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# Fire Requirements for Mass Timber Elements

## Code Applications, Construction Types, and Fire Ratings

For many years, exposed heavy timber framing elements have been permitted in U.S. buildings due to their inherent fire-resistance properties. The predictability of wood's char rate has been well-established for decades and has long been recognized in building codes and standards.

Today, one of the exciting trends in building design is the growing use of mass timber—i.e., large solid wood panel products such as cross-laminated timber (CLT) and nail-laminated timber (NLT)—for floor, wall, and roof construction. Like heavy timber, mass timber products have inherent fire resistance that allows them to be left exposed and still achieve a fire-resistance rating (FRR). Because of their strength and dimensional stability, these products also offer an alternative to steel, concrete, and masonry for many applications, but have a lower carbon impact. It is this combination of exposed structure and strength that developers and designers across the country are leveraging to create innovative designs with a warm yet modern aesthetic, often for projects that go beyond traditional norms.

This paper has been written to support architects and engineers exploring the use of mass timber for commercial and multi-family construction. It introduces fire-related requirements in the International Building Code (IBC) applicable to all mass timber buildings, and serves as a foundation for other fire design resources available at woodworks.org. Unless otherwise noted, references refer to the 2024 IBC.

### Mass Timber & Construction Type

Before demonstrating FRRs of exposed mass timber elements, it is important to understand under what circumstances the IBC currently allows the use of mass timber in commercial and multi-family construction.

A building's assigned construction type is the main indicator of where and when all wood systems can be used. IBC Section 602 defines five main options (Type I through V); Types I, II, III, and V have subcategories A and B, while Type IV has subcategories IV-HT, IV-A, IV-B, and IV-C. Types III, IV, and V permit the use of wood framing throughout much of the structure and are used extensively for modern mass timber buildings.

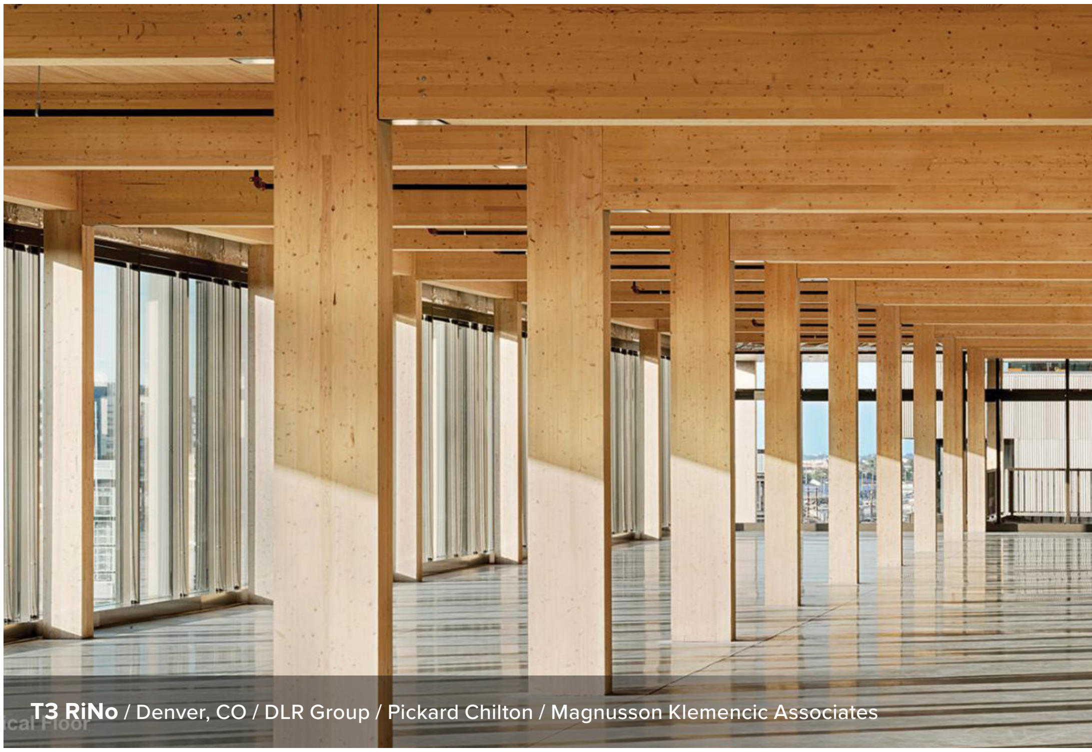

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Photo Eric Laignel

***Type III*** (IBC 602.3) – Timber elements can be used in floors, roofs, and interior walls. Fire-retardant-treated wood (FRTW) framing is permitted in exterior walls required to have an FRR of 2 hours or less.

***Type V*** (IBC 602.5) – Timber elements can be used throughout the structure, including floors, roofs, and both interior and exterior walls.

***Type IV*** (IBC 602.4) – Often referred to as 'heavy timber' construction, this option has been in the building code for over a hundred years in one form or another, but its use has increased along with renewed interest in exposed wood buildings. In the 2021 IBC, the historic heavy timber construction type was renamed IV-HT and three new construction types were created for mass timber—IV-A, IV-B, and IV-C. Type IV construction types are unique in that fire-resistive behavior is based in part on the inherent and long-demonstrated fire resistance of large solid wood framing.

In Type IV-HT construction, structural wood components are permitted in floors, roofs, and interior walls when they meet minimum cross-section sizes. Per IBC Sections 602.4.4.1 and 602.4.4.2, walls required to have an FRR of 2 hours or less are also permitted to use FRTW framing or CLT when the exterior is covered with FRTW sheathing or noncombustible materials. In general, heavy timber components used in Type IV-HT construction can be exposed.

In Types IV-A, IV-B, and IV-C buildings, timber components are permitted when they meet the minimum cross-section sizes required for Type IV-HT plus additional FRR requirements and exposure limits in IBC Sections 602.4.1, 602.4.2, and 602.4.3. For information on the design of tall mass timber structures using Type IV construction, see the WoodWorks Tall Mass Timber webpage.

**TABLE 1:** Heavy timber minimum member sizes

| Application | Minimum Nominal Size |
|---|---|
| Floor decking | 3" decking planks w/ 15/32" WSP* or<br>4" boards on edge (NLT) w/ 15/32" WSP or<br>4" CLT |
| Roof decking | 2" decking planks or<br>3" boards on edge (NLT) or<br>3" CLT |

*Source: IBC Section 2304.11*
**WSP = Wood structural panel*

## Heavy Timber Requirements

The fire resistance of heavy timber construction is based on the inherent size of large timber elements. In a fire, large members tend to retain their load-carrying ability longer than members with small cross sections; this is because a char layer forms on the surface while the interior remains undamaged and structurally sound. IBC Section 2304.11 provides minimum heavy timber sizes for columns, floor framing and decking, roof framing and decking, and walls. Minimum sizes for heavy timber framing are provided for sawn members and actual (net) sizes are provided for structural glue-laminated timber (glulam) and structural composite lumber (SCL).

**TABLE 2:** Minimum dimensions of heavy timber structural members

| | | Minimum Nominal Sawn Size | | Minimum Glulam Net Size | | Minimum SCL Net Size | |
|---|---|---|---|---|---|---|---|
| **Supporting** | **Heavy Timber Structural Elements** | Width (in.) | Depth (in.) | Width (in.) | Depth (in.) | Width (in.) | Depth (in.) |
| Floor loads only or combined floor and roof loads | Columns | 8 | 8 | 6-3/4 | 8-1/4 | 7 | 7-1/2 |
| | Wood beams and girders | 6 | 10 | 5 | 10-1/2 | 5-1/4 | 9-1/2 |
| Roof loads only | Columns | 6 | 8 | 5 | 8-1/4 | 5-1/4 | 7-1/2 |
| | Framed timber trusses and other roof framing[a] | 4[b] | 6 | 3[b] | 6-7/8 | 3-1/2[b] | 5-1/2 |

*Source: IBC Table 2304.11 / See IBC for footnotes*

## Fire-Resistance Rating Requirements

The IBC defines FRR as *the period of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or the methods based on tests, prescribed in Section 703.*

## FRR based on Construction Type

A building's construction type determines many of the minimum FRRs required for its components, as shown in IBC Table 601. A couple features of this table are relevant to mass timber.

Footnote c allows timber components meeting the requirements for heavy timber to be used in the construction of all roofs having an FRR of 1 hour or less. This means that a timber roof meeting the minimum heavy timber size requirements can be used in roof framing of Types I-B, II-A, and II-B construction, which otherwise prohibit the use of combustible framing.

With the exception of Type IV, interior nonbearing walls and partitions generally do not have an FRR requirement based on construction type. Bearing and nonbearing exterior walls may have additional FRR requirements in IBC Table 705.5 based on the fire separation distance from the property line or adjacent building.

## Other FRR Requirements in the IBC

For multi-unit residential buildings, walls and floors between dwelling or sleeping units are required to have an FRR of 1/2 hour in Types II-B, III-B, and V-B construction when sprinklered throughout with an NFPA 13 system, and 1 hour for all other construction types (Sections 420, 708, and 711). Multiple separated occupancies (Section 508.4), incidental uses (Section 509), and special provisions (Section 510) also require FRRs of select components and assemblies.

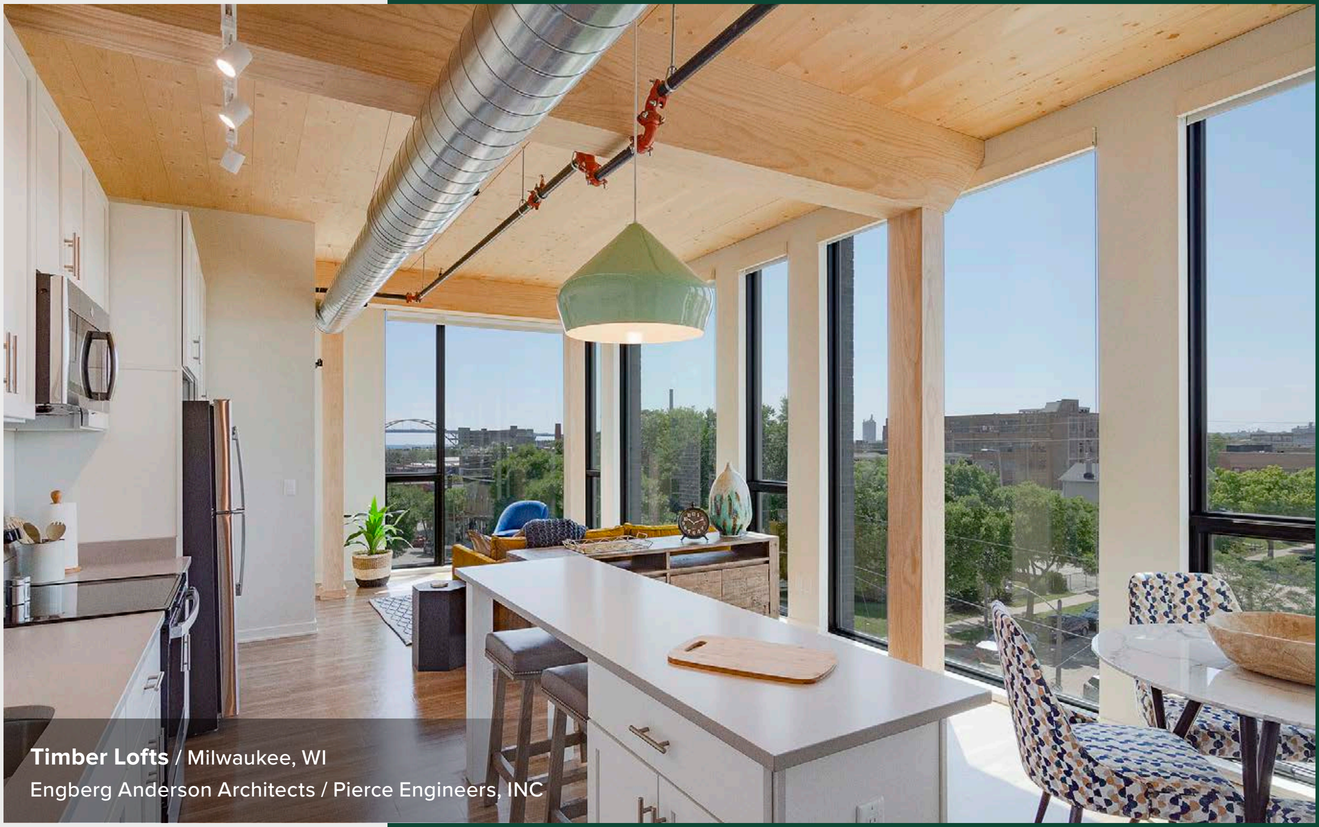
## Selecting a Construction Type

Selecting a construction type is one of the more significant design considerations on a mass timber project. While it is common to choose based on structural material—i.e., to assume that steel and concrete structures should be Type II, light-frame wood should be Type V, and exposed heavy timber should be Type IV—this approach can lead to less efficient designs. While Type IV construction can be used for exposed mass timber projects, it is beneficial to have a full understanding of the allowable use of materials in all five construction types, and the unique allowances and limitations associated with each.

**TABLE 3:** FRR Requirements for building elements (hours)

| Building Element | Type I | | Type II | | Type III | | Type IV | | | | Type V | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | A | B | A | B | A | B | C | HT | A | B |
| Primary structural frame[f] (see Section 202) | 3[a,b] | 2[a,b] | 1[b] | 0 | 1[b] | 0 | 3 | 2 | 2 | HT | 1[b] | 0 |
| Bearing walls – exterior[e,f] | 3 | 2 | 1 | 0 | 2 | 2 | 3 | 2 | 2 | 2 | 1 | 0 |
| Bearing walls – interior | 3[a] | 2[a] | 1 | 0 | 1 | 0 | 3 | 2 | 2 | 1/HT[g] | 1 | 0 |
| Nonbearing walls and partitions – exterior | See Table 705.5 | | | | | | | | | | | |
| Nonbearing walls and partitions – interior[d] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | See Section 2304.11.2 | 0 | 0 |
| Floor construction and associated secondary members (see Section 202) | 2 | 2 | 1 | 0 | 1 | 0 | 2 | 2 | 2 | HT | 1 | 0 |
| Roof construction and associated secondary members (see Section 202) | 1-1/2[b] | 1[b,c] | 1[b,c] | 0[c] | 1[b,c] | 0 | 1-1/2 | 1 | 1 | HT | 1[b,c] | 0 |

*Source: IBC Table 601 / See IBC for footnotes*



**Timber Lofts** / Milwaukee, WI
Engberg Anderson Architects / Pierce Engineers, INC

Photo: ADX Creative

## Common Mass Timber Products

Mass timber refers to a category of framing styles characterized by the use of large engineered wood panels, often paired with engineered wood columns and beams. Common mass timber panel products include:

- Cross-laminated timber (CLT) – Made from layers (or plies) of sawn lumber or structural composite lumber (SCL) oriented at right angles to one another and glued to form structural panels; typically three, five or seven layers
- Glue-laminated timber (GLT when fabricated into panels) – Made from sawn lumber members (typically 2x), layered parallel on their wide faces, with adhesive between layers
- Nail-laminated timber (NLT) – Made from sawn lumber members (typically 2x) oriented on edge and connected with nails
- Dowel-laminated timber (DLT) – Similar to NLT but joined with friction-fit hardwood dowels instead of nails

*Heavy timber* has a long history associated with large cross sections of sawn members (beams, purlins, and columns), and is often used with tongue-and-groove decking for floors and roofs. The IBC continues to recognize these products as acceptable for use in all Type IV construction, provided the minimum required size and detailing requirements are met.

For more information, see the WoodWorks publication, *What is mass timber?*

**TABLE 4:** Comparison of Types III, IV, and V construction

| Construction Type | III-A | III-B | IV-A | IV-B | IV-C | IV-HT | V-A | V-B |
|---|---|---|---|---|---|---|---|---|
| Exterior wood wall materials | FRTW | FRTW | CLT | CLT | CLT | FRTW or CLT | Any wood including mass timber | Any wood including mass timber |
| Exterior bearing wall FRR | 2-hour | 2-hour | 3-hour | 2-hour | 2-hour | 2-hour | 1-hour | 0-hour |
| Interior framing materials | Any wood including mass timber | Any wood including mass timber | Heavy timber including mass timber | Heavy timber including mass timber | Heavy timber including mass timber | Heavy timber including mass timber | Any wood including mass timber | Any wood including mass timber |

*Sources: IBC Section 602, Table 601, and Section 2304.11*

To optimize a building design from a construction type perspective, it is best to start with Type V-B construction and work toward construction types with larger allowable heights and areas and more stringent requirements. This avoids unnecessary defaults or assumptions—and unnecessary costs. The fact that certain materials are being used doesn't mean there is only one option for construction type. For example, a building may have steel, concrete, or masonry structural elements, but this doesn't mean Type I or II construction is necessary, nor does it preclude mass timber framing for the remainder of the building. Likewise, a building with mass timber elements has options other than Type IV construction. Note IBC Section 602.1.1:

> ***602.1.1 Minimum requirements.*** *A building or portion thereof shall not be required to conform to the details of a type of construction higher than that type which meets the minimum requirements based on occupancy even though certain features of such a building actually conform to a higher type of construction.*

This section permits the use of elements commonly used in a different construction type without requiring that the entire building meet all the provisions of that construction type. For example, if a building's size permitted the use of Type V-B construction, it could still be completely framed with noncombustible materials while being classified as V-B. Similarly, a Type III or V building could be framed with a combination of combustible and noncombustible materials.

As noted, it is usually best from a cost-efficiency perspective to start a building analysis with Type V-B construction. Type V-B provides the most flexibility in terms of allowable use of materials throughout the building while minimizing requirements for fire-resistance-rated assemblies and structural elements. However, it is also the most restrictive in terms of allowable building size. All three of these factors—allowable building size, allowable use of structural materials, and required fire-resistance levels—are interconnected. The Heights and Areas Calculator at woodworks.org can be used to determine maximum heights and areas for buildings of various occupancies and levels of fire protection.

IBC construction types provide trade-offs between allowable building size and fire-resistance requirements. Allowable building sizes also vary between occupancies to account for differing levels of fire and life safety risks associated with various building functions. FRRs measure how long a building element (wall, floor) can be exposed to a standardized fire while providing fire containment and structural performance (i.e., 1 hour, 2 hours).

If Type V-B construction doesn't allow as large a building as desired, the next step is often to check Type V-A. The main differences between V-B and V-A are FRR requirements and allowable building size. If Type V-A doesn't allow the desired size, Type III-B is the next choice, with Type III-A following. However, there are situations where a design team may want to consider construction types "out of order." For example, Table 601 does not require fire ratings for interior elements in Type III-B construction, but they are required in Type V-A. In some cases, using Type III-B may be beneficial to the project even though the building could qualify as Type V-A. Type IV-HT construction has similar allowable building size limits as Type III-A; however, there are nuances to the selection of one or the other as discussed later in this paper.

Table 5 summarizes the main differences between Types III-A and IV-HT construction, as well as the wood systems permitted in each. These allowances are shown in IBC Section 602, Table 601, and Section 2304.11.

**TABLE 5:** Comparison of construction Types III-A and IV-HT, Group B occupancy

| | Type III-A | Type IV-HT | IBC Reference |
|---|---|---|---|
| **Allowable Height/Area** | | | |
| Base allowable area per story[1, 2] | 85,500 | 108,000 | Table 506.2 |
| Allowable stories[1] | 6 | 6 | Table 504.4 |
| Allowable building height[1] | 85' | 85' | Table 504.3 |
| **FRR Requirements** | | | |
| Primary structural frame | 1 hour | HT | Table 601 |
| Exterior bearing walls | 2 hours | 2 hours | |
| Interior bearing walls | 1 hour | 1 hour/HT | |
| Nonbearing exterior walls | Table 602 | Table 602 | |
| Nonbearing interior walls | 0 hours | 1-hour or per 2304.11.2.2 | |
| Floor construction & associated secondary members | 1 hour | HT | |
| Roof construction & associated secondary members | 1 hour[3] | HT | |
| **Other Considerations** | | | |
| FRTW required in exterior walls | Yes | Yes (except CLT) | Sections 602.3 & 602.4.4.1 |
| CLT allowed in exterior walls | No | Yes with stipulations | Section 602.4.4.2 |
| Concealed spaces allowed in floor systems | Yes | Yes | Sections 602.3 & 602.4.4.3 |
| Exterior wall projections | Any approved material | Any approved material | Section 705.2.2 |
| Interior finish requirements | Table 803.13 | Exempt | Section 803.3 |
| Minimum roof covering classification | B | B | Section 1505.1 |

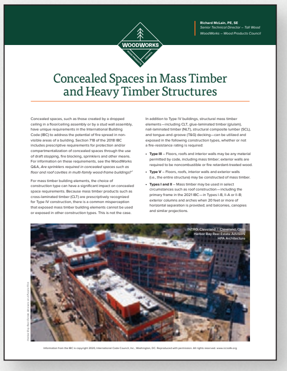
*[1]NFPA 13 sprinklered throughout building per IBC Section 903.3.1.1*
*[2]No frontage increase included*
*[3]Note ability to use heavy timber in Type III-A roof construction in lieu of FRR per IBC Table 601 footnote c*
*HT = heavy timber; see minimum wood member sizes in IBC Section 1203.11*

## Concealed Spaces in Type IV Construction

As of the 2021 IBC, concealed spaces are permitted in Type IV-HT heavy timber construction provided one or more of the following measures are in place:

- The building is sprinklered throughout and sprinkler protection is provided in the concealed space
- Combustible surfaces framing the concealed space are protected with 5/8-inch Type X gypsum board
- The concealed space is completely filled with a noncombustible material such as mineral wool insulation

For more information, see the WoodWorks publication, *Concealed Spaces in Mass Timber and Heavy Timber Structures*.



When looking to maximize the code's building size allowances for mass timber structures, the differences between Type III-A and IV-HT construction are important. For example:

- Types III-A and IV-HT permit concealed spaces, but protection requirements vary. For Type III-A, protection of concealed spaces is not prescriptively addressed in the IBC. Concealed spaces in IV-HT construction are addressed in IBC Section 602.4.4.3. In either case, requirements for NFPA 13 sprinkler systems may impact the design of these spaces.
- With the exception of bearing walls, Type IV-HT does not require that FRR be demonstrated for structural elements. Type III-A and V-A buildings have many elements with FRR requirements per Table 601, where Type IV-HT does not. Type IV-HT allows the use of CLT in exterior walls; FRTW CLT is not available to meet the Type III requirement for FRTW in the exterior walls.

Table 5 illustrates these and other differences for a Group B occupancy building.

Type IV-HT construction requires that all interior partition walls be noncombustible, solid wood, or 1-hour rated—which can significantly impact its utility for some applications. The alternative of using Type III construction (or Type V where building size permits) avoids this limitation; however, the processes for demonstrating FRRs also vary between Types IV-HT, III, and V.

## Methods of Demonstrating Mass Timber FRRs

There are two main ways to demonstrate the FRR of a mass timber member: testing as described in IBC Section 703.2.1 and analytical methods described in Section 703.2.2. IBC-recognized test methods comply with ASTM E119 Standard Test Methods for Fire Tests of Building Construction and Materials or UL 263 Standard for Fire Tests of Building Construction and Materials.

Mass timber elements and assemblies have achieved FRRs of 3 hours or more during testing, and additional tests by manufacturers and others are ongoing. Most tests are conducted according to ASTM E119 or its Canadian equivalent, CAN/ULC S101 Standard Methods of Fire Endurance Tests of Building Construction Materials. Both utilize the same time-temperature curve and performance criteria and, as such, CAN/ULC S101 fire tests are usually acceptable for U.S. projects under the IBC. However, the Authority Having Jurisdiction (AHJ) should be consulted if choosing this design route.

**1 De Haro** / San Francisco, CA
SKS Partners / Perkins&Will / DCI Engineers

Photo: David Wakely

IBC Section 703.2.2 defines the analytical methods to demonstrate FRRs as:

1. *Fire-resistance designs documented in approved sources*
2. *Prescriptive designs of fire-resistance-rated building elements, components or assemblies as prescribed in Section 721*
3. *Calculations in accordance with Section 722*
4. *Engineering analysis based on a comparison of building element, component or assemblies designs having fire-resistance ratings as determined by the test procedures set forth in ASTM E119 or UL 263*
5. *Fire-resistance designs certified by an approved agency*

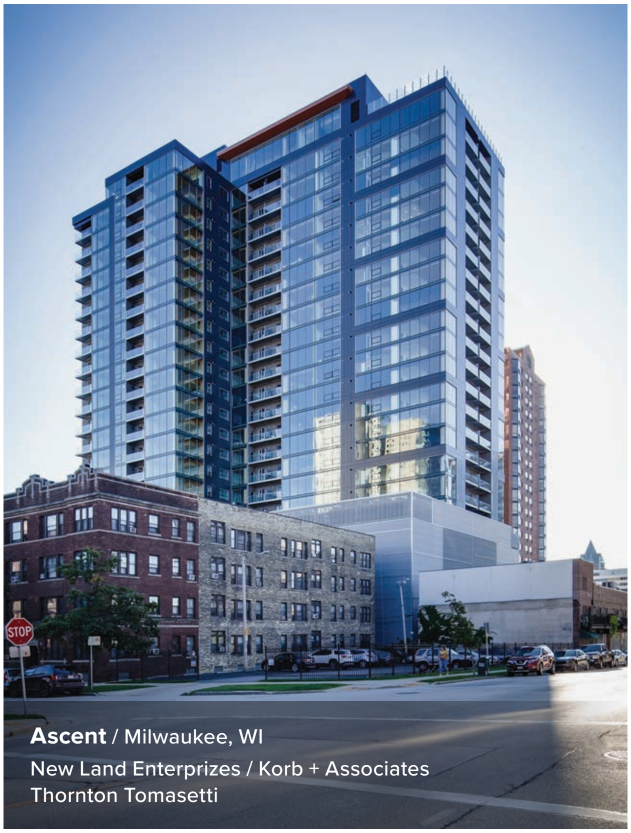
Methods 1, 2, and 5 are all expedient routes that require neither analysis nor test reports presented by the design team. For method 1, the *Fire Resistance Design Manual* by the Gypsum Association and *Fire-Resistance-Rated Wood-Frame Wall and Floor/Ceiling Assemblies* (DCA 3) from the American Wood Council (AWC) are commonly referenced as "approved sources." If using method 2, some tested FRR assemblies are now prescribed in the tables of IBC Section 722. For method 5, the most referenced source of fire-resistance designs certified by an "approved agency" are UL-listed fire designs. The use of these designs is strictly for convenience as the IBC neither requires nor explicitly accepts them. As a newer class of products, mass timber is not well represented in methods 1, 2, or 5, but this will evolve over time.

Methods 3 and 4 recognize analytical methods performed for the specific project. Method 4 recognizes the comparison of designs having an FRR as determined through testing with a proposed design as performed by an engineer familiar with fire-resistance testing and material performance. Method 3 references the IBC-recognized fire-resistance calculation methods in Section 722, which includes char calculation.

Calculated fire resistance is a common approach to demonstrating FRRs of exposed mass timber systems. As shown in Figure 1, IBC Section 722.1 references Chapter 16 of AWC's National Design Specification (NDS®) for Wood Construction® for calculating fire ratings of exposed timber elements. Calculations are used in nearly all instances when demonstrating FRRs for exposed timber beams and columns. For mass timber floor and wall panels, a mix of calculations and fire-tested assemblies is used.

Tested fire-resistance-rated mass timber floor and walls assemblies, connections, and penetrations can be found in WoodWorks' Mass Timber Fire & Acoustic Database.

For information on how to calculate the FRR of mass timber elements using analytical methods, see the WoodWorks paper, *Fire Design of Mass Timber Structural Members: Demonstrating Fire-Resistance Ratings of Mass Timber Products*. Discussion includes code requirements for encapsulating mass timber elements with non-combustible materials in Type IV-A, IV-B, and IV-C construction, and how to use a combination of the noncombustible materials and timber to calculate the FRR.




**Ascent** / Milwaukee, WI
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Thornton Tomasetti

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## Fire Protection of Penetrations

It is often necessary to penetrate a fire-resistance-rated floor, roof, or wall assembly to accommodate mechanical, electrical, plumbing, or fire suppression (MEPF) elements. These elements can range from combustible pipe or tubing to noncombustible wiring with combustible coverings to noncombustible members such as pipe, conduit, and ductwork. To maintain the continuity and integrity of rated assemblies, penetrations must be properly sealed and protected in accordance with IBC Section 714.

Note that Sections 707.7, 708.7, 712.1.4, and 713.8, which cover penetrations in fire partitions, fire barriers, shaft enclosures, and horizontal assemblies (respectively), all point to Section 714 for their protection.

Section 714.4.1 addresses penetrations in wall assemblies, and gives the following options for demonstrating acceptable protection measures:

1. *Penetrations shall be installed as tested in an approved fire-resistance-rated assembly (i.e., incorporated during the conduct of an ASTM E119 test of the wall assembly, per Section 714.4.1.1) or, more commonly,*
2. *Protected by an approved penetration firestop system installed as tested in accordance with ASTM E814 [Standard Test Method for Fire Tests of Penetration Firestop Systems] or UL 1479 [Standard for Fire Tests of Through-Penetration Firestops], with a minimum positive pressure differential of 0.01 inch of water and shall have an F (flame) rating of not less than the required fire-resistance rating of the wall penetrated (per Section 714.4.1.2).*

The requirements for penetration protection in floor/roof assemblies are given in IBC Section 714.5.1 and are similar to those for walls. The main difference is that, when using a tested and approved firestop system, a T (temperature) rating is required for floors in addition to an F (flame) rating.

The purpose and construction of common firestop systems are described in the commentary to Section 714.4.1.2:

> *A through-penetration firestop system consists of specific materials or an assembly of materials that are designed to restrict the passage of fire and hot gases for a prescribed period of time through openings made in fire resistance-rated walls or horizontal assemblies. In certain instances, the through-penetration firestop system is also required to limit the transfer of heat from the fire side to the unexposed side. In order to determine the effectiveness of a through penetration firestop system in restricting the passage of fire and the transfer of heat, firestop systems are required to be subjected to fire testing. ASTM E814 and UL 1479 are the test methods developed specifically for the evaluation of a firestop system's ability to resist the passage of flame and hot gases, withstand thermal stresses and restrict transfer of heat through the penetrated assembly.*

**FIGURE 1:** Code path for exposed wood fire-resistance calculations

**IBC Section 703.2.2**
**Methods for determining fire resistance**

- Prescriptive designs per IBC 721.1
- ***Calculations in accordance with IBC 722***
- Fire-resistance designs documented in sources
- Engineering analysis based on a comparison

↓

**IBC Section 722**
**Calculated Fire Resistance**

"The calculated *fire resistance* of exposed wood members and wood decking shall be permitted in accordance with **Chapter 16 of the National Design Specification for Wood Construction (NDS)**

↓

**NDS Chapter 16**
**Fire Design of Wood Members**

- Limited to calculating fire resistance up to 2 hours
- Char depth varies based on standard exposure time (i.e., FRR)

Beyond ASTM E814 and UL 1479, several tests conducted for these conditions on mass timber assemblies have achieved F and T ratings up to 2 hours. A summary of these tests is included in WoodWorks' Mass Timber Fire & Acoustics Database.

## Fire Protection of Connections

In addition to FRR requirements for wood members such as beams, columns, and floor/roof panels, connections between members (e.g., beam-to-column connections) must have sufficient protection to provide the same FRR. With a few exceptions, IBC Section 704 requires structural members, including connections, supporting a fire-resistance-rated assembly, to have an FRR not less than the FRR of the supported assembly.

There are several methods for achieving a fire-rated connection. For example, Section 16.5 of the NDS states:

> *Structural wood connections, including connectors, fasteners, and portions of wood members included in the connection design, shall be protected from fire exposure for the required fire-resistance time in accordance with the FDS. Protection shall be provided by wood, fire-rated gypsum board, other approved materials, or a combination thereof.*

Detailing strategies to protect structural connections of wood members include:

- Concealed connections protected by the predictable charring of wood in a fire event
- Exposed timber-on-timber bearing connections, where critical bearing surfaces are protected by charring of wood
- Concealed connections protected by fire-rated gypsum board
- Other materials or methods approved by the AHJ

As with other mass timber elements, fire testing and analytical methods may be used to demonstrate compliance for connections.

For more information, see the WoodWorks paper, *Fire Design of Mass Timber Connections*.

Photo: Travis Mark

**Timber House** / Brooklyn, NY / MESH Architectures / Silman

## Interior Finish Requirements

When using exposed mass timber framing, structure also functions as finish, making it necessary to consider interior finish provisions of the code. IBC Chapter 8 provides requirements and limitations for items such as flame spread index, heat release and flashover, and flame propagation limitations for interior finishes. Section 803 covers wall and ceiling finishes, which are the most common applications of exposed mass timber. Per Section 803.3, exposed heavy timber elements complying with the requirements of Type IV construction or the minimum size requirements of Section 2304.11 are not subject to interior finish requirements except in interior exit stairways, interior exit ramps, and exit passageways.

In the locations where the interior finish requirements apply, IBC Section 803.1.2 defines how materials are classified for flame spread and smoke-development performance. It states:

> *Interior wall and ceiling finish materials shall be classified in accordance with ASTM E84 [Standard Test Method for Surface Burning Characteristics of Building Materials] or UL 723 [Test for Surface Burning Characteristics of Building Materials]. Such interior finish materials shall be grouped in the following classes in accordance with their flame spread and smoke-developed indexes.*
>
> *Class A: Flame spread index 0-25; smoke-developed index 0-450*
>
> *Class B: Flame spread index 26-75; smoke-developed index 0-450*
>
> *Class C: Flame spread index 76-200; smoke-developed index 0-450*

IBC Table 803.13 provides the requirements for interior finish class (A, B, or C), which is a function of the building's occupancy, whether or not it is sprinklered, and where in the building the finish is located. For sprinklered buildings, most occupancies and building areas require a class B or C finish per Table 6.

AWC's *Design for Code Acceptance 1 – Flame Spread Performance of Wood Products Used for Interior Finish* (DCA 1) lists flame spread values for a number of wood species and panel products. Table 7 shows values for common species used in softwood mass timber framing members. Mass timber product manufacturers have conducted ASTM E84 tests on their products and have found results matching or exceeding those presented in DCA 1.

**TABLE 6:** Interior wall and ceiling finish requirements by occupancy

| Group | Sprinklered[1] | | | Nonsprinklered | | |
|---|---|---|---|---|---|---|
| | Interior exit stairways and ramps and exit passageways[a,b] | Corridors and enclosure for exit access stairways and ramps | Rooms and enclosed spaces[c] | Interior exit stairways and ramps and exit passageways[a,b] | Corridors and enclosure for exit access stairways and ramps | Rooms and enclosed spaces[c] |
| A-1, A-2 | B | B | C | A | A[d] | B[e] |
| A-3[f], A-4, A-5 | B | B | C | A | A[d] | C |
| B, E, M, R-1 | B | C | C | A | B | C |
| R-4 | B | C | C | A | B | B |
| F | C | C | C | B | C | C |
| H | B | B | C[g] | A | A | B |
| I-1 | B | C | C | A | B | B |
| I-2 | B | B | B[h,i] | A | A | B |
| I-3 | A | A[j] | C | A | A | B |
| I-4 | B | B | B[h,i] | A | A | B |
| R-2 | C | C | C | B | B | C |
| R-3 | C | C | C | C | C | C |
| S | C | C | C | B | B | C |
| U | No restrictions | | | No restrictions | | |

*Source: IBC Table 803.13 / See IBC for footnotes*

**TABLE 7:** Flame spread values for common mass timber species

| Species | Flame Spread Index | Smoke Developed Index | Flame Spread Class |
|---|---|---|---|
| Douglas fir | 70 | 80 | B |
| Hem-fir species group | 60 | 70 | B |
| Pine, eastern white | 70 | 110 | B |
| Pine, southern yellow | 70 | 165 | B |
| Spruce, black (4"-thick, 3 layers of cross laminations) | 35 | 55 | B |

*Source: DCA 1, AWC*

## Conclusion

The increased use of exposed mass timber in multi-family and commercial buildings has created a need for greater understanding of the fire design procedures for these types of structures. Under the IBC, many mass timber products are permitted and multiple design routes exist for demonstrating compliance with fire-related provisions of the building code. As wood members are exposed to fire and the wood begins to burn, a char layer is formed. The char layer acts as an insulator and protects the core of the wood section. Mass timber elements can be designed so a sufficient cross-section of wood remains to sustain the design loads for the required duration of fire exposure. This sets mass timber apart as a unique building material—one that is able to achieve structural performance and passive fire-resistance objectives for larger and taller wood buildings than ever before, while offering enhanced aesthetic value and environmental responsibility.

For more information, including other resources noted in this paper, visit woodworks.org.

**The Offices at Southstone Yards** / Frisco, TX
DudalPaine Architects / Gensler (AOR) / Thornton Tomasetti

Photo: Ryan Conway, courtesy of Gensler

## About WoodWorks – Wood Products Council

WoodWorks provides education and free project support related to the design, engineering, and construction of commercial and multi-family wood buildings in the U.S. For assistance with a project, visit www.woodworks.org/project-assistance or email help@woodworks.org.



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