tolerances or allow independent movement. Panels and members rigidly connected, as specified by this code change, do not meet the definition of a joint. Joints have their own requirements for testing, installation and inspection in IBC Section 715.

CODE CHANGE FS6-18

Section 718.2.1 – Fire-blocking Material

The purpose of this code change was to recognize mass timber as a suitable fire-blocking material. The current list of acceptable materials for fire blocking lists "nominal lumber;" accordingly, since mass timber (e.g. sawn, glued-laminated timber, and cross-laminated timber) is of greater mass, mass timber was determined to be of equal or greater blocking resistance to the movement of fire, smoke and gasses to different parts of the building through concealed spaces.

CODE CHANGE G28-18

Section 403.3.2 – High Rise Sprinkler Water Supply

In response to the events of September 11, 2001, ICC had earlier adopted requirements for redundant water supply to super high-rise buildings of 420 feet and higher. In this TWB code change, this requirement was adopted for mass timber buildings taller than 120 feet due to the recognized importance of ensuring a continuous water supply to active fire protection systems in the event of a fire in these structures. This recommendation had been highlighted in the National Institute of Standards and Technology's (NIST) report on the structural collapses occurring on September 11.

CODE CHANGE F88-18

Section 701.6 – Owners Responsibility

Mass timber construction will allow greater heights and areas than previously permitted for lightweight wood-frame construction. As the surfaces of mass timber may burn in a fire until they char, tall mass timber buildings are required to include specific active and passive features to protect occupants and the structure. *The International Fire Code* (IFC) currently requires active systems to be inspected periodically for performance and, for these unique structures, it is reasonable to require the same for the applicable passive aspects. This fire code change required the owner to annually inspect, and repair or restore if needed, any required passive protection of mass timber elements that may have been damaged or removed, and also to maintain records of such inspections and repairs.

CODE CHANGE F266-18

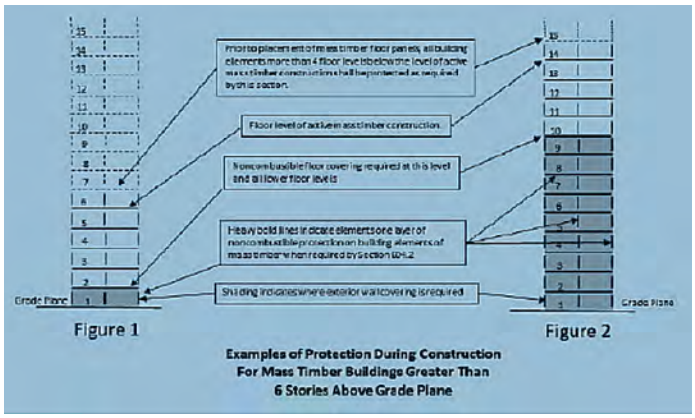
Section 3308.4 of the IFC - Fire Safety During Construction

Additional active and passive fire protection features provide added safety for the increased height and area being allowed for mass timber buildings (Types IV-A, IV-B & IV-C). The changes to this section require this additional protection when mass timber buildings are under construction and, therefore, most vulnerable.

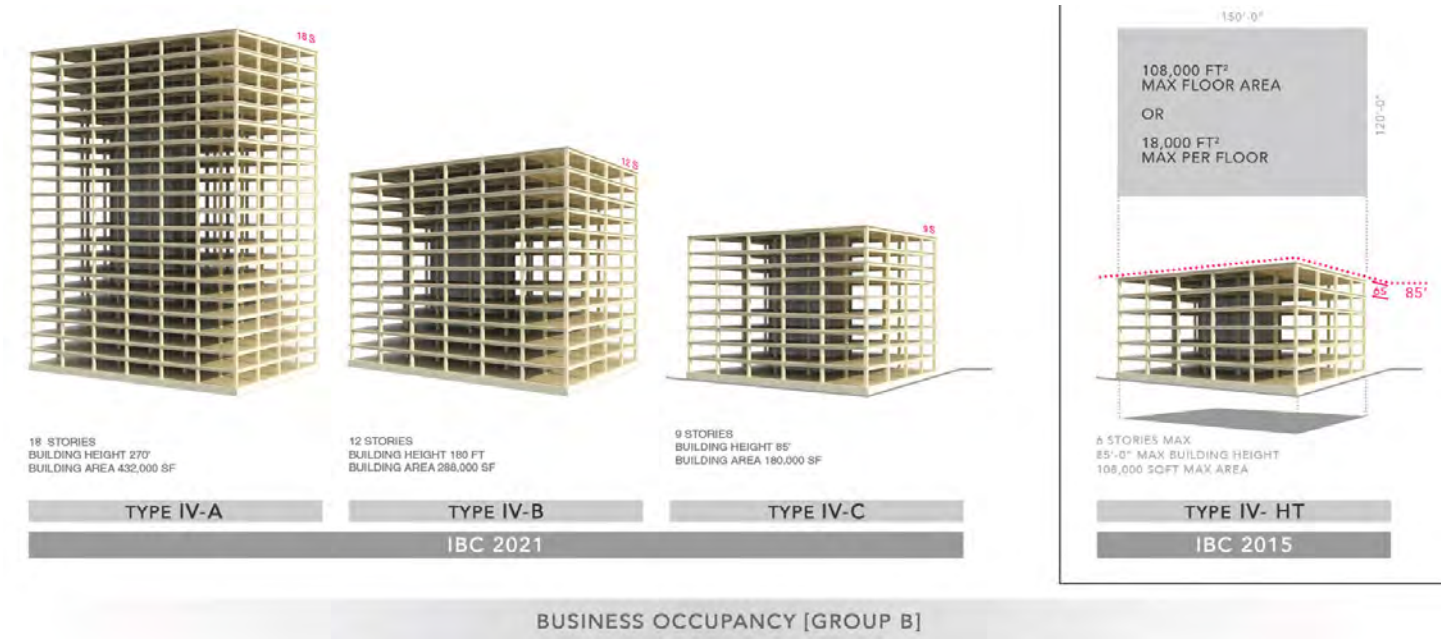
In recent years, there have been a number of fires in buildings under construction. Most of these occurred in large structures of light-frame wood prior to the installation of active and passive fire protection systems. Even though these losses were in lightweight construction, and mass timber has inherent fire resistance and structural integrity due to the mass of the timber elements, the potential risk of fire was considered. In the construction process, mass timber is generally installed as it arrives at the job site. Therefore, smaller amounts of combustible building materials can be expected to be stored than on a traditional construction site. This code change required protection of the installed material before the project extends above a specified number of levels, which is very different, and more stringent, than conventional construction processes.

The TWB extensively debated water supplies to construction sites where substantial quantities of combustible building materials might exist. It was agreed that developers should confer with the local fire service to establish the fire department's on-site water needs for flow pressures and manual fire suppression for the specific site. Subsections 1 and 2 of the change apply to the delivery of water to a job site and structure. Subsections 3 and 4 are specific to passive protection aspects of the structure. Due to the increased allowable heights and areas of mass timber buildings, interior and exterior passive protection is required as construction progresses. This helps ensure lower portions of the combustible structure have redundant, active and passive protection in place as greater heights are reached.

As a result, the likelihood of catastrophic structural failure during a fire and adverse impact to surrounding structures are reduced. The TWB included two figures with its proposals to illustrate requirements for passive protection of mass timber structures under construction. As shown, when buildings under construction exceed six stories, protection is required on building elements in accordance with the associated construction type, as well as for exterior wall coverings, more than four floor levels below before additional levels can be erected. For example, prior to placing seventh floor panels, with construction therefore still being performed on level six, passive protection must be provided for all elements under level two.



Examples of Protection During Construction For Mass Timber Buildings Greater Than 6 Stories Above Grade Plane



GENERAL FACTS CONCERNING TYPE IV CONSTRUCTION

Type IV-A

- Maximum 18 stories (but for many occupancies, such as M and S, less)
- Noncombustible protection for 2/3 of the FRR time
- Sprinkler system operation provides a redundant level of protection
- Tests show fuel load contents burn-out without fire service intervention

Type IV-B

- Maximum 12 stories (but for many occupancies, such as M and S, less)
- Limited area exposed mass timber
- Sprinkler system operation provides a redundant level of protection
- Tests show fuel load contents burn-out without fire service intervention

Type IV-C

- Maximum of 9 stories (in Group B, all other occupancies, less)
- Limited to current HT height, in feet
- Two-hour fire resistance rating (E 119 or calculated)
- Proven performance with sprinklers for buildings of this height

Enhancements for Types IV-A and IV-B that are more conservative than Types I-A and I-B

- All material outboard of the CLT exterior wall must be noncombustible (except weather resistive barrier)
- No one-hour reduction allowed in fire resistance rating for including supervised sprinkler valves as in IBC 403.2.1 (Table 601)
- No combustible lightweight walls, floors, shafts or roofs
- In addition to noncombustible protection having a minimum contribution to required fire resistance ratings of 2/3 of Table 601, mass timber has its own redundant fire resistance rating calculated based on size
- Limitations on height, area and number of stories (tall buildings of mass timber can't be unlimited in area like Type I-A and I-B)
- Minimum of 80 minutes of noncombustible protection also provided for roof construction
- Owner responsibilities for maintenance
- Limits on exposed combustible materials during construction

CODE CHANGE G75-18 AND G80-18

Allowable Height in Feet and Number of Stories

The approved changes take a conservative approach to height limits for the new construction types. The majority of the TWB recommendations were based on reviews of fire safety and structural integrity performance for occupancy groups A, B, E, R and U. This resulted in Type IV-B being equated to existing

Type I-B for height (in feet and number of stories). Although Section 403.2.1.1 of the IBC allows many occupancies of Type I-B construction to have reduced one-hour fire resistance ratings, the same reduction was not proposed for Type IV-B. This means that Type IV-B mass timber construction will have a two-hour fire resistance rating while noncombustible Type I-B will only have a one-hour fire resistance rating.

In general, two-hour mass timber construction, which is allowed to be partially exposed in Section 602.4, was determined to warrant the same heights as allowed for one-hour Type I-B construction. Even though Type IV-A construction is entirely protected (no exposed mass timber permitted) and the required rating of the structure is equivalent to Type I-A construction (three-hour rating for the structural frame), the TWB determined that it was not appropriate to allow Type IV-A to be of unlimited height as is Type I-A.

The TWB also determined that Type IV-A should be somewhat larger than Type IV-B. To establish reasonable height allowances for IV-A construction, a multiplier of 1.5 was applied to the heights proposed for Type IV-B construction (then rounded up or down).

While interior elements of both Type IV-C and Type IV-HT (no change from current code) may be unprotected, Type IV-C requires a two-hour fire rating of structural elements. It was the conservative judgment of the TWB to treat Type IV-C similarly to Type IV-HT, which uses traditional large dimensional lumber and is considered to provide approximately one-hour fire resistance based on member sizes and known charring rates. Even though additional stories for some lower hazard occupancies are allowed for Type IV-C in recognition of its greater fire resistance rating, the height in feet is limited to the same allowed for Type IV-HT. More hazardous occupancies were limited to the number of stories permitted for Type IV-HT. Fully sprinklered mercantile occupancies were the only use recognized for a single additional story.

Tables 504.3 and 504.4 currently allow a height of 160 feet and 11 stories for non-sprinklered (NS) Type I-B construction for many occupancy types; the heights approved for Types IV-A, IV-B and IV-C are the same as those allowed for the current Type IV-NS. As unprotected mass timber is required to provide at least a two-hour fire resistance rating or twice that of the one-hour fire resistance rating required for Type I-B (when using the reduction in 403.2.1.1), the three new approved mass timber construction types are more conservative than present requirements.

Reduced heights were included for certain specific occupancies which, in the professional judgment of the TWB, were deemed to be more hazardous.

CODE CHANGE G84-18

Table 506.2 Allowable Area

Allowable area changes should be considered a companion to changes to height. Each new construction type was examined for its fire safety characteristics and compared with existing Type IV-HT for allowable area. A multiplier was developed for each to reflect the additional fire protection provided.

- Type IV-C is proposed to be 1.25 times the HT allowable area.
- Type IV-B is proposed to be 2.00 times the HT allowable area.
- Type IV-A is proposed to be 3.00 times the HT allowable area.

These multipliers were then reexamined by the TWB based on relative hazard and occupancy classification. When hazards were perceived to be greater, allowable areas were adjusted downward. Hazardous and Institutional occupancies were reduced from what the multiplier method would allow. In addition, allowable area and the associated height changes were reconsidered by the TWB to ensure a conservative approach to combined allowances.

The TWB also reconsidered this change with respect to companion height change. This review was to ensure that allowable areas were commensurate with the risk posed on any allowed story or height.

CODE CHANGES G146-18 AND G152 - MEMBRANE STRUCTURES

Chapter 31 – Section 3102 – Special Construction (Membrane Structures) and Appendix D D102.2.5 – Fire Districts

These code changes were approved to retain current Type IV-HT provisions and do not modify existing requirements.

CODE CHANGE G89-18 - FIRE BARRIERS

Fire Barriers Sections 508.4 and 509.4

Where mass timber serves as a fire barrier or horizontal assembly, the TWB required additional protection measures to meet performance-based objectives. Without modification to the provisions regulating separated occupancies and incidental uses, this change prevents mass timber from being used as a fire barrier or horizontal assembly in Types IV-B and IV-C construction.

Section 508.4 provides a new option for separating mixed occupancies within a building. Section 509.4 discusses the fire-resistance-rated separation required for incidental uses within a larger use group. Section 509 also permits, when stated by the IBC, protection by an automatic sprinkler system without a fire barrier. However, the construction enclosing the incidental use must resist the passage of smoke in accordance with Section 509.4.2.

The TWB incorporated existing thermal barrier requirements into these two sections. The intent of the thermal barrier is to delay or prevent ignition of the mass timber, thus delaying or preventing any mass timber contribution to fuel load. Mass timber walls or floors serving as fire barriers for separated uses (Section 508.4) are required to have a thermal barrier on both faces of the assembly. The thermal barrier is only required to cover exposed wood surfaces and is not required in addition to noncombustible protection required by Section 602.4 (i.e. materials providing the fire-resistance rating can also serve as the thermal barrier). In addition, the thermal barrier is not recognized as adding fire resistance to the mass timber rating. This requirement will allow occupants additional time to evacuate as well as allow first responders additional time to perform.

Section 509.4 (separation of incidental uses) only requires the thermal barrier be on the side where the hazard exists; that is, the side facing the incidental use. For example, a mass timber floor assembly with a noncombustible topping would not require a thermal barrier on the mass timber floor assembly when the incidental use area is located on that specific floor. In addition, the thermal barrier would not be required if the optional substitution of fire suppression for the thermal barrier is exercised. It should be noted that this change only addresses the contribution of exposed mass timber and does not relax any of the fire resistance requirements of Sections 508 or 509 or other mass timber provisions.

CONCLUSION

The International Code Council (ICC) adopted a comprehensive set of changes to the 2021 *International Building Code* (IBC) for the safe construction and use of mass timber buildings. The changes were developed through an Ad Hoc Committee of subject matter experts after years of study, peer review, full-scale fire testing at the ATF Fire Research Laboratory, and review and approval by code experts at the ICC Committee Action Hearings in 2018 and 2019.

The ICC process was undertaken recognizing that taller mass timber structures are already being approved globally and in the United States at the local level without specific support or recognition by the IBC. The approved code changes require a highly redundant and rigorous package of active and passive systems of fire protection to permit taller and larger buildings made from mass timber materials. The fire protection requirements are intended to ensure that, under any reasonable fire scenarios, life safety is provided, and in addition no structural collapse will occur despite complete burn-out of content fuels. Conservatively, the performance was dictated without consideration of the operation of automatic sprinkler systems required for mass timber buildings. Fire testing has also demonstrated that the charring properties of exposed mass timber elements provide a reliable and predictable measure of fire-resistive performance, even without the protection of added noncombustible materials.

The result of the ICC process is that each of the new types of construction, Type IV-A, Type IV-B and Type IV-C tall mass timber buildings has fire protection requirements more robust than those required for comparable noncombustible buildings.

Tall Mass Timber Type of Construction Comparison

Feature	Type IV-A	Type IV-B	Type IV-C
	100% Noncombustible (NC) protection on all mass timber (MT) surfaces	Noncombustible (NC) protection on most mass timber (MT) surfaces	Exposed mass timber (MT), except shafts, concealed spaces, and outside of exterior walls
PERMITTED MATERIALS			
Structural Building Elements	MT or NC	MT or NC	MT or NC
Nonloadbearing Ext Walls	MT or NC	MT or NC	MT or NC
Nonloadbearing Int Walls	MT or NC	MT or NC	MT or NC
EXIT AND HOISTWAY ENCLOSURES			
Highrise (based on IBC definition) to 12 stories or 180 feet:	NC or MT protected with 2 (or 3 when 3 hr FRR) layers of 5/8" Type X.	NC or MT protected with 2 layers of 5/8" Type X gypsum or equiv each side of enclosure.	NC or MT protected with one layer of 5/8" Type X gypsum each side of shaft or enclosure.
Above 12 stories or 180 feet:	NC	Not Permitted	Not Permitted
NONCOMBUSTIBLE PROTECTION			
Interior Protection Required with 3 hr Fire Resistance Rating	3 layers of 5/8" Type X gypsum	Same as Type IV-A for protected MT. Limited exposed MT elements must have same FRR but may be calculated.	All MT is allowed to be exposed except a requirement for 1 layer of 5/8" Type X on outside surfaces of exterior walls, inside and outside of shafts and exit enclosures, and in concealed spaces.
Required for 2 hr or less Fire Resistance Rating	2 layers of 5/8" Type X gypsum	Same as Type IV-A for protected MT. Limited exposed MT elements must have same FRR but may be calculated.	All MT is allowed to be exposed except a requirement for 1 layer of 5/8" Type X on outside surfaces of exterior walls, inside and outside of shafts and exit enclosures, and in concealed spaces.
Exterior Protection	Minimum of 1 layer of 5/8" Type X gypsum	Minimum of 1 layer of 5/8" Type X gypsum	Minimum of 1 layer of 5/8" Type X gypsum
Floor Surface	1" of NC protection	1" of NC protection	No protection required
Roof	No NC protection required on exterior roof surface; 2 layers of 5/8" Type X gypsum on underside of roof deck.	No NC protection required on exterior roof surface; 2 layers of 5/8" Type X gypsum on underside of roof deck.	No protection required on roof surface or underside of roof deck (unless concealed space).
Concealed Spaces	No exposed MT in concealed spaces. NC protection in concealed spaces.	No exposed MT in concealed spaces. NC protection in concealed spaces.	No exposed MT in concealed spaces. One layer of 5/8" Type X gypsum NC protection required in concealed spaces.
TABLE 601 FIRE RESISTANCE RATING (FRR)[1]			
Primary Frame or Bearing Wall	3 hr FRR (2 hr at roof)	2 hr FRR (1 hr at roof)	2 hr FRR (1 hr at roof)
Floors	2 hr FRR	2 hr FRR	2 hr FRR
Roof	1.5 hr FRR	1 hr FRR	1 hr FRR

[1] **Note:** FRR reduction for sprinklers in Section 403.2.1 is not permitted.

Tall Mass Timber Buildings

The strength and efficiency of mass timber construction has been well documented for generations. Massive wood structural elements, combined with solid wood floor assemblies, create structures that are strong and resist fire. Mass timber buildings have favorable constructability features and offer energy savings not found in traditional steel and concrete buildings.

The greater availability of mass timber technology has spurred a new generation of taller mass timber buildings. Examples from across Europe and North America have proven the efficiency, cost effectiveness and safety of this type of construction.

MASS TIMBER SYSTEMS ARE QUITE DIFFERENT FROM TRADITIONAL DIMENSION LUMBER.

Unlike light-weight framed structures, mass timber buildings are built with large pre-manufactured panels for floor, wall and roof assemblies. These components, including Cross-Laminated Timber (CLT), Nail-Laminated Timber (NLT), Dowel-Laminated Timber (DLT), Glued Laminated Timber (Glulam), and Structural Composite Lumber (SCL), offer distinctive benefits:

- The resilience of mass timber offers the strength of steel with lower weight;
- Mass timber is manufactured from a renewable resource that uses the sun's energy to sequester atmospheric carbon and is manufactured using less energy than substitute materials;
- Mass timber buildings offer design options and precise building envelopes that significantly reduce energy consumption;
- Mass timber panels and components can be installed by a diverse labor force in less time than other construction methods, and is less disruptive to neighbors;
- Mass timber is inherently fire resistant because a layer of charring in a fire event protects the inner structure of the panel.

The International Code Council (ICC) approved code changes to the 2021 *International Building Code* that provides local officials with the tools they need to ensure new mass timber buildings meet the standards by the code. The suite of changes were introduced by the ICC Ad Hoc Committee on Tall Wood Buildings following two years of study. Their work was aided by multiple fire performance tests on mass timber structures conducted at the federal Alcohol, Tobacco, Firearms and Explosives (ATF) National Fire Research Laboratory, the world's largest fire investigations lab. The fire tests confirmed mass timber structures can be constructed to provide fire performance equivalent to non-combustible buildings. This action makes ICC a worldwide leader in the development of tall mass timber code requirements.

The Facts

About Mass Timber and its Inherent Benefits in Tall Building Construction

A combination of fire resistance, structural integrity and environmental attributes make new tall wood buildings among the most innovative structures in the world. Here are the facts about mass timber:

MASS TIMBER IS FIRE RESISTANT

During a fire resistance test of a 5-ply cross-laminated timber (CLT) panel wall, the panel was subjected to temperatures exceeding 1,800 Fahrenheit and lasted 3 hours and 6 minutes, far more than the two-hour rating that building codes require.[I]

During fire exposure, mass timber chars on the outside, which forms an insulating layer protecting interior wood from damage. Additionally, when the code requires mass timber to be protected with gypsum wall board, the mass timber can achieve nearly damage-free performance during a contents-fire burnout event.[II]

MASS TIMBER IS STRONG

A recent mass timber building weighs approximately 1/5th that of comparable concrete buildings,[III] which in turn reduces the building's foundation size, inertial seismic forces and embodied energy. High strength-to-weight ratios enable mass timber to perform well during seismic activity.

MASS TIMBER IS SUSTAINABLE

Replacing steel with mass timber could reduce carbon dioxide emissions by between 15% and 20%.[IV]

The White House Domestic Policy Council estimated that the near term use of CLT and other emerging wood technologies in buildings 7-15 stories could have the same emissions control effect as taking more than 2 million cars off the road for one year.[V]

The fire tests confirmed that mass timber structures meet and generally exceed the fire resistance requirements in the current code. Studies have shown that building with wood produces fewer greenhouse gas emissions than building with other materials.[VI]

MASS TIMBER MAKES CONSTRUCTION COST-EFFICIENT

In one engineering firm's experience, mass timber buildings are roughly 25% faster to construct than concrete buildings[VII] and required 90% less construction traffic.[VIII]

Since mass timber panels are prefabricated and then assembled on site, buildings made from mass timber have much shorter project timelines and safer construction sites.

Photo Source: Tiia Monto

CITATIONS

I. http://www.awc.org/pdf/education/des/ReThinkMag-DES610A-MassTimberinNorthAmerica-161031.pdf

II. https://www.fpl.fs.fed.us/documnts/pdf2016/fpl_2016_pei001.pdf

III. http://www.architectmagazine.com/technology/t3-becomes-the-first-modern-tall-wood-building-in-the-us_o

IV. http://www.sciencemag.org/news/2016/09/would-you-live-wooden-skyscraper

V. https://www.usda.gov/media/blog/2014/10/10/announcing-us-tall-wood-building-prize-competition-innovate-building

VI. https://www.tandfonline.com/doi/full/10.1080/10549811.2013.839386

VII. http://www.awc.org/pdf/education/des/ReThinkMag-DES610A-MassTimberinNorthAmerica-161031.pdf

VIII. http://www.awc.org/pdf/education/des/ReThinkMag-DES610A-MassTimberinNorthAmerica-161031.pdf